KU LEUVEN

RETROSPECTIVE ANALYSIS OF TEMPORAL TRENDS AND VARIABILITY IN PATIENT OUTCOMES WITHIN THE BELGIAN HOSPITAL LANDSCAPE

Helping to uncover the wood for the trees towards healthier hospitals

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Supervised by

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November 2023

Dissertation presented in partial fulfillment
of the requirements for the degree of
Doctor in Biomedical Sciences (PhD)

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KU LEUVEN

DOCTORAL SCHOOL
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In God we trust;

all others must bring data.

W. Edwards Deming.

SUMMARY

Quality of hospital care is recognised as an important aspect of patient care that is studied worldwide. An essential facet of this study involves the study of patient outcome measures. However, for Belgian hospitals, knowledge of nationwide patient outcome prevalence and variability between hospitals is lacking. This PhD research aimed to close this knowledge gap by providing an overview of how hospital quality of care has evolved over time and how it varies across Belgian hospitals.

Our research setting of Belgium is characterised by a particular healthcare organisation, wherein quality policy is primarily based on regional governmental decisions. Within the northern region of Flanders, which encompasses the majority of acute-care hospitals, quality policy mainly centred around the Quality-of-Care Triad. Within this Triad, hospitals were encouraged to participate in hospital-wide accreditation programmes and public reporting initiatives, while regularly being inspected by the government. However, our research discovered that the evidence-base for such interventions is scant. Nevertheless, we found how Flemish hospitals had a high adoption rate of the initiatives within the Quality-of-Care Triad. Due to a lack of coordination, implementation of the quality improvement initiatives was often concomitant. Moreover, hospitals indicated to participate in multiple additional initiatives, underlining the high commitment of Belgian hospitals towards quality of care. Today, however, hospitals have stated the unsustainability of the Quality-of-Care Triad, with multiple hospitals opting out of their accreditation programmes.

It is in this setting that our research discovered how the surveyed *vital few* patient outcomes mortality, length of stay, readmissions and patient experiences along with multiple Patient Safety Indicators (PSIs) demonstrated only small improvements between the study period of 2008 to 2018. In hospital all-cause mortality was for example seen to decrease from on average 3.4% to 3.1%, overall length of stay decreased from an overage 7.6 days to 6.5 days and patient experiences improved from 56% of patients awarding a 9 or 10 out of 10 for their hospital experience to 61%. On average, prevalence of PSIs was observed to be low across Belgian hospitals, with a PSI detected in on average 0.1% (n=3,082) of medical and in 1.2% (n=23,993) of surgical hospital stays. Yet, even though these numbers might look promising, they are far removed from comparable mortality, patient experience or PSI rates in other countries such as the US. What's more the numbers are accompanied by other worrying averages, such as increasing readmissions (4.8% to 5.2%) or 23% of patients with a serious but treatable complication (including pneumonia, sepsis or gastro-intestinal bleeding) dying during their hospital stay.

To our concern, this PhD dissertation also exposed alarming between-hospital variation in Belgian acute-care hospitals. It was seen how individual hospitals had isolate temporal trends, with some hospitals seen to improve, while others deteriorated, stagnated or fluctuated. In addition, differences between high achieving hospitals when compared to bottom-performers was exceptionally large. For PSIs for example, some hospitals exceeded nationwide central-line bloodstream infections or pressure ulcer rates by a factor of 8. Both in urological and cardiovascular care, it was medical diagnoses rather than surgical procedures that exhibited the largest inter-hospital variability, with the odds of dying from a urinary tract infection or hypertension approximately being 50% and 150% larger, respectively, in a bottom-performing versus high-achieving hospital. When attempting to quantify the hypothetical effect of reducing this unwarranted variation, this dissertation revealed staggering potential. Should the upper-quartile, i.e. worst-performing hospitals, succeed in improving their patient outcomes to the median

Belgian rate, a total of 412 urological or 633 cardiovascular deaths could potentially be avoided every single year. Looking at the overall hospital-wide picture and calculating improvements across 20 disease groups, resulted in a total of 4,086 lives potentially saved every year. This holds true despite elaborate adjustments for patient risk factors. We observed that known hospital factors such as volume, region or teaching status cannot adequately explain this variability. So, in all likelihood, other organisation-wide factors, which are to date undisclosed, are at the base of the observed differences.

As the majority of this research was conducted on the basis of readily available and inexpensive administrative discharge data, continued monitoring and benchmarking of these important patient outcome measures seems feasible. Our analyses revealed important shortcomings in the delivery of hospital care and allowed for the determination of priorities for policy makers, hospital managers, physicians and all those (close to people) receiving care. Therefore, it is our hope that this thesis can serve as a wake-up call that spurs targeted action to improve overall Belgian hospital care and reduce the indefensible variability observed.

BEKNOPTE SAMENVATTING

Kwaliteit van ziekenhuiszorg wordt erkend als een belangrijk aspect van patiëntenzorg dat wereldwijd wordt bestudeerd. Een essentieel facet binnen dit onderzoek is de studie van patiëntuitkomsten. Voor Belgische ziekenhuizen ontbreekt het echter aan kennis over de prevalentie van patiëntuitkomsten op nationaal niveau en ook omtrent de variabiliteit tussen ziekenhuizen heerst een gebrek aan kennis. Dit doctoraatsonderzoek had als doel deze kenniskloof te dichten door een overzicht te geven van hoe de kwaliteit van ziekenhuiszorg in de loop van de tijd geëvolueerd is en hoe ze varieert tussen Belgische ziekenhuizen.

Onze onderzoekssetting, België, wordt gekenmerkt door een specifieke organisatie van de gezondheidszorg, waarin het kwaliteitsbeleid voornamelijk gebaseerd is op regionale overheidsbeslissingen. In de noordelijke regio Vlaanderen, waar de meerderheid van de acute ziekenhuizen gevestigd is, concentreerde het kwaliteitsbeleid zich voornamelijk rond de Triade van Kwaliteit van Zorg. Binnen deze Triade werden ziekenhuizen aangemoedigd om deel te nemen aan ziekenhuisbrede accreditatieprogramma's en publieke rapporteringsinitiatieven, terwijl ze regelmatig door de overheid werden geïnspecteerd. Ons onderzoek ontdekte echter dat de bewijsbasis voor dergelijke interventies schaars is. Desondanks stelden we vast dat Vlaamse ziekenhuizen een hoge adoptiegraad hadden van de initiatieven binnen de Triade. Door een gebrek aan coördinatie verliep de implementatie van de kwaliteitsverbeteringsinitiatieven vaak gelijktijdig. Bovendien gaven ziekenhuizen aan deel te nemen aan meerdere bijkomende initiatieven, wat de grote betrokkenheid van Belgische ziekenhuizen bij de kwaliteit van zorg onderstreept. Vandaag de dag hebben ziekenhuizen echter aangegeven dat de Triade van Kwaliteit van Zorg niet langer houdbaar is en meerdere ziekenhuizen hebben hun accreditatieprogramma's stopgezet.

Het is in deze omkadering dat ons onderzoek ontdekte hoe de onderzochte *'vital few'* patiëntuitkomsten mortaliteit, verblijfsduur, heropnames en patiëntervaringen samen met meerdere Patiëntveiligheidsindicatoren (PSI's) slechts kleine verbeteringen vertoonden tussen de onderzoeksperiode van 2008 tot 2018. De algemene ziekenhuissterfte daalde bijvoorbeeld van gemiddeld 3,4% naar 3,1%, de totale verblijfsduur daalde van gemiddeld 7,6 dagen naar 6,5 dagen en de patiëntervaringen verbeterden van 56% van de patiënten die hun ziekenhuiservaring een 9 of 10 gaven naar 61%. De prevalentie van PSI's was gemiddeld laag in de Belgische ziekenhuizen, met een PSI gedetecteerd in gemiddeld 0,1% (n=3.082) van de medische en in 1,2% (n=23.993) van de chirurgische ziekenhuisverblijven. Maar ook al lijken deze cijfers veelbelovend, ze staan ver af van vergelijkbare sterftecijfers, patiëntervaringen of PSI-percentages in andere landen zoals de VS. Bovendien gaan de cijfers gepaard met andere zorgwekkende gemiddelden, zoals toenemende heropnames (4,8% tot 5,2%) of 23% van de patiënten met een ernstige maar behandelbare complicatie (waaronder longontsteking, sepsis of maag-darmbloeding) die tijdens hun ziekenhuisverblijf overlijden.

Tot onze bezorgdheid bracht dit doctoraat ook alarmerende variatie tussen ziekenhuizen in Belgische acute zorgziekenhuizen aan het licht. We zagen hoe individuele ziekenhuizen geïsoleerde temporele trends hadden, waarbij sommige ziekenhuizen er op vooruit gingen, terwijl anderen verslechterden, stagneerden of schommelden. Bovendien waren de verschillen tussen ziekenhuizen die goed presteerden en ziekenhuizen die slecht presteerden uitzonderlijk groot. Voor PSI's bijvoorbeeld, overtroffen sommige ziekenhuizen de nationale gemiddelde percentages van bloedbaaninfecties in de centrale lijn of decubitus met een factor 8. Zowel in de urologische als cardiovasculaire zorg waren het eerder de medische diagnoses dan de chirurgische procedures die de grootste variabiliteit tussen de ziekenhuizen

vertoonden, waarbij de kans om te sterven aan een urineweginfectie of hypertensie respectievelijk 50% en 150% groter was in een slecht presterend ziekenhuis versus een goed presterend ziekenhuis. Bij een poging om het hypothetische effect van het verminderen van deze ongerechtvaardigde variatie te kwantificeren, onthulde dit proefschrift een duizelingwekkend potentieel. Als de ziekenhuizen in het bovenste kwartiel, d.w.z. de slechtst presterende ziekenhuizen, erin zouden slagen om hun patiëntuitkomsten te verbeteren tot het niveau van de Belgische mediaan, zouden in totaal 412 urologische of 633 cardiovasculaire sterfgevallen per jaar kunnen worden vermeden. Als we kijken naar het algemene beeld voor het hele ziekenhuis en de verbeteringen berekenen overheen 20 ziektegroepen, komen we uit op een totaal van 4.086 levens die elk jaar mogelijk gered kunnen worden. Dit geldt ondanks uitgebreide correcties voor risicofactoren van patiënten. We stelden vast dat bekende ziekenhuisfactoren zoals volume, regio of onderwijsstatus deze variabiliteit niet adequaat kunnen verklaren. Dus naar alle waarschijnlijkheid liggen andere organisatie brede factoren, die tot op heden niet bekend zijn, aan de basis van de waargenomen verschillen.

Aangezien het grootste deel van dit onderzoek werd uitgevoerd op basis van gemakkelijk beschikbare en goedkope administratieve ontslaggegevens, lijkt het haalbaar om deze belangrijke uitkomstmaten voor patiënten te blijven monitoren en benchmarken. Onze analyses onthulden belangrijke tekortkomingen in het leveren van ziekenhuiszorg en maakten het mogelijk om prioriteiten te bepalen voor beleidsmakers, ziekenhuismanagers, clinici en al diegenen die (dicht staan bij mensen die) zorg ontvangen. Daarom hopen we dat deze thesis kan dienen als een alarmsignaal die aanzet tot gerichte actie om de algemene Belgische ziekenhuiszorg te verbeteren en de waargenomen onverdedigbare variabiliteit te verminderen.

CONTENTS

LIST OF ABBREVIATIONS

AHRQ	Agency for Healthcare Research and Quality (US)
AI	Artificial intelligence
APR-DRG	All-Patient-Refined Diagnosis-Related-Groups
AUC-PR	Area Under the Receiver Operating – Characteristic Curve
CI	Confidence interval
CLABSI	Central venous catheter-related blood stream infection rate
CPOE	Computerised Physician Order Entries
CV	Coefficient of variation
DEV	Malfunction, reaction, complication of genitourinary device or procedure
DIAL	Renal dialysis access device procedure only
DRG	Diagnosis Related Groups
FHN	Flemish Hospital Network (BE)
FlaQuM	Flanders Quality Model
FPS	Flemish Patient Survey
HAI	Hospital acquired infection
HSMR	Hospital standardised mortality ratio
ICD-10-CM	International Classification of Diseases 10-Clinical Modification
ICD-9-CM	International Classification of Diseases 9-Clinical Modification
IHI	Institute for Healthcare Improvement
IOM	Institute of Medicine
IQR	Inter Quartile Range
JCI	Joint Commission International
KCE	Federal Knowledge Centre for Healthcare
KTr	Kidney transplant
LOS	Length of stay
M&M	Morbidity and Mortality Meeting
MBP	Major bladder procedures
MDC	Major Diagnostic Category
MHD	Minimum Hospital Data
MMPP	Major male pelvic procedures
MMRSD	Malignancy, male reproductive system
MRSD	Male reproductive system diagnoses except malignancy

NEPH	Nephritis & nephrosis
OBl	Other bladder procedures
OECD	Organisation for Economic Co-operation and Development
OMRP	Other male reproductive system & related procedures
OUT	Other kidney, urinary tract & related procedures
OUTD	Other kidney & urinary tract diagnoses, signs & symptoms
P4P	Pay-for-Performance
PE/DVT	Pulmonary embolism / Deep vein thrombosis
PENP	Penis Procedures
pLOS	Prolonged length of stay
POA	Present on admission
PR	Public reporting
PSI	Patient Safety Indicator
PU	Pressure Ulcer
QI	Quality improvement
RF	Renal failure
RIZIV-INAMI	National Institute for Health and Disability Insurance (BE)
ROM	Risk of mortality
SMR	Standardised mortality ratio
SOI	Severity of Illness
TRUP	Transurethral prostatectomy
TSP	Testes & scrotal procedures
TUP	Urethral & transurethral procedures
USO	Urinary stones & acquired upper urinary tract obstruction
UTI	Kidney & urinary tract infections
UTM	Kidney & urinary tract procedures for malignancy
UTMD	Kidney & urinary tract malignancy
UTNM	Kidney & urinary tract procedures for non-malignancy
VIKZ	Flemish Institute for Quality of Care (BE)
WHO	World Health Organisation

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Chapter 1

GENERAL INTRODUCTION AND RESEARCH OBJECTIVES

1.1 Quality as a key element of healthcare

1.1.1 What is quality of care?

The concept of assessing quality has had a long history in manufacturing industry, but became introduced within healthcare only in the beginning of the previous century.[1] Pioneers such as Ernest Codman advocated for retrospectively analysing how healthcare processes affect outcomes and argued for practice standardisation.[2] Edwards W. Deming would assert that understanding the organisation-wide healthcare system and measuring variation within this system are fundamental aspects of successful organisations.[3] Avedis Donabedian contended the need to examine healthcare into three domains, i.e. structure, processes and outcome measures, while Joseph M. Juran developed the Pareto principle. The principle states that approximately 80% of detected problems within a system stem from about 20% of possible causes. There should therefore be a considerable focus on the "vital few".[4] Based on the works of these trailblazers, the groundwork for qualitative healthcare was laid.

However, it wouldn't be until the publication of the National Academy of Medicine's, formerly known as the Institute of Medicine (IOM), seminal report 'To Err is Human: Building a Safer Health System' in 1999, that the importance of quality of care and patient safety would truly become recognised.[5] The report brought to light how mortality from medical errors in hospitals exceeded those derived from motor vehicle accidents, breast cancer and AIDS combined. An estimated minimum of 44,000 people were found to be dying in US hospitals every year as a result of medical errors that could have been prevented. In accordance with James Reason's "Swiss cheese model", which demonstrated how failures of system design upstream can lead to accidents downstream at the point of healthcare delivery,[6] IOM's report also stated how systemic errors contributed significantly to patient harm. IOM responded to the report by formally defining healthcare quality as *"the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge."*[7] They established how healthcare quality consisted of six domains: safety,

effectiveness, efficiency, patient-centredness, timeliness and equity.[8] These six domains would become the golden standard of quality thinking.

Today, the six domains have become integrated within a revised multidimensional quality model, as developed by key opinion leaders Lachman, Batalden and Vanhaecht in healthcare quality and patient safety (Figure 1.1).[9] The six original technical dimensions have been expanded by new domains such as eco-friendliness and transparency and the concept of patient-centred care has been broadened to person- and kin-centred care. As such, the model acknowledges the shared humanity of people involved in the interdependent work of healthcare, wherein patients and their loved ones play an active role and wherein care providers involved in a patient safety incident can be considered as "second victims".[10,11] The importance of a quality culture was emphasised by taking healthcare leadership and care provider resilience into account. While previous developments of establishing thresholds and organisation-wide quality management systems remain relevant, the model helps to move towards a service-oriented care system wherein health is coproduced. To achieve this, quality of care should include four core values, which lie at the heart of the model, i.e. kindness with compassion, dignity and respect, a holistic approach and partnership & co-production.

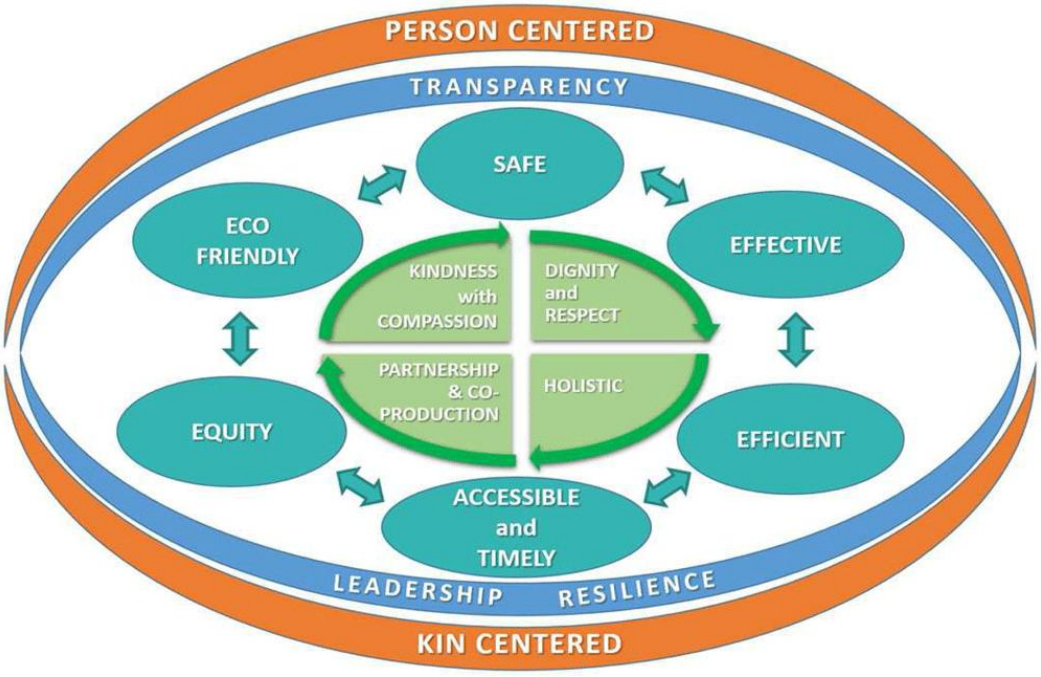

Figure 1.1 Lachman, Batalden and Vanhaecht's multidimensional quality model.[9] Reproduced with permission.

1.1.2 Quality of care today

The past two decades have been characterised by an increased awareness of healthcare quality issues with numerous efforts towards QI.[12] Stimulated by IOM's '*To Err is Human'* report,[5] dedicated research funding towards quality of care expanded, allowing progress across all dimensions of healthcare quality as depicted within Lachman's multidimensional quality model.[9] Improved timeliness helped to achieve better outcomes in e.g. stroke patients,[13] developments of clinical guidelines and clinical care pathways increased the effectiveness of our care,[14–16] and the introduction of concepts such as *'What Matters to*

You?' and the Mangomoment™ put focus on person-centred care.[17,18] However, the largest attention would be put on the aspect of patient safety. Examples include developments of computerised physician order entries (CPOE) systems to decrease adverse drug events,[19] implementation of surgical checklists to reduce complications and mortality,[20] or declines in hospital-acquired infection (HAI) rates.[21,22] Over time, reductions could be observed in hospital-wide mortality rates or hospital length of stay.[23–27]

Yet, in the beginning of 2023, Bates and colleagues published how adverse events (AE), defined by IOM as *'Injuries caused by medical management rather than by underlying disease or condition of the patient'*,[28] remain common during hospital admissions.[29] The authors reported the detection of an AE in nearly one in four patients.[29] Other key studies confirm worrying patient safety numbers, with patient harm detected in a range from 10 to 50%.[30–35] What's more, a large proportion of AEs, estimated to be up to one in two cases, are deemed to be preventable.[30–35] Even though exact numbers vary depending on different AE definitions, data collection methods, settings and in- and exclusion criteria, it is clear that patient safety remains an important issue in need of continuing improvement. Another major concern is that patient outcomes are seen to vary extensively between hospitals. The World Health Organisation (WHO) has suggested that this variation between hospitals poses one of global healthcare's largest threats today.[33] Mortality rates were for example seen to vary greatly between surgical patients of different hospitals.[36] Not only is such unwarranted variability detrimental for healthcare quality and patient safety, it exposes an equity issue wherein patients can expect different outcomes simply by choosing a different hospital.[37] Patient harm has put a substantial burden on healthcare systems of high-income countries. It is even estimated that the annual cost of measurable medical errors harming patients in the US rose up to $17.1 billion dollars for the year 2008.[38] In Organisation for Economic Co-operation and Development (OECD) countries, it is approximated how over 10% of total hospital expenditures are used to treat harm caused by preventable medical errors and HAIs.[33] Policy makers looking to contain healthcare costs can therefore improve value in healthcare by including efforts to improve quality of care and patient safety.[39]

In order to move forward, one important suggestion is to routinely and continuously measure the frequency and types of patient harm, aided by the increasing availability of electronic data.[12] Important QI initiatives should be continued, adapted or expanded on, provided they have demonstrated benefits for hospital quality. Many initiatives have been introduced in the past couple of decades, including hospital-wide or disease-specific strategies. Important initiatives with world-wide implementation include accreditation surveys, public reporting, inspection audits and financial actions such as pay-for-performance (P4P). Accreditation can be defined as an *'assessment of a pre-determined set of quality standards by an external agency'.*[40] Well-known agencies across the globe include the US-based Joint Commission International (JCI) or the Dutch-based Qualicor Europe.[40,41] Public reporting can involve the dissemination of structure, process or outcome measures on the level of either a country, state, individual hospital, department or physician. Inspections can occur system-wide or can target specific patient groups. Finally, P4P programmes have encompassed smaller or larger budgets and can be geared towards rewarding well-performing hospitals or taking a punitive approach for hospitals not up to par with pre-defined standards of care.[42]

Despite the widespread application of each of the above-mentioned initiatives, a growing number of voices are currently questioning their added value. Both clinicians and policymakers alike are expressing concerns on the continued application of accreditation, supported by international evidence describing it as bureaucratic and time consuming,[43] costly,[44] and not promoting what actually matters to patients.[45] Regarding public reporting, worries are mainly about the possibility of risk aversive behaviour in physicians that might harm patient outcomes,[46] about misinterpretation or gaming of data,[47] about the significant financial and administrative burden[48] and finally about the lack of reach to patients.[49]

Concerning inspection, apprehension exists on the topic of 'decoupling', i.e. the gap between the paper-based reality of rules and guidelines and actual clinical practice.[50] On the other hand, initiatives such as accreditation, public reporting and P4P have shown promise in multiple healthcare segments. Examples include accreditation promoting change and professional development[43] or public reporting further stimulating quality improvement (QI) activity and altering hospital selection by the patient.[51] However, knowledge on how the implemented QI initiatives are associated with patient outcomes is scant and the symbiotic effects of compound initiatives remain a neglected area of research at present. Knowledge on the effectiveness of QI initiatives can help policymakers and hospital managers to make well-informed decisions on the way ahead for hospital quality.

1.2 Quality of care in Belgium

1.2.1 Belgium, a complex political country

Belgium is a federal country situated in western-Europe with 11 million inhabitants. It encompasses three regions, i.e. Flanders in the north, Wallonia in the south and Brussels central within the country. It also recognises three language communities, i.e. the Dutch-speaking community largely overlapping with Flanders, the French-speaking community largely overlapping with Wallonia and a German-speaking community situated in the east of the country. Each region and community has its own government, topped by an overarching federal government. Every government has jurisdiction in respect of different areas within healthcare. The federal government for example is responsible for financing healthcare, while the regions are authorised to develop policies regarding quality of care or prevention. Within this particular political landscape, healthcare policy always requires complex coordination with different partners in order to avoid duplication of effort and to achieve a streamlined healthcare organisation.

Besides specialised, geriatric and psychiatric hospitals, which fall outside the scope of this PhD dissertation, Belgium encompasses 99 general hospitals, the result of multiple hospital mergers occurring over the past 20 years. Of these, seven hospitals are university hospitals. About one in three hospitals are public institutions, while the majority are private non-profit institutions. Public hospital are generally owned by municipal welfare centres or intermunicipal organisations, while private hospitals mostly fall under the ownership of religious charitable organisations, health insurance funds or universities.[52] No private for-profit hospitals exist. The financing scheme by the public authorities is organised in an identical manner for both public and private hospitals.

1.2.2 Quality of care policy in Belgium

The regional level of Flanders

As stated above, the responsibility of organising a healthcare quality policy falls on a regional level. For the 53 Flemish general hospitals, a government agreement that forms the basis of today's *'Quality-of-Care Triad for the hospital setting'* was established in 2009.[53] This Triad (Figure 1.2) encompasses (1) voluntary announced hospital-wide accreditation, defined as an assessment of a pre-determined set of

standards by an international external agency, (2) mandatory inspection by the Flemish government and (3) voluntary measurement and public reporting of quality indicators.

Figure 1.2 The Quality-of-Care Triad of the Flemish government.

Within the first pillar of the Triad, general hospitals were being stimulated to engage in a process of hospital-wide accreditation by an international external organisation. Accreditation bodies would visit a hospital at an announced time and evaluate whether the hospital meets predetermined standards of care.[54] If a hospital is found to have met the quality criteria, it would receive a quality label valid for a limited period of time, often three or four years. Accreditation is not mandatory within the Flemish healthcare policy. Instead, hospitals can voluntarily choose to initiate an accreditation trajectory, at the individual hospital's own expense. Participation is, however, incentivised by the government. First, hospitals who take part in an international accreditation trajectory are exempt from announced systemic inspections by the Flemish government (see below). Second, hospitals can earn points and incentive payments within the federal government's P4P programme (see below). At the start of this PhD research, the majority of Flemish hospitals had opted to become accredited by either JCI or Qualicor Europe. However, during the course of this PhD research, many hospitals have expressed they no longer wish to renew the validity of their accreditation label, stating they are instead looking for a more durable and bottom-up quality approach.[55] Today, this has resulted in a large proportion of Flemish hospitals without active accreditation status.

Within the second Triad pillar, the Flemish government visits individual hospitals to conduct two types of inspections.[56] The first type involves audits of care trajectories which are mandatory for all hospitals. By means of unannounced compliance monitoring of pre-defined standards, the government aims to obtain a snapshot of care provided in clinical practice, with a specific yearly focus on demarcated themes. Back in 2013-2014 for example, focus lied on the surgical care trajectory, followed by internal medicine patient trajectories, cardiac care and most recently geriatric care. The second type of inspection encompasses an announced system-wide survey of the quality system behind the healthcare delivery. It is preceded by intense self-evaluation by the hospital with the purpose of quality guarantees on the long term. Hospitals that have opted to enter into an accreditation trajectory are exempt from this latter type of inspection. However, as a large selection of Flemish hospitals have opted out of their accreditation trajectory over the course of this PhD, former Flemish Minister of Health Wouter Beke has decided to put the systemic announced inspections, of which accredited hospitals are exempt, temporarily on hold, at least for a time period of two years.[57]

Finally, the third pillar within the Quality-of-Care Triad covers the public reporting of quality indicators. The Flemish Institute for Quality of Care (VIKZ) develops and collects a set of quality indicators, of which a large selection is publicly reported on www.zorgkwaliteit.be since 2014.[58] Measurement occurs

twice a year in general and public transparency occurs on a voluntary basis for each hospital. So far, the majority of Flemish hospitals have opted to participate to and publish at least one quality indicator. Indicators are subdivided into three overarching themes: patient safety, patient experiences and effective care. Examples of indicators include overall patient experience of the hospital stay, hand hygiene, implementation of surgical checklist, unplanned readmissions and survival rates for lung and rectum cancer.

In line with international movements, such as Denmark's decision to move away from hospital-wide accreditation,[59] questions are also being raised by Flemish physicians and hospital managers concerning the continuation of current quality policy during the time of this PhD research. Instead of choosing for hospital-wide accreditation programmes such as JCI or Qualicor Europe, hospitals have opted to engage in novel, locally designed quality initiatives. This led to the latest government coalition agreement,[60] wherein an evaluation of the added value of the current policy with the inclusion of accreditation is requested. Perhaps after being implemented for over a decade, the development of a new overarching quality model to stimulate, safeguard, control and make quality of care transparent is required. A necessary component of the evaluation of the current Quality-of-Care Triad, is the research of how individual hospitals have adopted the Flemish hospital policy, which is currently unknown. Additionally, overall attitudes towards the policy have not yet been investigated. Generating such insights can help policy makers and hospital managers to make informed decisions on how future hospital quality policy could be organised.

The federal level of Belgium

Apart from the QI initiatives undertaken on a Flemish level, the federal governmental level has also implemented several actions to improve quality of care. They have provided specific funding towards scientific institutions such as Sciensano or the Federal Knowledge Centre for Healthcare (KCE), which in turn help to develop quality indicators, evaluate care pathways, monitor hospital infections and follow up on health crises such as the recent COVID-19 pandemic. As the federal level is in charge of financing hospitals, one important aspect to incentivise quality is by tying reimbursements to the delivered healthcare quality. An overarching patient safety contract was drawn up between the government and general acute-care hospitals from 2007 onwards, rewarding hospitals financially that committed to implementing QI initiatives with a small, fixed portion of hospital payment. After ten years of lump sum payments, the government intended to reward hospitals dependent on their score on a select set of quality indicators from 2018. The contract would from then on become known under the heading of Pay-for-Performance (P4P). As is the case for the Flemish hospital policy, it remains unknown how hospitals have adapted to this quality strategy. An overview of which hospitals participated to the P4P programme or which internal initiatives hospitals have undertaken is currently lacking.

In an attempt to increase efficiency in the Belgian healthcare system, a 2013 task force at the National Institute for Health and Disability Insurance (RIZIV-INAMI) was installed.[61] They helped to introduce a reduced payment system in 2014, which limits reimbursements to 82% for hospital admissions that were readmissions occurring within 10 days after discharge. While this financial penalisation could be perceived as a cost containment measure, its target to reduce readmissions can be viewed as a QI initiative. At the start of this PhD, it remained inconclusive how hospital readmissions have evolved over time and whether or not this initiative has left any durable impact on readmission rates in Belgium.

1.2.3 Quality of care levels in Belgium

Despite federal institutes such as Sciensano or KCE regularly publishing important metrics within Belgian hospital care, an overview of the quality of care within Belgian hospitals is currently absent. To our knowledge, recent analyses on quality of care remain limited to a study of AE in patients with unplanned transfers to a higher level of care from 10 years ago.[62,63] This is in part explained by a lack of available quality registries in Belgium. While VIKZ and disease-specific registries provide meaningful metrics for individual hospitals, primarily concerning care processes or disease-specific structures and outcomes, they do not provide cumulated information on temporal trends in outcomes or provide nationwide outcome rates that allow for benchmarking. As such, there is e.g. no knowledge of how patient experiences have evolved over time, or how they vary between hospitals. What's more, there is a scarcity of hospital-wide overarching patient outcome information, on outcomes such as for instance mortality, readmissions or length of stay. Initiatives such as the Flemish Hospital Network (FHN) have started to supply these outcomes with the possibility of benchmarking, but only for a limited selection of Flemish hospitals who have agreed to learn from each other in a trusted environment.[25,64]

A potential solution to gather nationwide information, is to utilise the discharge information provided to the federal government for financial reimbursement purposes, i.e. the Minimum Hospital Dataset (MHD). This administrative database was commissioned by the Belgian Ministry of Public Health via the Royal Decree of 6 December 1994. On the basis of Article 10 of the Royal Decree of 27 April 2007,[65] the MHD can be employed for scientific purposes, next to its primary purpose of providing financial information. The dataset contains patient demographics, hospital characteristics and clinical data, i.e. primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 9-Clinical Modification (ICD-9-CM) up until 2014 and ICD-10-CM from 2016 onwards. Registration of diagnoses and procedures using ICD was not mandatory for the year 2015, due to the ongoing transition from ICD-9-CM coding to ICD-10-CM. The ICD-coding system provides possibilities to study representative and comparable population-level data. In addition, the coding system is used internationally, allowing for relevant comparisons across countries. This could provide valuable information for policy makers who are looking to assess Belgium's current quality of care level in order to determine priorities for future healthcare policy. We recognise that administrative data such as the MHD have their disadvantages, such as a lack of prognostic factors in the form of detailed clinical data and raised concerns about the accuracy and completeness of the data.[66] However, them being inexpensive and without additional registration burden for healthcare workers, readily available, computer readable and encompassing large populations makes the MHD worth exploring for potential usability.[66–68]

Already back in 2006, one observational study explored the use of the MHD for prevalence of adverse events for the year 2000.[69] They discovered how adverse events occur in 7.1% and 6.3% of medical and surgical inpatients, respectively. Yet, ever since this publication, the MHD has not been utilised formally to assess quality of care in Belgium. For the purpose of this PhD dissertation, the federal government provided the MHD from all general acute-care hospitals in Belgium for the years 2008-2018. This unprecedented access will provide the opportunity to generate novel insights on the current status of quality of care in Belgium and how it has evolved over time.

1.3 Research objectives

1.3.1 Aims and objectives of the PhD dissertation

In light of the recent awareness of gaps in delivery of hospital care internationally and growing concerns on current quality policy in clinical practice, policymakers, governments and hospital managers are searching to make a formal evaluation of healthcare quality in Belgium. In particular, they are searching for evidence concerning the effectiveness of QI initiatives, information regarding their implementation and knowledge on temporal trends and variability in patient outcomes for Belgian hospitals. Closing these knowledge gaps can aid in determining priorities for future hospital policies concerning quality of care.

This PhD dissertation, which summarises research that started in 2019, aims to provide an overarching answer to the following research question: "How have quality improvement initiatives been adopted and how has quality of care and patient safety evolved over time across Belgian hospitals?" In order to answer this research question, three research objectives have been integrated in this dissertation:

1. First, we aimed to uncover the international evidence-base concerning the impact quality improvement initiatives have on patient outcomes.
2. A second objective was to outline the implementation of quality improvement initiatives across Flanders, Belgium, between 2008 and 2019.
    a. In a first subsection, research focused on providing an overview of implementation and gathering perspectives on governmentally-imposed QI initiatives. The initiatives included were those within the Flemish Quality-of-Care Triad (accreditation, inspection and public reporting) and the P4P initiative undertaken by the federal government.
    b. A second subsection focused on the internal initiatives individual Flemish hospitals have undertaken to improve their quality of care.
3. Finally, we aimed to assess trends and variation in several patient outcomes across Belgium between 2008 and 2019.
    a. In a first subsection of this research objective, assessment was made of how patient experiences have evolved over time, how they vary across Flemish hospitals and how they are associated with quality improvement initiatives specifically targeted towards improving the patient's experience.
    b. The second subsection included research focused on temporal trends and unwarranted variability in mortality, readmissions and length of stay within Belgian hospitals.
    c. The last subsection involved the research of important adverse events occurring during hospital care.

1.3.2 Ethical approval

The study protocol encompassing aforementioned research objectives was approved by the Ethics Committee of University Hospitals Leuven (S63449).

Our study provides an overview of trends and variability of patient outcomes up until 2018 for the majority of our assessments. Due to the impact the COVID-19 pandemic has had on the provision of hospital care, analysis of more recent study years such as 2020, was not included within this PhD dissertation.

1.3.3 Composition of the dissertation

This dissertation is built up around the research objectives disseminated in the aforementioned section 1.3.1. Chapter 2 includes the study result of a narrative review aiming to uncover the effectiveness of important QI initiatives. Considering how Flemish hospital policy has been centred around the Quality-of-Care Triad involving accreditation, inspections and public reporting, the review targeted these three initiatives within the literature search. The literature search focused on the impact of the QI initiatives on patient outcome measures, including mortality, readmissions, length of stay, adverse events and other outcome measures detected within the investigation.

Chapter 3 focuses on the second research objective aiming to study QI initiative implementation in Flemish hospitals. A first section of the chapter concentrates on the initiatives undertaken as encouraged by the government, i.e. accreditation, inspection, public reporting and P4P. By means of a multi-method study, data on QI initiative implementation was gathered from governmental and institutional sources and through an online survey among hospital quality managers. This resulted in the compilation of QI initiative implementation across all Flemish hospitals between 2008 and 2019. In addition, healthcare stakeholders' perspectives on current government policy were assessed by means of a second survey available to all healthcare professionals and a focus group among healthcare policy experts. The second section of this chapter depicts the results of a survey sent out to hospital quality managers concerning other initiatives individual hospitals undertake besides P4P and the Quality-of-Care Triad. It aims to provide an inexhaustive overview of the commitment Flemish hospitals make towards quality of care.

Chapters 4 through 5 bundle the results of the third and final research objective, concerning trends and variability in patient outcomes. Chapter 4 involved the study of all available data on patient experiences, mortality, readmission and length of stay. As the patient is considered the most pivotal feature of hospital care, evaluating their experience of their care provision is an important accountability measure for hospitals. Mortality can be considered as the pinnacle measure of patient safety, readmissions relate to efficient care and can also be considered an accountability measure for hospitals, while finally prolonged length of stay (pLOS) has been found to correlate with complications occurring during care and with excess costs.[70–73] Because of their overarching hospital-wide importance, we consider the outcomes displayed within this Chapter 4 as the *'vital few'* patient outcomes among the 'trivial many' to be assessed, just as was described by healthcare pioneer Joseph Juran. Examining the 'vital few' together can help in determining the optimal path to increasing health gains. Moreover, studying combined outcomes can help to expose the existence of perverse relationships between outcomes and uncover potential competing risks between outcomes. In a first section of the chapter we displayed patient experiences within Flemish hospitals from the start of data collection (2014) up to 2019. Trends and between-hospital variability were consequently associated with QI initiatives individual hospitals have undertaken in order to increase their patients' hospital experience. The latter information was gathered by means of an online survey disseminated to all Flemish quality managers of hospitals participating in patient experience measurements. The chapter continues in a second section with an overview of how hospital-wide mortality, readmissions and pLOS has evolved between 2008 and 2018 across all Belgian hospitals. From this second section onwards, the results presented are derived from analysis of the MHD. The following sections 3 to 5 focus on variability in the vital few patient outcomes between Belgian hospitals. In sections 3 and 4, variability was assessed for two disease-specific case studies, i.e. urological care and cardiovascular care. Thereafter, variability was studied across the hospital-wide spectrum, subdivided into 20 disease groups. A final sixth section within this chapter provides a

methodological assessment of measuring in-hospital mortality via administrative databases such as the MHD. The section aims to determine the construct validity of mortality measurements in a sample of 22 hospitals, by comparing two commonly used measurement models used for estimating hospital standardised mortality ratios (HSMRs) in Belgium.

Chapter 5 concludes the results segment of this dissertation and surveys prevalence and variability of important adverse event measures within Belgium in its first section. The quality measures are derived from the Patient Safety Indicators (PSIs) as developed by the US-based Agency for Healthcare Research and Quality (AHRQ) and include potentially preventable and severe or sentinel adverse events.[74] The chapter concludes with a final section displaying an opinion paper on current patient safety numbers as recently published by Bates and colleagues.[29] Finally, a general discussion of the results presented in chapters 2 through 5 can be found in chapter 6.

1.3.4 Related doctoral research

In April 2019, the Leuven Institute for Healthcare Policy at Leuven University was granted the research chair: "Zorgnet-Icuro: Future of Hospital Quality", financed by hospital umbrella organisation Zorgnet-Icuro. This research chair aims to scientifically evaluate current healthcare policy, its effect on outcomes and how outcomes can be improved through future policy. This PhD dissertation is part of the awarded research chair and will examine the implementation of the current policy triad and how patient outcomes vary and evaluate over time. Within the Research Chair "Zorgnet-Icuro: Future of Hospital Quality", another PhD project was initiated in August 2019. Jonas Brouwers studied the following topic: 'Exploring the future of hospital quality management and policy in Flanders.' Herein, current policy, governance, vision and financial context are outlined for the Flemish hospital landscape. Additionally, national and international expertise are consulted to establish the vision for the future of quality policy. In combining both PhD projects, a scientific policy advice 'Future of Hospital Quality' can be drafted by the Leuven Institute for Healthcare Policy to inform governmental and institutional policy. Additionally, the research topic of Fien Claessens 'Towards a sustainable quality management system in hospitals', will provide further insights into the embedment of quality into the daily workflow of professionals. Together, the three PhD projects will provide a scientific basis for a new Flanders Quality Model (FlaQuM) for hospitals.

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Chapter 2

UNCOVERING THE EVIDENCE-BASE CONCERNING THE IMPACT OF QUALITY IMPROVEMENT INITIATIVES ON PATIENT OUTCOMES

This chapter was previously published as:

Van Wilder A, Bruyneel L, De Ridder D, Seys D, Brouwers J, Claessens F, Cox B, Vanhaecht K. (2021). Is a hospital quality policy based on a triad of accreditation, public reporting and inspection evidence-based? A narrative review. *International Journal for Quality in Health Care.* 33 (2) mzab085.

Summary

This chapter covers the first research objective of this PhD project. It aims to provide an overview of the existing evidence-base concerning the impact that quality improvement initiatives such as accreditation, public reporting and inspection – the basis of Flemish hospital quality – have on patient outcomes. The literature search was conducted in a systematic manner and followed by a narrative synthesis. Overall, evidence of the effectiveness of quality improvement initiatives was found to be limited on patient outcomes.

2.1 Is a hospital quality policy based on a triad of accreditation, public reporting and inspection evidence-based? A narrative review.

2.1.1 Abstract

Background: Since 2009, hospital quality policy in Flanders, Belgium, is built around a Quality-of-Care Triad, which encompasses accreditation, public reporting and inspection. Policy makers are currently reflecting on the added value of this Triad.

Objective: To examine the evidence-base of the impact of accreditation, public reporting and inspection, both individually and combined, on patient processes and outcomes.

Methods: We performed a narrative review of the literature published between 2009 and 2020. The following patient outcomes were examined: mortality, length-of-stay, readmissions, patient satisfaction, adverse outcomes, failure-to-rescue, adherence to process measures and risk aversion. The impact of accreditation, public reporting and inspection on these outcomes was evaluated as either positive, neutral (i.e. no impact observed or mixed results reported) or negative.

Results: We identified 69 studies, of which 40 on accreditation, 24 on public reporting, three on inspection and two on accreditation and public reporting concomitantly. Identified studies reported primarily low-level evidence (level-IV, n=53) and were heterogenous in terms of implemented programs and patient populations (often narrow in public reporting research). Overall, a neutral categorization was determined in 30 papers for accreditation, 23 for public reporting and 4 for inspection. Ten of these recounted mixed results. For accreditation, a high number (n=12) of positive research on adherence to process measures was discovered.

Conclusion: The individual impact of accreditation, public reporting and inspection, the core of Flemish hospital quality, was found to be limited on patient outcomes. Future studies should investigate the combined effect of multiple quality improvement strategies.

Key words: Hospital; Accreditation; Public Reporting of Healthcare Data; Quality Control; Patient Outcome Assessment

2.1.2 Introduction

The IOM's *To Err Is Human* served as a global tipping point for hospital quality.[1] Two decades have passed since its publication, resulting in the research and implementation of many quality improvement (QI) initiatives, including accreditation, public reporting (PR) and inspection, stimulating patient safety and hospital quality.[2] In Flanders, the northern region of Belgium, a government coalition agreement was established in 2009[3] that forms the basis of today's 'Quality-of-Care Triad': 1) voluntary announced hospital-wide accreditation by an international external agency, 2) voluntary measurement and PR of quality indicators and 3) mandatory inspection by the Flemish government. The latter consists of an announced systemic inspection of which accredited hospitals are exempt, as well as an unannounced examination of patient trajectories, which occurs on average every year. All 55 Flemish acute-care hospitals have since entered into an accreditation process, defined as an assessment of pre-determined standards,[4] by either the USA-based Joint Commission International (JCI) or the Dutch Qualicor. To date, most hospitals (n=35) have either achieved their first-cycle accreditation label or have gone through consecutive cycles. Recently, two hospitals successfully passed third reaccreditation. From 2015 onwards, all but one hospital chose to publicly report quality indicators on cancer survival rates, patient experiences and patient safety measures.[5] However, despite the widespread application of each Triad component, a growing number of voices are questioning the added value of current healthcare policy. Several Flemish hospitals have decided to discontinue their accreditation trajectories based on global concerns on its bureaucratic nature, often described as time consuming,[6] merely market-driven,[7] costly,[8] and not promoting what actually matters to patients.[9] Furthermore, there is worry that PR leads to risk aversive behaviour in physicians that might harm patients,[10] that data can be misinterpreted or gamed,[11] that reporting may impose a significant financial and administrative burden[12] and finally that it does not reach the patient.[13] Concerning inspection, apprehension exists on the topic of 'decoupling', i.e. the gap between the paper-based reality of rules and guidelines and actual clinical practice.[14,15] Lastly, evidence of associations with patient outcomes is scant, as reported in several reviews.[16–19] Our research aims to extend previous literature by investigating the joint impact of various types of QI initiatives (accreditation, PR, inspection) exclusively on several patient outcomes. We aim to provide a systematic identification and narrative synthesis of all empirical research published between January 2009 and February 2020.

2.1.3 Methods

Study design

We performed a narrative literature review of studies on the effects of hospital accreditation, PR and inspection on patient outcomes. We employed a narrative rather than statistical method because first, the number of interventional studies is limited, second, research methods are heterogeneous and last, because of the considerable complexity and variety in the organisation of different Triad components in multiple jurisdictional and legislative environments. Quantitative comparison of outcomes between studies is problematic due to this context heterogeneity.

Data sources and search strategy

We searched MEDLINE, the premier database for biomedical research, for literature published between January 1st 2009 and February 29th 2020. From three established research questions (What associations can be observed between accreditation/PR/inspection and quality and patient safety outcomes in hospital

care?), a PICO-searching strategy for each component was determined, wherein combinations of key words and MESH terms were searched. Each individual search was subsequently combined to find literature on shared components. A detailed transcript of this search strategy can be found in Appendix A.1.1. We included original research in English or Dutch, the research team's first language, conducted in high- or middle-income countries and concerning secondary and tertiary care. We assigned literature to a QI component when the impact of an initiative similar to a Quality-of-Care Triad component was assessed on a patient outcome, i.e. the mere mention of the e.g. term 'accreditation' did not suffice. We excluded literature describing disease-specific accreditation, as this differs vastly from the hospital-wide assessment used in Flanders and therefore falls outside the research scope. This exclusion was not applied to PR and inspection literature, as they contain both hospital-wide and disease-specific components. We included all quantitative original research, i.e. level-II (randomised controlled trials (RCT)), III (quasi-experimental) and IV (case-control and cohort) evidence,[20] therefore excluding reviews (level-I and V), original qualitative and descriptive research (level-VI) and expert opinion papers (level-VII). Lastly, we only included papers with full-text availability within our institution. The reference lists of selected articles were searched for potentially relevant studies meeting the inclusion criteria. In addition, we explored search terms on Google Scholar and repeated the search strategy of the Belgian Health Care Knowledge Centre (KCE) on accreditation literature (Appendix A.1.1).[21]

Study characteristics

The following study characteristics were identified: country, setting, patient population, design, level of evidence, type of QI initiative, studied patient outcome(s) and reported impact of the initiative on the outcome(s). We performed a manual content analysis to determine the frequency with which eight thematic categories were examined: mortality, length-of-stay, readmissions, patient satisfaction, adverse outcomes, failure-to-rescue, adherence to process measures and risk aversion. The latter was added based on anecdotal evidence of risk aversion occurring in PR.[10] It is possible a single publication studied the impact of one or more Triad components on several patient outcomes. The reported direction of impact on patient outcomes was recorded as either positive, neutral or negative, inspired by Deneckere *et al.*'s systematic review on care pathways.[22] A neutral impact was defined when either no associations between the Triad component and the patient outcome were found or when mixed results were reported for several indicators or patient groups of the same patient outcome. Due to the range of different studied patient outcomes and varied designs and quality, we opted to not reach conclusions on the strength of evidence by means of meta-analysis. Alternatively, we provide an overall picture by identifying the frequency of records per outcome and reported impact. The search was executed by AVW and revised and validated by JB, who independently examined a subsample of 25 references. Disagreement between authors occurred in only two studies and was resolved after discussion among the research team.

2.1.4 Results

Search results

We identified 59,694 records via the MEDLINE database. Screening of title and abstract led to the exclusion of a vast amount of records that did not relate to the impact of accreditation, PR and inspection on patient outcomes. Subsequently, 93 full-text articles were read for accreditation, 70 for PR and 5 for inspection. The search on combined components led to duplicates of the search on individual components and did not provide additional studies on either individual or combined components. An overview of the search results is visualised in Figure 2.1 and further detailed in Appendix A.1.1.

Concerning accreditation, the main reason for excluding publications was the description of disease-specific accreditation (n=26). After chain searching (n=7), the final number of studies included for accreditation totalled 42. Two of these discussed the impact of both accreditation and PR on patient outcomes. Out of the 70 papers read on PR, 48 were excluded and four chain references included, leading to a final sample of 26 papers on PR, of which two aforementioned publications acknowledged both PR and accreditation. Finally, three of the five papers on inspection were excluded and one added through chain referencing, leaving a final sample of three publications. No studies encompassing all three components of the Quality-of-Care Triad could be identified. Appendix A.1.2 provides an overview of the excluded fully-read articles. Lastly, no additional studies could be discovered from the Google Scholar search engine and repeated KCE strategy.

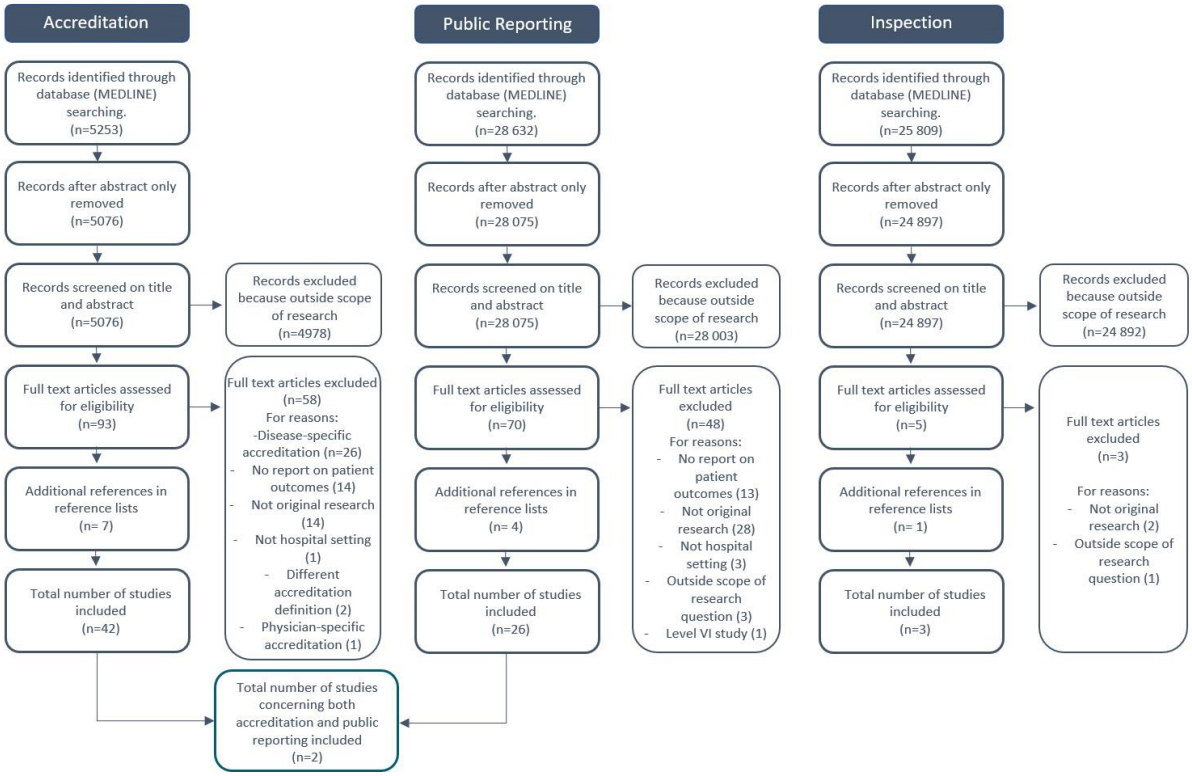

Figure 2.1 Flowchart of search strategy

Characteristics of included studies

A summary and full reference list of 69 included publications can be found in Appendix A.1.3, including first author, publication year, journal, country, setting and patient population, objectives, research design, level of evidence, studied QI initiative with its specified program description, studied patient outcome(s) and impact of the component on this outcome. The gathered evidence was quite evenly spread across the study years and conducted in 24 countries across North-America (n=33), Europe (n=20), Asia (n=13) and Australia (n=3). All inspection literature (n=3) was UK-based, while studies on PR were predominantly conducted in the USA (n=21). Included publications reported mainly level-IV evidence (n=53), while five papers reported level-III studies and one recounted a RCT. The research settings varied largely, ranging between the study of just one hospital and over 1000 hospitals. As detailed in Appendix A.1.3, a plethora of programmes was assessed. Accreditation programmes were

primarily developed nationally (n=29), while five publications reported on international programmes. Concerning PR, different levels of reporting were observed, such as individual-level (n=5) or hospital-wide (n=2). However, the majority recounted disease-specific (n=16) and unit-based (n=6) levels of reporting. Finally, many different patient populations were studied. In general, most accreditation literature reported hospital-wide outcomes or assessed a wide spectrum of diseases to reflect overall care. In contrast, PR literature predominantly surveyed narrow patient groups, of which the fields of cardiology (n=17) and respiratory disease (n=6) were observed most frequently. Concerning inspection literature, one study assessed a hospital-wide patient sample, while the other two studied a more restricted sample (maternity and emergency room).

Study categorisation

An overview of the number of identified papers categorised according to type of QI initiative, patient outcome and direction of impact can be found in the heatmap displayed in Figure 2.2. The most frequently studied patient outcomes are adherence to process measures (n=27), followed by mortality (n=26), whereas only few studies (n=4) assessed failure-to-rescue. For PR specifically, mortality is most frequently explored (n=15), followed by the impact on risk aversion (n=11). Inspection papers have only addressed adherence to processes (n=2), adverse outcomes (n=1) and readmission rates (n=2). Overall, a neutral impact was observed in 30 papers for accreditation, 23 for PR and 4 for inspection. The neutral category includes ten studies reporting mixed results (see Appendix A.1.3). For accreditation, 26 papers narrate a positive impact on patient outcomes, primarily due to the high number (n=12) of positive results on adherence to process measures. Several papers (see Figure 2.2) reported inconsistent directions of impact for multiple patient outcomes, as exemplified by Gupta *et al.*[23] or Lam *et al.*[24] Two studies researched the impact of both accreditation and PR on process measures.[25,26] Schmaltz *et al.* found that accredited hospitals already outperformed non-accredited hospitals prior to PR and the difference between the two groups increased after PR.[26] Howell *et al.*, however, found no association between the PR of accreditation standards and maternal morbidity.[25]

Accreditation impact

The majority of identified publications reported that accreditation had no observable impact on patient outcomes. Numerous studies reported an unsustainable impact. In e.g. several adherence to process measures studies,[27–32] it was reported how compliancy with processes improved steadily in the build-up towards an accreditation survey, but continued at a slower rate after the survey or even returned to baseline. Similarly, Barnett *et al.* observed a significant decrease in 30-day mortality in the week of the survey visit, which was nullified within the next three weeks.[33] While a consecutive accreditation cycle reduced variation in compliancy with processes, it could not deliver more improvement than the first visit.[31] At baseline, hospitals with lower performance improved at greater rates than those with higher performance.[34,35] The positive associations found between accreditation and patient satisfaction were primarily due to a better observed satisfaction of hospital structures.[36,37] Conversely, Lam *et al.*, reported superior patient satisfaction in non-accredited hospitals, despite readmission rates being better in accredited centres.[24] The type of accreditation programme had no apparent influence on patient outcome impact, although the reported impact of national Magnet-accreditation was positive in all[38–41] but one[42] study.

PR impact

A duality was observed in Gupta *et al.*, [23] where the PR of readmission rates led to reduced readmissions, but increased mortality. Several publications (n=11) studied whether PR led to risk-avoidant behaviour,

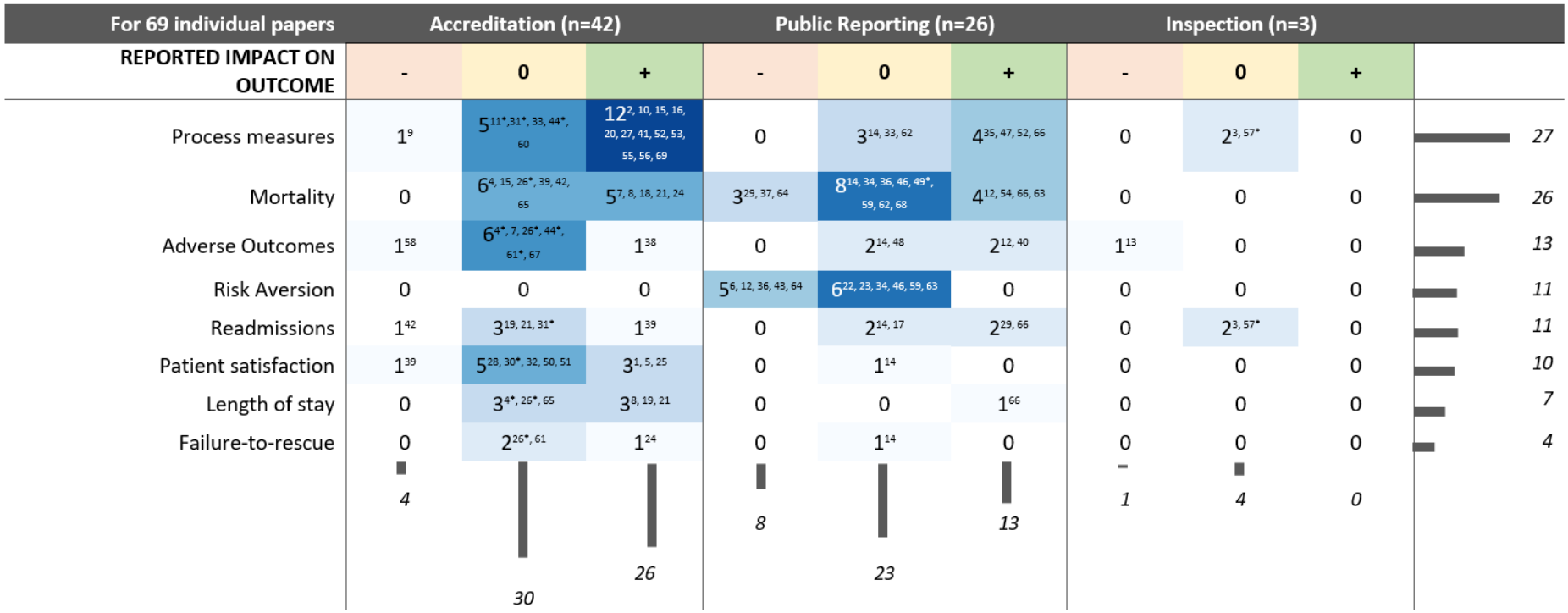

Figure 2.2 Heatmap of number of identified records on the impact of accreditation, public reporting and inspection on patient outcomes.

Heatmap displaying the number of identified papers, classified according to type of quality improvement initiative, patient outcome, and impact of quality improvement initiative on said outcome (negative impact = "-", neutral impact = "0", positive impact = "+"). A darker color indicates a higher number of publications. Quality improvement initiatives and patient outcomes are sorted according to the total number of publications for each (represented by the grey bars). The references added to each number of identified papers refer to the summary of included articles, displayed in Supplemental File 3. When a reference is followed by an asterisk in the neutral category, the reference makes notice of mixed results in either multiple patient populations or multiple outcome indicators for that particular patient outcome.

which was contested in the majority of them.[43–49] However, evidence of risk-avoidance by physicians was found in some of the cardiology reports[50–52] and was even demonstrated to increase mortality rates.[53] Only one RCT was identified, which could not find any impact of PR on cardiac process indicators. Consistent with accreditation literature, hospitals with low baseline performance had the largest quality gains[54] and the repeated release of data[55] had no further impact on outcomes, despite improvements gained from the initial PR. Hospitals with a higher baseline performance were most likely to make use of PR.[56]

Inspection impact

No associations were found between hospital inspection and emergency department processes and readmissions,[57,58] while rates of falls and pressure ulcers[59] were negatively associated with inspection.

2.1.5 Discussion

Healthcare policy in Flanders on the quality of hospital care is based on initiatives commonly concurring worldwide. However, no evidence exists on the impact of the complex intervention that combines both accreditation, PR and inspection on patient outcomes. This review identified 67 studies that investigated the impact on patient outcomes of one single improvement initiative and two studies that investigated the impact of both accreditation and PR. Only three studies were found on the impact of inspection. The majority of publications could not find evidence of associations between policy components and patient outcomes and some even described a negative impact. The latter needs to be nuanced as studied patient populations were narrow (primarily cardiology) in most of the negative studies. As the focus of accreditation is primarily on processes within their accreditation standards, it comes as no surprise that impact on adherence to process measures is predominantly positive. However, one could inquire whether achieving formal compliance is truly an indication of QI in clinical practice or merely a required cornerstone from which improvement can be built. Despite the lack of high-level evidence on patient measures, international reports suggest current policy has benefited other healthcare segments, with accreditation promoting change and professional development[6] and PR stimulating QI activity and altering hospital selection by the patient.[19] Along with inspection, accreditation and PR have provided a solid foundation for monitoring and promoting healthcare organisation performance and achieving quality of care, particularly in low baseline performers. However, the reported lack of further improvement in consecutive accreditation and PR cycles, suggests a rethink of the current policy is required. Potential opportunities for next steps lie in introducing unannounced,[60] short-notice[61] or mandatory[62] accreditation programmes, although the evidence remains inconclusive. Additional initiatives could be considered that have shown promise, such as internal audits,[63] total-quality-management[64] or peer-review.[50,65] Multiple Flemish hospitals have already implemented initiatives besides the Quality-of-Care Triad, like ISO-certifications, Magnet-accreditation or disease-specific accreditation. The latter is consistently associated with more favourable results on patient outcomes,[66] including mortality,[67] length-of-stay,[67] care processes,[68] patient satisfaction,[68] and adverse outcomes.[67] Additionally, all Belgian hospitals have been subject to a pay-for-performance scheme since 2018. How this financial incentivisation impacts Flemish hospitals, remains to be seen. International evidence suggests equivocal results.[69]

Remarkably, no research was discovered conducted in a Flemish setting. With the passing of the 10-year anniversary of the Quality-of-Care Triad, we would argue it is high time to study how well each independent QI initiative is integrated within participating hospitals and evaluate its synergistic effects,

both within the Triad as well as with other implemented initiatives. The detected evidence-base in this paper found only a limited individual impact of accreditation, PR and inspection on patient outcomes. Flanders should look at the added value of the current system by further investigating the combined effect of multiple improvement strategies. First, the implementation of Triad components and other initiatives should be mapped out historically and studied for associations with patient outcomes. Additionally, how healthcare professionals perceive current policy should be studied within the Flemish setting, as current views are primarily based on international evidence and hearsay. The financial impact on hospitals of present policy should be considered and we recommend further research into perspectives of national and international stakeholders to decide the appropriate and supported next steps. Finally, the sustainability of current and future policy should be assessed and improved upon. This review brought to light how accreditation and PR might have failed to leave a durable impact. Future research into both internal and external QI initiatives should therefore focus on the solid anchoring of quality policy.

Several study limitations merit attention. First, despite the systematic search strategy, we might have missed other relevant research. Nevertheless, the reported method aimed to encompass a broad range of articles and the narrative nature of this review is not hindered by an inexhaustive list of papers. Second, we did not formerly asses the quality of papers or tested categorisation validity. However, we feel this would not be meaningful considering the large heterogeneity of identified records and the unambiguous characterisation. Third, considering the paucity of inspection literature, our results remain limited to the effects of accreditation and PR on patient outcomes. Further research is thus required to study how inspections affect patient outcomes. Fourth, the described evidence-base did often not disclose the context in which patient outcome improvement could (not) be discovered, such as financial and staff support or baseline quality level. Therefore, implementation science remains an area for future research. Fifth, we could not attempt a statistical meta-analysis due to the heterogenous research contexts and study designs. Future research could provide more robust analyses for each individual component. Nonetheless, our narrative synthesis has provided valuable insight into the impact accreditation, PR and inspection has on patient outcomes.

2.1.6 Conclusion

The discovered evidence-base on how accreditation, PR and inspection - the core of Flemish hospital quality - impacts patient outcomes, primarily reported no overall effect. Still, accreditation was discovered to positively influence processes of care. Further studies should investigate the combined impact of multiple QI strategies. We recommend a thorough policy revision in Flanders to determine the added value of the current system and move towards a sustainable future quality system that benefits the patient above all.

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Chapter 3

OUTLINING THE IMPLEMENTATION OF QUALITY IMPROVEMENT INITIATIVES IN FLEMISH HOSPITALS

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Van Wilder A*, Brouwers J*, Cox B, Bruyneel L, De Ridder D, Claessens F, Eeckloo K & Vanhaecht K. (joint first author), (2021). A decade of commitment to hospital quality of care: overview of and perceptions on multicomponent quality improvement policies involving accreditation, public reporting, inspection and pay-for-performance. *BMC Health Services Research.* 21(990).

Summary

This chapter focuses on the second research objective aiming to study the implementation of quality improvement initiatives in Flemish hospitals. A first section of the chapter concentrates on the initiatives undertaken as encouraged by the government, i.e. accreditation, inspection, public reporting and pay-for-performance. The multi-method study summarises the various initiatives that were adopted by Flemish hospitals between 2018 and 2019. It also gathered the perspectives of healthcare stakeholders on the current quality of care policy. The second section of this chapter centres around additional internal initiatives individual hospitals undertake to improve quality of care, besides those encouraged by the government.

3.1 A decade of commitment to hospital quality of care: overview of and perceptions on multicomponent quality improvement policies involving accreditation, public reporting, inspection and pay-for-performance

3.1.1 Abstract

Background: Quality improvement (QI) initiatives such as accreditation, public reporting, inspection and pay-for-performance are increasingly being implemented globally. In Flanders, Belgium, a government policy for acute-care hospitals incorporates aforementioned initiatives. Currently, questions are raised on the sustainability of the present policy.

Objective: First, to summarise the various initiatives hospitals have adopted under government encouragement between 2008 and 2019. Second, to study the perspectives of healthcare stakeholders on current government policy.

Methods: In this multi-method study, we collected data on QI initiative implementation from governmental and institutional sources and through an online survey among hospital quality managers. We compiled an overview of QI initiative implementation for all Flemish acute-care hospitals between 2008 (n=62) and 2019 (n=53 after hospital mergers). Stakeholder perspectives were assessed via a second survey available to all healthcare employees and a focus group with healthcare policy experts was consulted. Variation between professions was assessed.

Results: QI initiatives have been increasingly implemented, especially from 2016 onwards, with the majority (87%) of hospitals having obtained a first accreditation label and all hospitals publicly reporting performance indicators, receiving regular inspections and having entered the pay-for-performance initiative. On the topic of external international accreditation, overall attitudes within the survey were predominantly neutral (36.2%), while 34.5% expressed positive and 29.3% negative views towards accreditation. In examining specific professional groups in-depth, we learned 58% of doctors regarded accreditation negatively, while doctors were judged to be the largest contributors to quality according to the majority of respondents.

Conclusions: Hospitals have demonstrated increased efforts into QI, especially since 2016, while perceptions on currently implemented QI initiatives among healthcare stakeholders are heterogeneous. To assure quality of care remains a top-priority for acute-care hospitals, we recommend a revision of the current multicomponent quality policy where the adoption of all initiatives is streamlined and co-created bottom-up.

Key words: Hospital; Quality Improvement; Accreditation; Public Reporting of Healthcare Data; Quality Control

3.1.2 Introduction

Across all levels of healthcare, from micro- to macro-systems, initiatives to improve quality have been globally arising.[1] Still, patient harm continues to persist, with one in twenty patients experiencing preventable harm[2,3] and harm putting a substantial burden on healthcare systems of high-income countries.[4,5] Quality's position at the top of hospitals' agenda is therefore well-deserved.

In Flanders, the Dutch-speaking region of Belgium, a government agreement that forms the basis of today's 'Quality-of-Care Triad' for the hospital setting was established in 2009. This Triad encompasses 1) voluntary announced hospital-wide accreditation, defined as an assessment of a pre-determined set of standards[6] by an international external agency, 2) voluntary measurement and public reporting of quality indicators and 3) mandatory inspection by the Flemish government. An overarching patient safety contract was drawn up at federal level between the government and acute-care hospitals from 2007, rewarding hospitals financially that committed to implementing quality improvement (QI) initiatives with a small fixed portion of hospital payment. From 2018, the contract became known under the heading of P4P with adjusted reimbursements.

Since 2019, however, Flemish hospitals are starting to publicly express an alleged 'quality fatigue',[7,8] claiming the burden of the multicomponent government policy is becoming exorbitant. However, no overview exists on how hospitals have adopted the initiatives under government policy in the past decade to corroborate this statement. Both clinicians and policymakers alike are expressing concerns on the continued application of accreditation, supported by international evidence describing it as bureaucratic and time consuming,[9] merely market-driven,[10] costly,[11] and not promoting what actually matters to patients.[12] As a result, already about ten Flemish hospitals have declared their intention to abandon accreditation. Regarding public reporting, worries are mainly about the possibility of risk aversive behaviour in physicians that might harm patient outcomes,[13] about misinterpretation or gaming of data,[14] about the significant financial and administrative burden[15] and finally about the lack of reach to patients.[16] Concerning inspection, apprehension exists on the topic of 'decoupling', i.e. the gap between the paper-based reality of rules and guidelines and actual clinical practice.[17,18] On the other hand, initiatives such as accreditation,[19,20] public reporting[21] and pay-for-performance (P4P)[22] have shown promise in multiple healthcare segments. Examples include accreditation promoting change and professional development[9] or public reporting further stimulating QI activity and altering hospital selection by the patient.[23] This conflicting evidence urges a formal assessment on the perspectives of relevant healthcare stakeholders. Hence the objective of this study is twofold. First, to provide a detailed overview of the various initiatives that Flemish hospitals have adopted in line with current hospital policy between 2008 and 2019. Second, to study healthcare stakeholders' perspective on the current hospital policy.

3.1.3 Methods

History of quality improvement initiatives

We conducted a retrospective region-wide multi-method study of all acute-care hospitals (n=62 in 2008, n=53 in 2019 after hospital mergers) in Flanders, Belgium on government-imposed QI initiatives occurring between 2008 and 2019. Information about accreditation trajectories between 2008 and 2019 was obtained from multiple sources: an online survey, Qualicor Europe (a Dutch institute focused on accreditation, formerly known as NIAZ), and public websites of hospitals. The online survey was

distributed in January 2020 via Qualtrics© to all quality managers within the study sample, and contained retrospective questions about the accreditation body, the number of accreditation cycles, their audit and re-audit dates and their respective overall scores between 2008 and 2018. Secondly, data on public reporting was provided by the Flemish Institute for the Quality of Care (VIKZ), which is responsible for the measurement and the public reporting of quality indicators.[24] Thirdly, information on inspection dates and hospital mergers was obtained from the Department of Health at the Flemish government. Finally, the Federal Public Service for Health (federal government) provided information on the participants to each yearly patient safety contract between 2008 and 2017 as well as to the pay-for-performance initiative from 2018. A more detailed overview of the data collection guide and characteristics of the various QI initiatives under government policy in Flanders can be found in Appendix A.2.1.

Perspectives on current policy

We assessed healthcare professionals' perspectives on current policy in two ways: a widespread online survey and an in-depth questionnaire in a focus group with Flemish healthcare policy experts. First, a survey assessing respondents' attitudes towards current policy was distributed between July and September 2020. The survey was implemented in Sawtooth© and disseminated via email to the management of all Flemish acute-care hospitals, to government representatives and to the staff members of the Flemish Patient Association (hereafter called patient representatives). Reminders were sent with the encouragement of hospital association Zorgnet-Icuro. To further increase the number of returned surveys, survey invites were published in a medical newspaper (Artsenkrant), on social media (Facebook, LinkedIn, Twitter) and the research group's website (www.ligb.be) and participants were encouraged to further distribute the survey link to healthcare professionals. The following eight professional groups were invited to fill in the survey: doctors, nurses, paramedics, middle management & supervisors, quality staff & executives, hospital board members, government representatives and patient representatives. The survey first pertained to how respondents perceived the implementation of an external international accreditation programme (positive, neutral, negative). Subsequently, respondents were asked to rank the ten following groups according to their importance in the determination of hospital quality policy: doctors, nurses, hospital management, quality staff & executives, middle management & supervisors, paramedics, patients & family, government, board of directors and other care providers.

Second, we invited 22 Flemish top executive healthcare policy experts for a focus group in February 2020. The group consisted of hospital board members (n=7), government representatives (n=6), middle management (n=4), patient representatives (n=3) and doctors (n=2) and all made significant contributions to past or current hospital policy. The focus group was moderated by KVH and DDR, while AVW and JB acted as notetakers. The session aimed to discover what expert opinion considered as the most important aspects of current hospital policy to bring to future policy discussions. We adapted the focus group methodology[25] to generate quantitative data by introducing a Qualtrics© survey to all focus group members during the session. After a short introduction section, the survey was taken by all present focus group members (average survey time was 18 minutes), after which the results were discussed within the group. The survey consisted of 17 in-depth statements concerning current hospital policy (see Appendix A.2.2) and related to the currently implemented QI initiatives, i.e. accreditation (n=5), public reporting (n=5), inspection (n=5) and pay-for-performance (n=2). The focus group members were asked to indicate how important they considered the statement to be included in future hospital quality policy discussions by means of a slider scale ranging between 0 (not important) to 100 (very important).

Statistical analyses

For our first objective, an overview of the adopted QI initiatives was visualised. For clarity, inspection dates were grouped into 'compliance monitoring' and 'other inspections', while all individual release dates for public reporting across the four overarching domains are jointly displayed. Only the dates of the public release of indicators were presented, while data on measurement and benchmarking within hospitals were disregarded (see Appendix A.2.1). To generate healthcare professionals' perspectives on current policy, we first described results from the widespread Sawtooth© survey by describing the attitudes towards accreditation (positive, neutral or negative). Variation in accreditation attitudes across respondents (by one of eight invited professional groups) was assessed by means of a Kruskal-Wallis test. Data on the importance of the ten surveyed profession groups in the determination of quality policy were summarised by ranking the sum of ranks for all respondents and by invited profession (eight groups). This information was depicted by means of a radar chart, with the lowest rank representing the highest importance. Second, results from the Qualtrics© survey disseminated during the focus group were visualised in box plots ranked from highest to lowest importance for future policy discussions. Analyses were generated using SAS© software, Version 9.4 of the SAS System for Windows.

3.1.4 Results

Sample

An overview of the adoption of government-promoted QI initiatives was provided for all Flemish acute-care hospitals (n=62 in 2008, n=53 in 2019 after hospital mergers). Of these, 49 are general hospitals, while four are university hospitals. The online survey on the history of QI initiatives generated a response rate of 83% (n=44). The number of beds per hospital ranged between 170 and 1,955 with an average of 542. To assess perspectives on current policy, first, the widespread online survey targeted towards all healthcare professionals was filled in by 486 respondents. 19 had to be excluded because they could not be categorised within the eight established professional groups, resulting in a final sample of 467 respondents. Of these, the majority were quality staff & other executives (n=137), doctors (n=119) or hospital board members (n=74). Other respondents represented middle management & supervisors (n=57), nurses (n=39), government representatives (n=15), paramedics (n=14) and patient representatives (n=12). There was a balanced representation of Flemish hospitals within the surveyed sample, with an even distribution in working experience, region, type of hospital and accreditation status among respondents. Second, 17 policy experts participated in the focus group (response rate 77%) to assess perspectives on current policy. The final group consisted of hospital board members (n=6), government representatives (n=4), middle management (n=4), patient representatives (n=2) and one doctor.

History of quality improvement initiatives

Figure 3.1 depicts when accreditation, public reporting and inspection have taken place within Flemish hospitals and shows yearly participation to the patient safety contracts. Hospitals are ordered by date of their first accreditation audit. To date, all hospitals have entered into an accreditation trajectory by either the US-based Joint Commission International (JCI) or the Dutch Qualicor Europe (Qualicor). Only one hospital (number 62 in Figure 1) had not yet obtained its label by the end of 2019. Few (13%) hospitals achieved their first accreditation label before 2016, but the earliest adopter (number 1) was already accredited by the beginning of 2008 and had achieved three labels by the end of 2019. The majority of hospitals opted for the four-year-cycled Qualicor accreditation (n=31). JCI hospitals (n=22) are audited

every three years, except for the third audit in hospital 5 occurring within a year after the second due to the move to a new building. One hospital (number 10) additionally obtained a label by the US accreditation body ANCC Magnet. One hospital (number 16) opted out of the accreditation process by the end of 2019. Overall, the procurement of an accreditation label required a re-visitation in five hospitals (numbers 3, 7, 23, 40, 51) and was refused in three (numbers 4, 7, 8). Concerning public reporting, the majority of hospitals (n=45) agreed to immediately start reporting from 2016 (Figure 3.1). Four hospitals (numbers 10, 33, 44 and 60) waited to report their indicators until the second semester of 2016, while three started reporting from mid-2017 (numbers 11, 40, 59) and one from mid-2019 (number 39). Inspections were mostly carried out once a year, with about 30% of hospitals having inspections in 2008-2013 and nearly all hospitals from 2014 onwards. Some hospitals (e.g. numbers 22, 58) even received three inspector visits within the same calendar year, occasionally (e.g. numbers 3, 12, 14, 22, 58) concurring with accreditation visits. Finally, all but three (numbers 27, 39, 50 on Figure 3.1) hospitals agreed to the federal government's patient safety contract from 2008 (Figure 3.2). By 2010, all had entered the contract.

The chances of concomitant QI initiatives have increased throughout time, as the overall number of QI initiatives across hospitals has surged, in particular in 2016 and 2017. A summary of the occurrence of initiatives per study year aggregated over hospitals can be found in Figure 3.2. It demonstrates how more than 40% of hospitals received an accreditation audit in 2017, how over 90% of hospitals undertook yearly public reporting from 2016 and how inspection has monitored compliance for over 90% of hospitals in 2015 and 2019.

Table 3.1 provides more detailed information on the accreditation status of Flemish acute-care hospitals by the end of 2019 as well as on audit scores for each accreditation cycle. It demonstrates how the preponderance of hospitals have undergone one accreditation cycle (83%), while eight hospitals already went through re-accreditation. Accreditation details provided by 44 hospitals showed that audit scores were high on average, with global Qualicor scores ranging between 90% and 98% and the number of JCI elements not met and partially met (out of nearly 1300 measurable elements) ranging from 0 to 11 and from 0 to 43, respectively.

Table 3.1 Accreditation status in December 2019 and accreditation scores ranges between 2008 and 2018 in Flemish acute-care hospitals

Number of accreditation cycles undergone	Qualicor		JCI		
	Number of hospitals[1]	Global scores (%), range[2]	Number of hospitals[1]	Elements not met (n), range[3]	Elements partially met (n), range[3]
0	1	/	0	/	/
1	29	92-98	15	0-7	7-43
2	0	90-98	5	0-8	23-39
3	1	92-94	0	2-5	0-32
4	0	/	2	5-11	0-26

[1]Out of all 53 Flemish acute-care hospitals.

[2]For 24 completed surveys.

[3]For 20 completed surveys. JCI examines over 300 standards, each with their own number of measurable elements, resulting in just under 1300 measurable elements. The number displayed in this table refers to the unmet or partially met measurable elements as determined by the JCI-auditors. The exact number of standards and measurable elements varies between editions of the standards manual. In Flemish hospitals, the fourth, fifth and sixth edition of the manual were used between 2008 and 2018.

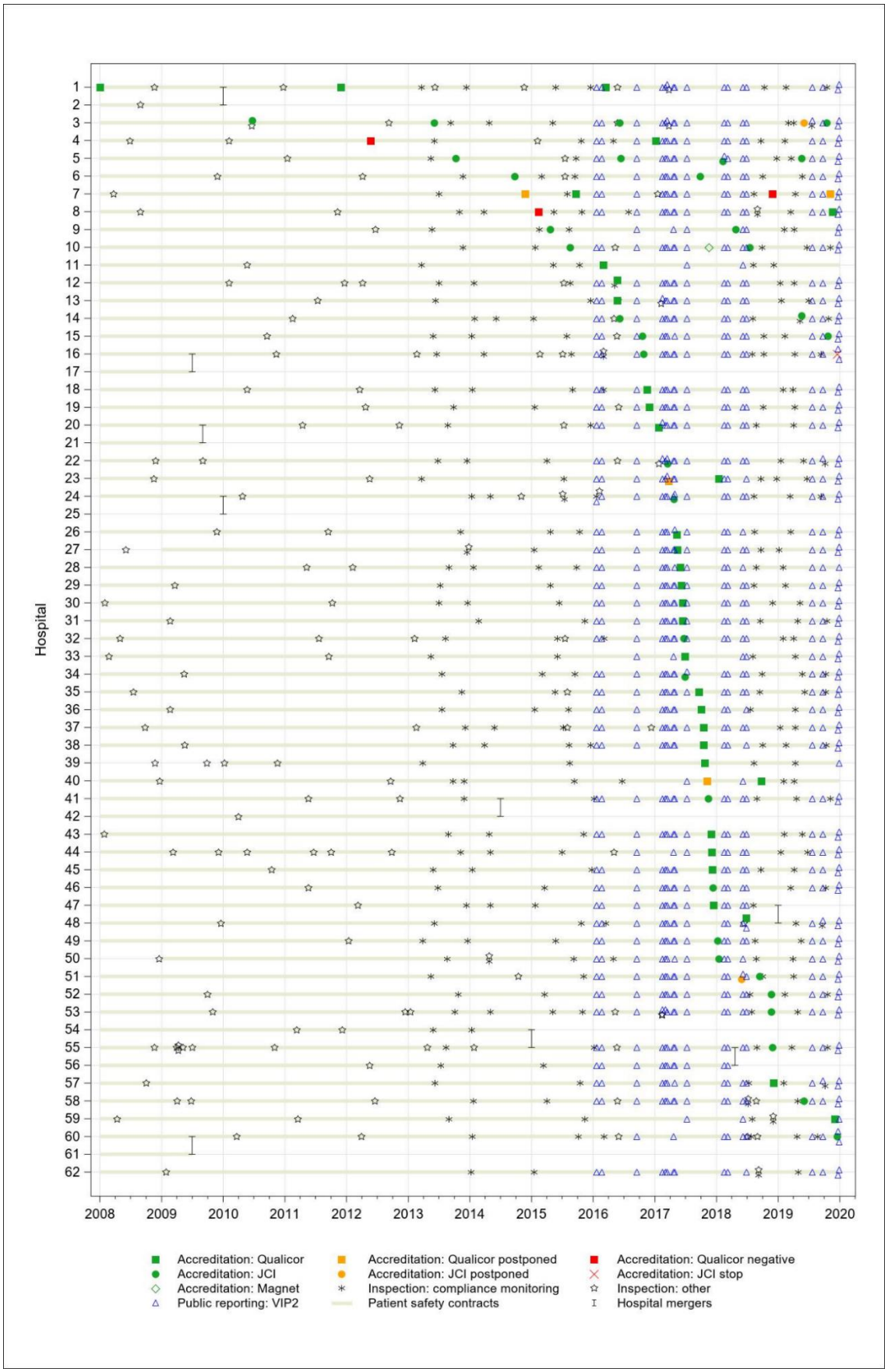

Figure 3.1 History of quality improvement initiatives in Flemish acute-care hospitals between 2008 and 2019

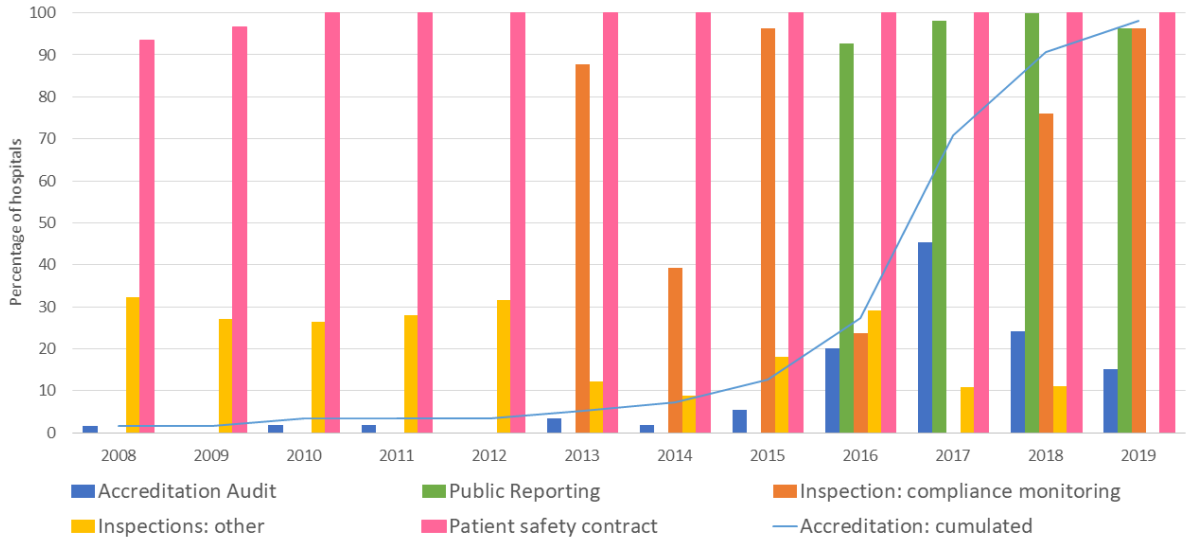

Figure 3.2 Number of quality improvement initiatives undertaken for aggregated Flemish acute-care hospitals between 2008 and 2019.

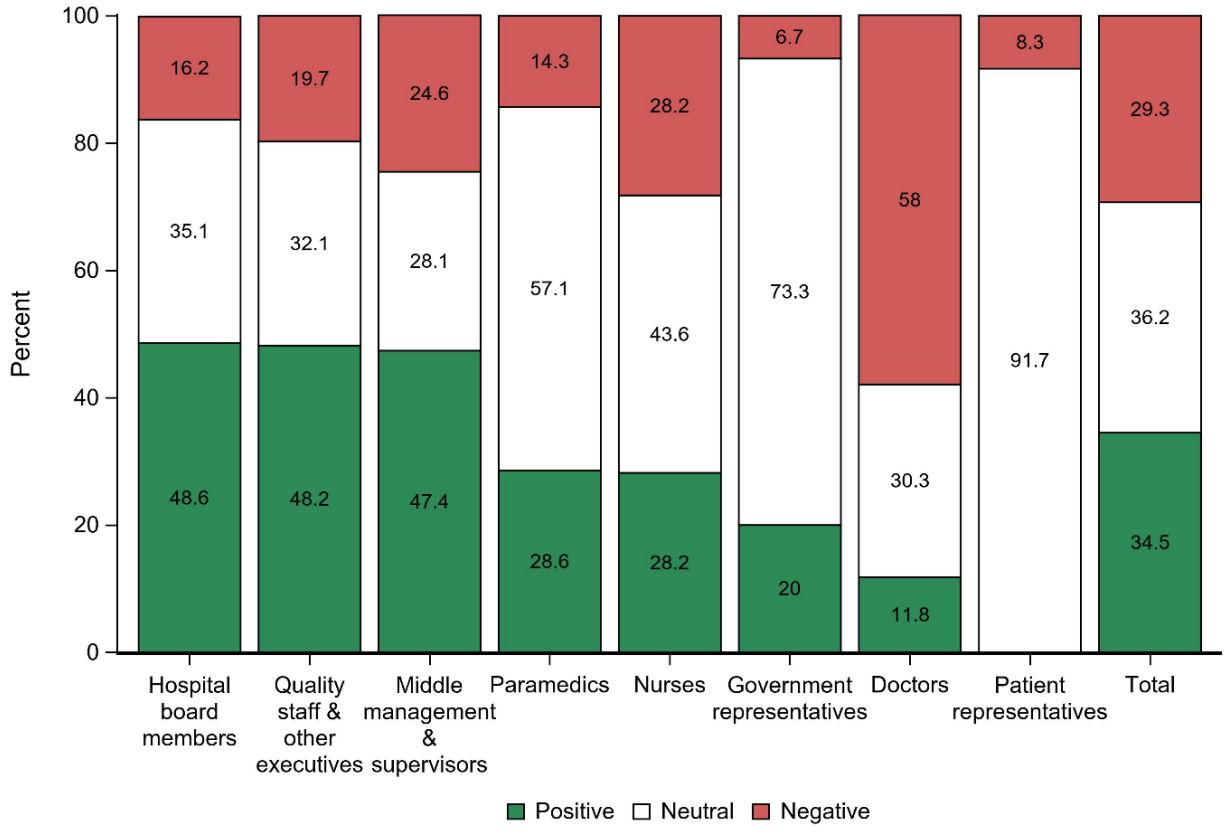

Figure 3.3 Perspectives of healthcare stakeholders on international external accreditation programmes

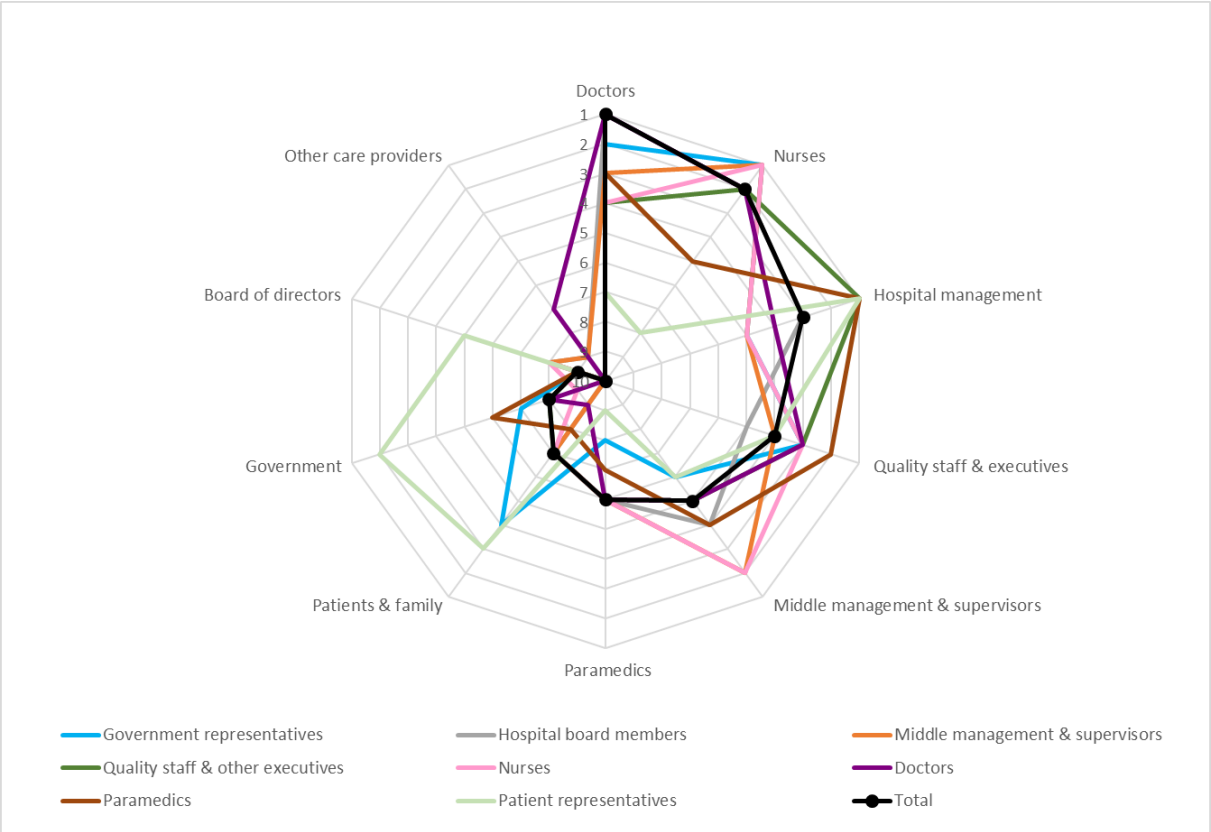

Figure 3.4 Radar diagram of healthcare stakeholders' rankings on the importance ten professional groups have in the determination of quality policy, with the lowest ranking representing the highest importance

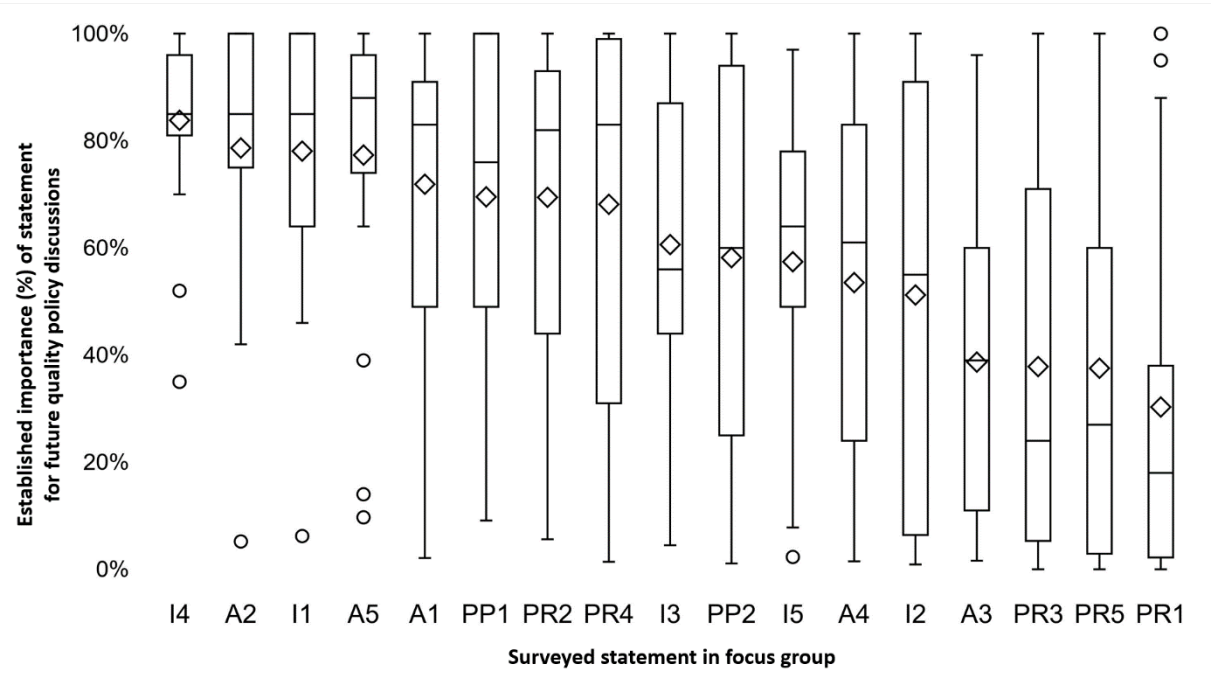

Figure 3.5 Established importance of surveyed statements for future quality discussions among focus group participants

Perspectives on current policy

Figure 3.3 displays the perspectives of 467 healthcare stakeholders on the topic of international external hospital accreditation per profession, ranked by decreasing positive views. Overall, the majority (36.2%) of respondents had a neutral attitude towards accreditation, while 34.5% had a positive view on accreditation and 29.3% perceived it negatively. Non-clinical hospital staff were more positive about accreditation than other professional groups, with nearly half of the hospital board members (48.6%), quality staff & other executives (48.2%) and middle management & supervisors (47.4%) rating accreditation as positive. Among nurses, paramedics, government representatives and patient representatives, the majority of respondents were neutral about accreditation (43.6%, 57,1%, 73,3% and 91.7% respectively). As much as 58% of doctors had a negative attitude towards accreditation. The observed differences among professional groups were significant (p=<.0001).

Overall, respondents of the online survey (n=467) ranked doctors as the group with the highest importance for the determination of hospital quality policy, followed by nurses and hospital management (Figure 3.4). Other care providers, government and board of directors were ranked as least important. However, different views could be observed when looking at specific types of respondents. Patient representatives, for example, found clinicians to be of minimal importance for policy setting, while they considered hospital management, government and patients & family most important. Alternatively, nurses, government and middle management & supervisors found nurses to be most important to determine policy, while quality staff & executives, patient representatives and paramedics ranked hospital management in the top position.

The focus group revealed large disagreement among policy experts (Figure 3.5) as there was a larger than 80% difference among the minimum and maximum range in established importance for future policy discussions in 13 out of 17 surveyed statements. Examples without concordance included the impact of accreditation on time for patient care (A3) and the involvement of mystery patients in future inspections (I2). The largest consensus as well as highest ranked importance among focus group members existed for two inspection and two accreditation statements, i.e. that inspection should focus on a minimum set of requirements (I4) and occur unannounced (I1) and that accreditation has brought about a positive dynamic within hospitals (A2) and has opened up conversation on quality within hospital boards (A5). The introduction of a minimum set of quality requirements (I4) was found most important (average importance 84%) to take to future quality policy discussions. On this topic, one focus group member stated: *"When considering to discontinue accreditation, we should be aware not to throw out the baby with the bathwater. Accreditation has opened up conversation on the topic of quality and ensured a base level we can build up from. This minimum quality level should be guaranteed in future policies."* In contrast, the concept of patient selection and risk-avoidance by physicians in public reporting (PR1) was found least important (average 30%) to bring to future discussions, followed by the topic of public reporting on physician-level (PR5 and PR3). One focus group member discoursed the topic as follows: *"Public reporting on a physician-level is irrelevant in today's hospital landscape. Patient care is no longer a single individual's merit, but always involves team effort."*

3.1.5 Discussion

To our knowledge, this is the first attempt at a region-wide overview of external QI initiatives. Strengthened by its multi-method approach, our research has recapitulated paramount quality strategies

implemented by hospitals between 2008 and 2019, as encouraged by the government, as well as established healthcare professionals' viewpoint on said strategies.

This study showed that substantial commitments were made into the improvement of hospital quality in the past decade. The majority of hospitals have demonstrated they highly prioritise quality, with all hospitals opting in to the pay-for-performance programme and over 90% of hospitals actively choosing for the public reporting of quality indicators and quality assurance via accreditation. The new inspection programme focusing on patient trajectories has further stimulated this tendency towards quality by enforcing all hospitals to regularly acknowledge organisations' current quality level. A recent surge in the implementation of accreditation, public reporting and inspections could be observed, in particular for accreditation from 2016 onwards. This growing investment into QI by acute-care hospitals is commendable. However, our research also highlights an incremental strain put on hospitals as initiatives stimulated by authorities are becoming more frequent and occasionally even concurrent. Despite all described initiatives being jointly encouraged by the government, they appear to be regarded as separate initiatives with their adoption not coordinated. This might have contributed to the alleged feeling of 'quality abundance' among hospital staff. To assure quality of care remains a top-priority for acute-care hospitals and current workload is reduced, we encourage a more streamlined and synchronised implementation of future quality improvement initiatives. Furthermore, this study has focused solely on external and government-encouraged QI initiatives. Coordination of initiatives should also include the supplemental initiatives hospitals have adopted internally on both patient-, department- and hospital-level, exemplified by the initiatives instigated within the domain of patient experiences.[26]

Today, in the wake of the first termination of one hospital's accreditation trajectory by an external body in December 2019, already about ten hospitals have declared their intention to abandon accreditation.[8] One potential reason for this decision might be that accreditation has failed to show distinctiveness among hospitals, with every hospital now having entered an accreditation trajectory and accreditation scores being high for all. With the large majority of hospitals also opting in to public reporting and P4P, hospitals hoped to differentiate themselves by accreditation. This distinction was encouraged by the government, as P4P points were rewarded to accredited institutions and systemic inspections were waived after entering an accreditation trajectory. However, being accredited today is no longer an assurance of competing among top-performers, it is now merely an indication of being a participant in the game, making being accredited a less coveted status to achieve prestige. Instead, accreditation has laudably provided a solid baseline level of quality for all hospitals, by ensuring they all comply with a large set of healthcare standards. Despite some doctors' negative attitudes towards accreditation being voiced loudly within printing press,[7,8] our study consequently revealed only a minority (29.3%) of healthcare stakeholders viewed accreditation negatively. Within the focus group of policy experts, rare agreement existed on the positive dynamics accreditation have brought to hospitals. These results are in line with international findings that described overall hospital staff's attitudes towards accreditation as positive,[27,28] with more scepticism found among physicians.[27] The latter corresponds with our finding of 58% of doctors perceiving accreditation negatively. Our study exposed a gap between clinical and non-clinical hospital staff in terms of perspectives on current policy, with clinicians most frequently displaying a negative stance towards accreditation and non-clinical staff such as hospital board, management and quality staff demonstrating a more positive attitude. While a disproportionate distribution in workload might partly explain this gap, illustrated by the fact that doctors were overall considered to be the largest contributors to quality, this also further confirms the existence of the concept of 'decoupling'. As previously described for inspections,[17,18] a paper-based reality of rules and guidelines in the boardroom is not always reflected within clinical practice. Even among top executive policy experts within the focus group, where one would assume congruity, disagreement dominated. There is therefore a need for future policies to be co-created by all stakeholders involved, i.e.

government, non-clinical staff , clinicians and patients.[29,30] Too often, QI initiatives have been considered as universal all-purpose solutions that work regardless of context, leading to poor fidelity and the disregarding of lessons learnt from local settings.[31] It is time quality policy was built bottom-up from clinical practice, rather than imposed top-down, making sure everyone involved can intrinsically claim ownership over quality of care.

To move forwards in the development of future healthcare policies, we recommend further research in a number of fields. First, we need stronger evidence concerning the benefits of currently employed QI initiatives. Current knowledge remains scarce and equivocal and the symbiotic effects of compound initiatives is a neglected area of research at present.[32] Minimum criteria should be determined such as a minimal set of accreditation cycles or requirements imposed by inspections. Contrastingly, maximum criteria should also be examined. Perhaps attempting more than two accreditation cycles is genuinely excessive and without additional benefit as is suggested by Devkaran *et al.*[33] Perhaps new policies should be considered where other high-potential initiatives should move to the forefront like disease-specific [34] or unannounced [35] accreditation or peer-review.[36] Some hospitals have already independently adopted these initiatives. We would recommend future research in the least labour-intensive way to avoid additional strain on hospital workers and management, preferably on objective data such as patient outcomes out of electronic healthcare records or discharge data sets. From the increasing adoption of QI initiatives demonstrated in this paper, it can be concluded there is a need to establish priorities for future policy, where evidence-based targets could facilitate a more coordinated and integrated policy implementation. Second, the cost of current and future employed initiatives should be assessed, to determine the further feasibility of the quality policy. QI efforts today are primarily funded by the hospitals themselves, with no additional funds provided by the government besides a limited portion of hospital finances through P4P. Policymakers should consider increasing funding for evidence-based QI initiatives. Investing in quality might result in a positive return-on-investment and at the very least could relieve some of the current pressure on hospitals and help facilitate a level of investment that can leave a durable impact on the quality of hospital care. Third, the support of the entire healthcare sector, from clinicians to hospital management to patients, should be considered for both current and potential elements of a future quality policy and a broad consensus should be strived for. As such, policy will move more towards a healthcare service that's endorsed by both patient and healthcare provider.[37,38] Finally, we stress the importance of a sustainability assessment of quality policy. Our paper has demonstrated the significant and increasing commitment hospitals have made in recent years. This raises questions on how much we should demand of our hospitals and especially what the threshold is above which we have asked too much. With the Covid-19 pandemic having shaken healthcare at its very core, there's potential for rethinking current quality practice and policy from the ground up, inclusive of all stakeholders involved.

A number of considerations that merit further attention and highlight a number of limitations to this study needs to be outlined. First, results derived from the survey on QI implementation might have suffered from a response and recall bias. As primarily objective data were procured from a survey with a commendable response rate of 83% and combined with objective data from other sources, we feel this bias is minimalised to the extent possible. Second, the survey on perspectives of healthcare stakeholders did not contain questions on other specific initiatives such as e.g. governmental inspections or public reporting. Perceptions on accreditation were specifically surveyed because accreditation programmes appeared most strongly connected to feelings of dissatisfaction within hearsay and due to hospital statements claiming accreditation abandonment. Our focus group with policy experts instead focused on all government-encouraged QI initiatives and revealed large disagreement on all initiatives. As stated above, additional research is required that takes all potential initiatives and all healthcare stakeholders into account and looks for a balanced compromise. Additionally, the widespread survey generated lower

sample sizes in specific groups, e.g. patient representatives. Still, those representatives constitute over a thousand patients among several patient organisations and the overall response of 467 healthcare stakeholders is laudable. Finally, our research remains limited to initiatives stimulated by government policy. The inclusion of initiatives instigated by individual hospitals might have provided a more comprehensive historic overview of QI initiatives. Nevertheless, our focus on government-encouraged initiatives exposed a disconnect between policymakers and clinicians which future policy will need to resolve, while capturing the essence of quality improvement within Flemish hospitals in the past decade.

3.1.6 Conclusion

Acute-care hospitals in Flanders, Belgium, have demonstrated an increased implementation of government-encouraged quality improvement initiatives over the past decade. From 2016 onwards, the adoption of accreditation, public reporting, pay-for-performance and inspection has surged and has demanded an incremental commitment. Our study revealed healthcare stakeholders were incongruous in their viewpoints on current policy. While doctors are overall considered as most crucial in quality policy, current accreditation programmes are frequently perceived negatively by them. Nonetheless, overall views on accreditation were predominantly neutral or positive among different healthcare stakeholders. With growing concerns on the sustainability and efficacy of today's multicomponent policy, we recommend a thorough policy revision with both patients' and all relevant stakeholders' involvement that prioritises and streamlines the implementation of future quality improvement initiatives.

3.2 Exploring additional quality improvement initiatives Flemish hospitals undertake beside the Quality-of-Care Triad

3.2.1 Abstract

Background: Flemish hospitals have demonstrated a large commitment towards quality improvement by increasingly implementing initiatives incorporated within the government policy's Quality-of-Care Triad. However, to date, it remains unknown what other initiatives hospitals undertake targeting hospital quality beside those directly encouraged by the government.

Objective: To explore the implementation of quality improvement initiatives beside those incorporated within the Quality-of-Care within Flemish acute-care hospitals.

Methods: We disseminated an online Qualtrics survey to the quality managers of all Flemish acute-care hospitals (n=53). The survey contained questions about currently valid certificates and quality labels the hospital obtained beside hospital-wide accreditation, as well as an open-ended question regarding other quality improvement initiatives hospitals had undertaken to improve hospital quality.

Results: Our survey was filled in by 36 quality managers, generating a response rate of 68%. It exposed a large number of quality improvement initiatives Flemish hospitals have implemented beside the Quality-of-Care Triad. Most frequently, hospitals opted to obtain ward- and disease-specific quality labels, such as disease-specific accreditation. Additionally, they indicated large internal commitments by monitoring own quality metrics or aiming to improve quality through means of learning from patient safety incidents, standardisation or quality education.

Conclusions: Flemish acute-care hospitals are highly committed to quality of care. They invest substantially in multiple quality improvement initiatives beside those encouraged within the Quality-of-Care Triad.

3.2.2 Introduction

In light of large quality of care issues being exposed, with an adverse event estimated to occur in one in ten hospitalized patients,[39,40] and preventable harm approximated to reach one in twenty patients,[2] both individual hospitals and policy makers have dedicated themselves towards quality improvement.[1,41] Governments worldwide have initiated policies targeting quality improvement, including initiatives such as accreditation or pay-for-performance (P4P) programmes. In Flanders, Belgium, a government agreement providing the foundations for today's 'Quality-of-Care Triad' for the hospital setting was established in 2009. This Triad encompasses 1) voluntary announced hospital-wide accreditation, defined as an assessment of a pre-determined set of standards[6] by an international external agency, either JCI or Qualicor Europe, 2) voluntary measurement and public reporting of quality indicators and 3) mandatory inspection by the Flemish government. An overarching patient safety contract was drawn up at federal level between the government and acute-care hospitals from 2007, rewarding hospitals financially that committed to implementing quality improvement (QI) initiatives with a small fixed portion of hospital payment. From 2018, the contract became known under the heading of P4P with adjusted reimbursements.

Previous research has highlighted how the implementation of the aforementioned government-encouraged QI initiatives within Flanders have demanded an incremental commitment of Flemish acute-care hospitals.[41] However, we hypothesise that QI initiatives as encouraged by governmental policy are not the sole commitment hospitals undertake towards quality improvement. As knowledge on evidence-based interventions expand exponentially, hospitals have initiated initiatives on their own in the interest of QI. Examples of quality-targeted interventions include disease-specific societies increasingly working towards certification of specific medical wards,[42,43] or electronic clinical registrations such as computerised physician order entries (CPOE) being used to improve patient safety and for continuous in-house quality monitoring.[44,45] To date, no overview exists of how hospitals undertake QI initiatives without direct government policy encouragement. Therefore, this study will aim to explore the implementation of QI initiatives within Flemish acute-care hospitals, as instigated by individual hospital and without direct government-encouragement.

3.2.3 Methods

We conducted a retrospective region-wide assessment of internal QI implementation across all acute-care hospitals (n=53) in Flanders, Belgium. Medical and quality directors from all 53 hospitals were contacted for participation in this study, encouraged by hospital umbrella organisation Zorgnet-Icuro. Email and telephone reminders were sent by the research team to non-responsive hospitals. After agreement to participate, an online survey was distributed in January 2020 via Qualtrics© to all quality managers within the convenience sample. The survey included questions about currently valid certificates and quality labels the hospital obtained beside hospital-wide accreditation, which was government-encouraged within the Quality-of Care Triad. Additionally, the survey contained an open-ended question regarding other QI initiatives hospitals had undertaken to improve hospital quality. Descriptive analyses were conducted via Microsoft Excel.

3.2.4 Results

Sample

The survey on internal initiatives undertaken by acute-care Flemish hospitals was filled in by 36 out of 53 possible quality managers, generating a response rate of 68%. The hospitals included in the sample had between 170 and 1955 inpatient beds, amounting to an average of 570.

Other certificates and quality labels beside hospital-wide accreditation

Respondents highlighted a wide range of certificates and quality labels that were currently valid within their hospital beside a hospital-wide accreditation label such as JCI or Qualicor Europe. An overview of the individual certificates and labels that were mentioned by at least two hospitals is provided in Table 3.2. The most prevalent certificate was an ISO-certificate (n=30), demonstrating compliance to international standards in products and services like pathological laboratories or hospital pharmacies. The certifier of this ISO-certificate was frequently BELAC-accredited (n=12). Subsequently, the Smiley label (n=9) was rewarded by the federal government for qualitative and safe hospital food, followed by two more federal initiatives, i.e. the Baby-Friendly Hospital (n=6) and Sciensano Lab Recognition (n=4). Finally, a whole range of disease- or ward-specific labels were reported, e.g. EUSOMA (n=3), JACIE (n=3) or DGU Trauma (n=2). All disease- and ward-specific accreditation certificates combined (including certificates that only occurred once and therefore are not included within Table 3.2) amounted to a total of 16 hospitals stating their implementation.

Table 3.2. Additional certificates and quality labels obtained by Flemish acute-care hospitals beside hospital-wide accreditation.[1]

Name certificate	Description	Number of hospitals
ISO (examples provided: ISO 9001:2015, ISO 15189, …)	ISO is an organisation that develops internationally recognised standards to make products compatible and identify safety issues of products and services. So*urce:* https://www.iso.org/publication/PUB100007.html	30
BELAC	BELAC accredits certification bodies. It demonstrates the competences as well as impartiality of the certification body. *Source:* https://economie.fgov.be/nl/themas/kwaliteit-veiligheid/accreditatie	12
Smiley	This label is awarded by the Federal Agency for Food Chain Safety for organisations who have a validated auto-control system for food safety in place. *Source:* http://www.favv.be/smiley/nl/watis/	9
Baby Friendly Hospital Initiative (BFHI)	This initiative launched by the World Health Organisation and UNICEF is rewarded to maternity wards that provide support and information about breast feeding. *Source:* https://www.health.belgium.be/nl/voeding/voedingsbeleid/voeding-en-gezondheid/borstvoeding/baby-friendly-hospital-initiative-bfhi	6
Sciensano lab recognition	Sciensano contains the Belgian Scientific Institute for Public Health and assesses if laboratories meet legal requirements. *Source:* https://www.sciensano.be/nl/over-sciensano/organigram-van-sciensano/kwaliteit-van-laboratoria/erkenning	4
EUSOMA	The European Society of Breast Cancer Specialists certifies centres who commit to improve breast cancer care. *Source:* https://www.eusoma.org/en/certification%2dprocess/1-346-1-	3

JACIE	JACIE develops and maintain global standards for the provision of quality medical and laboratory practice in cellular therapy. Based on these standards, JACIE offers accreditation to transplant programmes in order to encourage health institutions and facilities to establish and maintain quality management systems impacting on all aspects of their activities and to engage in continuous improvement. *Source:* https://www.ebmt.org/accreditation/about-jacie	3
DGU Trauma	TraumaRegister DGU® is setting global standards for the quality management of severely injured. Over 800 hospitals from more than 20 different countries are participating. *Source:* http://www.traumaregister-dgu.de/index.php?id=144	2
EBCOG	The European Board and College of Obstetrics and Gynaecology (EBCOG)'s aim is to improve the health of women and unborn and newborn babies by promoting the highest possible standards of care. EBCOG's core activities are education and training. They work with subspecialties, special interest societies, trainees and European interest groups to achieve this. They work closely with the European trainees' organisation, ENTOG and offer fellowships together annually. *Source:* https://www.ebcog.org/	2
QUATRO	Quality Improvement Quality Assurance Team for Radiation Oncology (QUATRO) provides independent quality audits through comprehensive reviews of radiotherapy practices. To improve quality of radiotherapy treatment, it focuses on peer reviews of and evaluation of the quality of all components of the practice of radiotherapy at a cancer centre, with a view to quality improvement. *Source:* https://www.iaea.org/services/review-missions/quality-improvement-quality-assurance-team-for-radiation-oncology-quatro	2
Investors in People	Investors in People is a quality mark for a strategic and sustainable staff policy. An organisation will be rewarded with this label if it continues to invest in the development and recognition of its employees. *Source:* https://www.mvovlaanderen.be/fiche/investors-people	2

[1]Excludes 23 certificates that were described by just one hospital, of which examples include the SOS Mains label (orthopaedics hands surgery), a label for PET/CT scan, or a Health on the Net (HON) label for a digestive centre.

Other quality improvement initiatives hospitals undertake

Within the online survey, 31 (86%) hospitals filled in the open-ended question regarding other initiatives they had undertaken internally to improve quality of care beside either the Quality-of-Care Triad or obtaining quality certificates or labels. Nine themes, each with their own sub-themes, could be identified (Table 3.3). Most frequently (n=29), hospitals opted to commit to additional quality indicator measurement beside the indicators used for public reporting, by e.g. joining clinical registries (n=4). Hospitals also gathered internal knowledge by assessing current practice (n=22) via e.g. internal audits (n=7) or tracers (n=5) as well as through electronic health records (n=20). They aimed to improve quality by learning from incidents (n=14), standardising processes of care (n=13), integrating quality within their policies (n=13) and educating staff on quality concepts (n=13). Lastly, a minority of hospitals put focus on improving patient communication (n=6) and rewarding qualitative care to champion wards or physicians (n=3).

Table 3.2. Other quality improvement initiatives identified within individual Flemish acute-care hospitals beside the Quality-of-Care Triad

Theme	Sub-Theme	Number of hospitals
Measuring quality indicators		**29**
	Follow-up of own set of indicators	12
	Indicators on quality platform/dashboard	*3*
	Feedback about patient experiences	*3*
	Installing Quality/Improvement boards on clinical wards	8
	Safety culture assessment	5
	Follow-up of indicators for clinical registries	4
Assessing current practice		**22**
	Internal audits	7
	Patient safety rounds	6
	Tracers	5
	Risk analyses	4
Electronic Health Records		**20**
	Electronic Patient File	9
	Bed side scanning	4
	Centralised file management	3
	Electronic Registrations (e.g. Cybertrack© for blood transfusions)	2
	Development of Rapid Response Teams	2
Response to incidents		**14**
	Follow-up after incident reporting	12
	Morbidity and Mortality Meetings	2
Standardisation of care		**13**
	Care/clinical pathways	6
	Development of lean projects	4
	Development of projects according to EFQM Excellence Model	2
	Implementation of discharge checklists	1
Quality integrated within policy		**13**
	Implementation of Quality & Safety Board	7
	Quality & Safety Board is multidisciplinary	*4*
	Implementation of quality policy plan	4
	Development of Quality Handbook	2
Education on quality of care		**13**
	Awareness campaign (e.g. 'Week of patient safety')	5
	Internal education on patient safety	4
	Quality coaches on clinical wards	4
Improving communication with patients		**6**
	Communication (e.g. leaflets, campaigns) about quality commitment towards patients	4
	Bedside briefing	2
Rewarding quality		**3**
	Rewarding clinical wards/projects/physicians that have demonstrated to improve patient quality/outcomes.	3

3.2.5 Discussion

This study demonstrated how acute-care hospitals in Flanders have invested substantially into quality of care. Not only do they prepare for inspections and have they adopted QI initiatives such as hospital-wide accreditation and public reporting,[41] they also engage in multiple additional initiatives without direct encouragement of government policy. Hospitals delineated a wide range of initiatives and all hospitals that responded to our survey mentioned at least one additional quality label they obtained

beside hospital-wide accreditation. Most frequently, hospitals reported to obtain additional certification towards standardisation of paramedical aspects of hospital care, such as laboratory and pharmacy ISO-labels, followed by the achievement of disease-specific accreditation labels.

While not directly included within Flemish hospital quality policy, disease-specific accreditation is in part externally incentivised in Belgium. Hospitals that obtain a select set of quality labels, including EUSOMA or Trauma DGU, can achieve up to 5 out of maximum 80 points towards the federal government's P4P programme.[46] In addition, achieving any of the wide array of disease-specific accreditation labels can help hospitals to distinguish themselves from others, demonstrating prestige and excellence. This level of distinction is highly coveted and no longer attainable through hospital-wide accreditation, which has been obtained by the majority of Flemish hospitals.[41] Disease-specific accreditation is found to be consistently associated with more favourable patient outcomes, including mortality, length of stay, care processes, patient satisfaction and adverse outcomes.[34,47,48] Therefore, implementation within individual hospital policy is highly laudable.

Our study also highlights the intrinsic motivation of hospitals to target quality of care. Already, a large set of quality indicators is being collected for the purpose of public reporting on www.zorgkwaliteit.be. Yet, the majority of respondents to our survey indicated they collect additional indicators of their own. Hospitals are highly committed towards quality control, through means of current practice assessments and registration within electronic health records. Additionally, they aim towards quality improvement, through learning from patient safety incidents, care standardisation, quality education or improved communication with patients.

Knowing QI initiative implementation within the Quality-of-Care Triad is not sufficiently streamlined and is being added to the already strong commitment of individual hospitals through initiatives this study has exposed, it is no wonder hospitals are expressing a 'quality fatigue'.[7,8] For the past decade, individual hospitals were not heard in the development of government quality policy. Perhaps the overview provided within this paper can stimulate policy makers to include them in future hospital quality development. Already, 450 Flemish healthcare stakeholders, ranging from clinicians to patient representatives and hospital board members were surveyed for their preferences in future policy.[49] In order to build a more sustainable policy with focused quality improvement, the incorporation of their perspective is vastly important.

This paper is subject to important limitations that merit attention. Most importantly, our results most likely underestimate the true internal QI implementation to a great extent. First, respondents to our survey might have suffered from a response and recall bias. Second, our survey was only filled in by hospital quality management, who do not always have knowledge on initiatives undertaken on clinical wards. Third, while our survey generated a commendable response rate (68%) from the majority of Flemish hospitals, the inclusion of closed-ended questions within the survey or further follow-up via in-depth semi-structured interviews might have generated a more comprehensive overview of QI implementation in Flanders. Nevertheless, this study was able to explore the initiatives hospitals take up in order to improve quality of care in Flanders beside the Quality-of-Care Triad.

3.2.6 Conclusion

This study is the first to explore quality improvement initiatives undertaken by Flemish hospitals to improve quality of care beside the initiatives incorporated within the government policy of the Quality-of-Care Triad. The study highlights the dedication of Flemish hospitals towards quality as they are found

to invest substantially in multiple quality initiatives, such as obtaining disease-specific accreditation or monitoring additional quality metrics. On the other hand, the results presented in this study also raise questions on the sustainability of current efforts. We recommend policy makers to better streamline and coordinate future quality improvement initiative implementation and to incorporate healthcare workers' perspectives to create a more supported quality strategy.

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Chapter 4

ASSESSMENT OF TRENDS AND VARIATION IN VITAL FEW PATIENT OUTCOMES PATIENT EXPERIENCES, MORTALITY, READMISSIONS AND LENGTH OF STAY

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Summary

This chapter bundles all the evidence gathered on trends and variation in patient experiences, mortality, readmission and length of stay across Belgian hospitals, four outcome measures which can be considered as '*the vital few'* patient outcomes to monitor. In a first section of the chapter we display how patient experiences have evolved within Flemish hospitals from the start of data collection (2014) up to 2019. Trends and between-hospital variability were consequently associated with quality improvement initiatives individual hospitals have undertaken in order to increase their patients' hospital experience, which was gathered from an online survey. The chapter continues in the following sections with information gathered through analysis of routinely collected administrative discharge information. In a second section, an overview of how hospital-wide mortality, readmissions and pLOS has evolved between 2008 and 2018 across all Belgian hospitals is disseminated. The following sections 3 to 5 focus on variability in the vital few patient outcomes between Belgian hospitals. In sections 3 and 4, variability was assessed for two disease-specific case studies, i.e. urological care and cardiovascular care. Thereafter, variability was studied across the hospital-wide spectrum, subdivided into 20 disease groups. A final sixth section within this chapter provides a methodological assessment of measuring in-hospital mortality via administrative databases, aiming to determine the construct validity of mortality measurements.

4.1 Six years of measuring patient experiences in Belgium: limited improvement and lack of association with improvement strategies.

4.1.1 Abstract

Objective: To examine trends in patient experiences in the period 2014-2019, describe improvement strategies implemented by hospitals in the same period, and study associations between patient experiences and implemented strategies.

Design: Multi-center retrospective region-wide observational design.

Setting: Flanders, Belgium.

Participants: 44 out of 46 Flemish acute-care hospitals publicly reporting patient experiences via the Flemish Patient Survey (FPS).

Main outcome measure(s): Primary outcomes were the two global FPS ratings: percentage of patients rating the hospital 9 or 10 and percentage of patients definitely recommending the hospital. Secondary outcomes were the average top-box score percentages for each of the 8 remaining dimensions of the FPS.

Results: Between 2014 and 2019, there was a significant improvement in patients scoring the hospital 9 or 10 (56% to 61%) and patients definitely recommending (67% to 70%) the hospital. Significant increases in patient experiences over time were also observed in other dimensions, except for the dimension discharge. Hospital key informants reported various improvement strategies related to patient experiences with care and the FPS. Feedback to nursing wards (n=44, 100%) and clinicians (n=39, 89%) were most common. Overall, most improvement strategies were not or only weakly associated with patient experience ratings in 2019 and changes in ratings over time. Still, positive associations were discovered between the strategies 'nursing ward interventions' and 'hospital wide education' and recommendation of the hospital.

Conclusions: Patient experiences have improved modestly in Flemish acute-care hospitals. Hospitals report to have invested in patient experience improvement strategies but positive associations between such strategies and FPS scores are weak, although there is potential in further exploring nursing ward interventions and hospital wide education. Hospitals should continue their efforts to improve the patient's experience, but with a more targeted approach, taking the lessons learned on the efficacy of strategies into consideration.

Key words: Quality improvement, Patient-centred care, Patient satisfaction, Hospitals

4.1.2 Introduction

Hospitals are increasingly integrating patient-centeredness within their policy statements. Its importance as one of the dimensions of healthcare quality[1] is becoming more and more recognized. Patient-centered care is associated with improved clinical outcomes and reduced costs.[1–4] Assessing the patient's perspective of quality has long been described as a valuable quality indicator and the foundation of patient-centeredness.[5] Many health systems have therefore developed survey instruments aimed at measuring patient experiences, like the Hospital Consumer Assessment of Healthcare Providers and Systems (USA)[6] and the NHS Patient Survey (UK)[7] for acute-care hospitals. In Flanders, the northern part of Belgium, a uniform instrument was developed by the Flemish Patient Platform and validated[8] under the heading of the Flemish Patient Survey (FPS). The stakeholder-initiated Flemish Hospital Indicator Initiative (VIP²) aimed to increase insight into the quality of its hospitals by using clinical process and outcome indicators. Amongst other indicators, patient experiences with care, are voluntarily gathered hospital-wide via FPS by nearly all Flemish hospitals. In order to support quality improvement initiatives, feedback is available to all organisations. Communication of individual results on hospital websites is encouraged. In 2015, a central website (http://www.zorgkwaliteit.be) was developed where findings can be consulted by the public in an aggregated manner. The top-box scores of two global patient experience measures, i.e. patients definitely recommending the hospital and patients rating the hospital 9 or 10, are publicly reported once a year since July 2015.

Merely implementing a patient experience survey does not suffice to improve patients' experiences.[9] Reporting of patients' perspectives of hospital care can, however, be an incentive to enhance and reinforce quality improvement, although international evidence remains scant and ambiguous[10] and is often based on case studies and expert opinion.[11–13] A recent systematic review[14] looked into initiatives to improve patient satisfaction and observed potential in strategies concerning communication,[15] patient[16] and physician education[17] and increasing pharmacists' involvement.[18] Making use of online platforms like Yelp or Facebook could be linked with improvements in patient experiences.[19,20] Aboumatar and colleagues[21] studied high-performing US hospitals of patients' reports of care and found involvement and responsibility at multiple levels of the organization, from leaders to clinicians, to be a common trait. They found that high-performing hospitals used multiple and similar concurrent interventions to improve patient experiences, like nursing ward interventions or hospital-wide feedback. External incentives like accreditation[22–24] or pay for quality in a Value Based Purchasing program[25] were found to have little impact on the patient's experience.

How patient experiences have evolved in Flanders since the first public release in July 2015 of 2014 scores, is unclear. Additionally, which quality improvement strategies concerning patient experiences have been introduced in Flemish hospitals remains unexplored. The aim of this study was to describe associations between improvement strategies and patient experiences as assessed via the FPS. We therefore first examined trends in patient experiences from 2014 to 2019. Subsequently, we described which strategies Flemish acute-care hospitals have implemented during the same time period. Finally, associations between patient experiences and improvement strategies were explored.

4.1.3 Methods

Study design

A multi-centre retrospective region-wide observational study.

Study sample and recruitment

The FPS is handed out to all eligible patients (i.e. all discharged non-psychiatric patients above 18 years of age) during two periods of the year (6 weeks in March-April and 6 weeks in September-October) and with a yearly minimum of 300 filled out surveys per hospital. Over the study period, on average 78% of hospitals distribute their surveys on paper, 11.6% handed out an electronic version of the FPS and 10.4% combined electronic with paper distributions. Key informants from all Flemish acute-care hospitals (n=55) who have chosen to publicly report (n=46) patient experience scores on http://www.zorgkwaliteit.be were contacted for participation in this study, encouraged by the hospital umbrella organization Zorgnet-Icuro. Email and telephone reminders were sent by the research team to non-responsive hospitals.

Data collection

To describe trends in FPS results, the Flemish Institute for the Quality of Care was contacted as the official organisation overseeing the development and measurement of quality indicators. Patient-mix adjusted quality indicators, aggregated at hospital-level, were provided from the earliest collections in 2014 to the first semester of 2019 within the 'patient experiences' domain of the Flemish Indicator Initiative. This encompasses the percentages of top-box scores on 28 questions concerning nine dimensions of patient experience: hospital stay preparation, information about condition, information about treatment and procedures, dealing with patients and collaboration between healthcare providers, privacy, safe care, pain management, discharge and global experience. The two global patient experience measures, i.e. patients grading the hospital and patients recommending the hospital, are the sole indicators publicly reported online at the time of the study. Patient-mix adjustments include patient age, sex, housing type, health status and level of education.

To outline currently implemented quality improvement strategies, an online survey with personal code was sent out in summer 2019 via Qualtrics© to all quality managers within the study sample. The survey was developed within the research team and contained 16 binary (yes/no) questions about hospital participation in strategies. The inquired strategies were based on international literature of frequently implemented initiatives aimed at improving patient experiences.

Statistical analysis

We first described our sample characteristics. Main outcomes were the two global patient experience measures: the percentage of patients rating the hospital 9 or 10 and the percentage of patients definitely recommending the hospital. Secondary outcomes were the average top-box score percentages for each of the 8 remaining dimensions of the FPS. To describe the trend in patient experiences, our first research objective, we plotted the two global top-box measures from 2014 to 2019 for each participating hospital. Linear changes in top-box percentages over time were modelled using a separate multilevel model for each outcome, accounting for repeated measures through a random intercept for hospital. In a second set of models, year was treated as a categorical variable to allow for non-linear trends. For our second objective concerning implemented strategies, we present the findings from the survey on quality improvement initiatives visually by percentage of participating hospitals and by percentage of implemented strategies. For our final research objective, we studied the effect of improvement strategies as potential predictors of superior patient experience scores on the FPS. Using separate models for each

outcome, we tested differences in percentage top-box scores measured in 2019 between hospitals with and without a specific strategy (linear regression), as well as differences in linear trends, i.e. the evolution of percentage top-box scores from 2014 to 2019 (multilevel linear regression). Differences in time trends between hospitals with and without a strategy were assessed using an interaction term between a binary indicator for strategy implementation and a linear variable for year. The strategy "FPS feedback to nursing wards" was not tested as this was implemented by all 44 hospitals. Statistical significance of the regression analyses was determined at an alpha level of 0.05. The critical threshold for the regression analyses concerning associations with implemented strategies was determined at $p<0.0033$, which is derived from a Bonferroni correction[26] to control for multiple testing, i.e. alpha level of 0.05 divided by 15, the number of strategies tested. The analyses for this paper were generated using SAS© software, Version 9.4 of the SAS System for Windows.

Ethical considerations

The study protocol was approved as part of a larger retrospective observational study concerning the impact of improvement initiatives on patient outcomes by the Ethics Committee of University Hospitals Leuven (S63449).

4.1.4 Results

Sample

Our final sample included 44 (response rate: 96%) acute-care hospitals who agreed to participate. Four included hospitals were university hospitals (9%) and the number of beds ranged from 170 to 1764. Seven (16%) hospitals did not start FPS measurements until 2015. Four hospitals (9%) did not measure patient experiences for one or two study years due to reasons like hospital mergers, external accreditation or moving to another building. The total number of participants filling out their patient experience increased each year from on average 613 per hospital (SD: 360.7) in 2014 to a mean of 741 (SD: 440.4) in 2018. For all participating hospitals, this totals to a sample set of 23 549 patients in 2014 and 32 464 in 2018. For the first semester of 2019, already 16 193 patients (on average 378 per hospital) filled out the FPS, which is in accordance with expectations.

Trend in patient experiences

The overall and hospital-specific trends in global patient experiences are plotted in Figure 4.1. Overall, the percentage of patients rating the hospital 9 or 10 has steadily increased from 56% in 2014 to 61% in 2019, while the percentage definitely recommending the hospital ranged from 67% in 2014 to 70% in 2019. Some hospitals (e.g. AI, AJ, and AQ) appear to follow an upward trend, while patient experiences seem to deteriorate in e.g. AH, BE and BJ. For each hospital, both global questions appear to follow similar trends, although exceptions exist (e.g. AO, AY, BA).

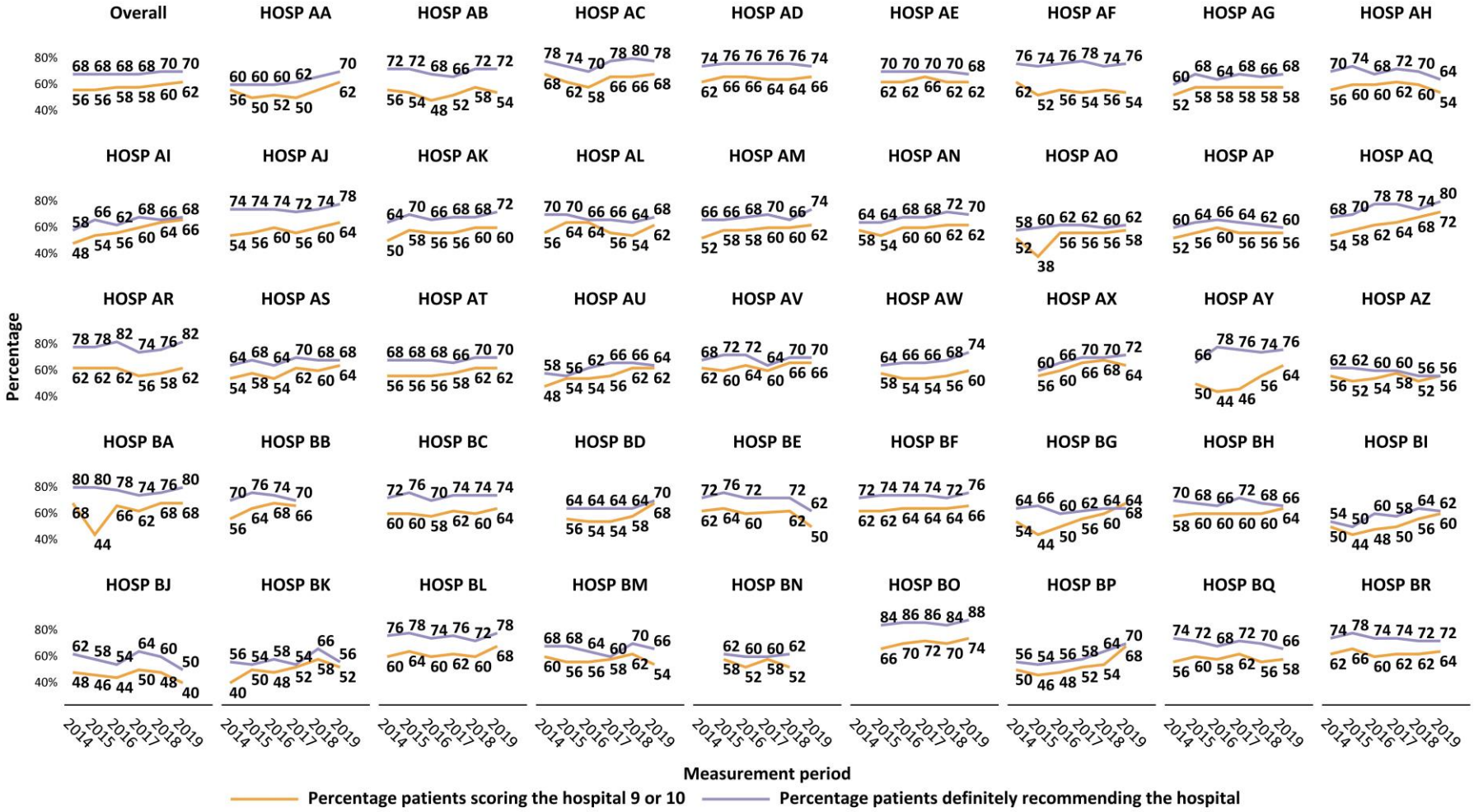


Figure 4.1. Hospital trends in patient experience scores for the two global questions.

Each figure represents the percentage top-box scores in one of 44 participating Flemish acute-care hospitals. The upper left figure represents results aggregated for all participating hospitals.

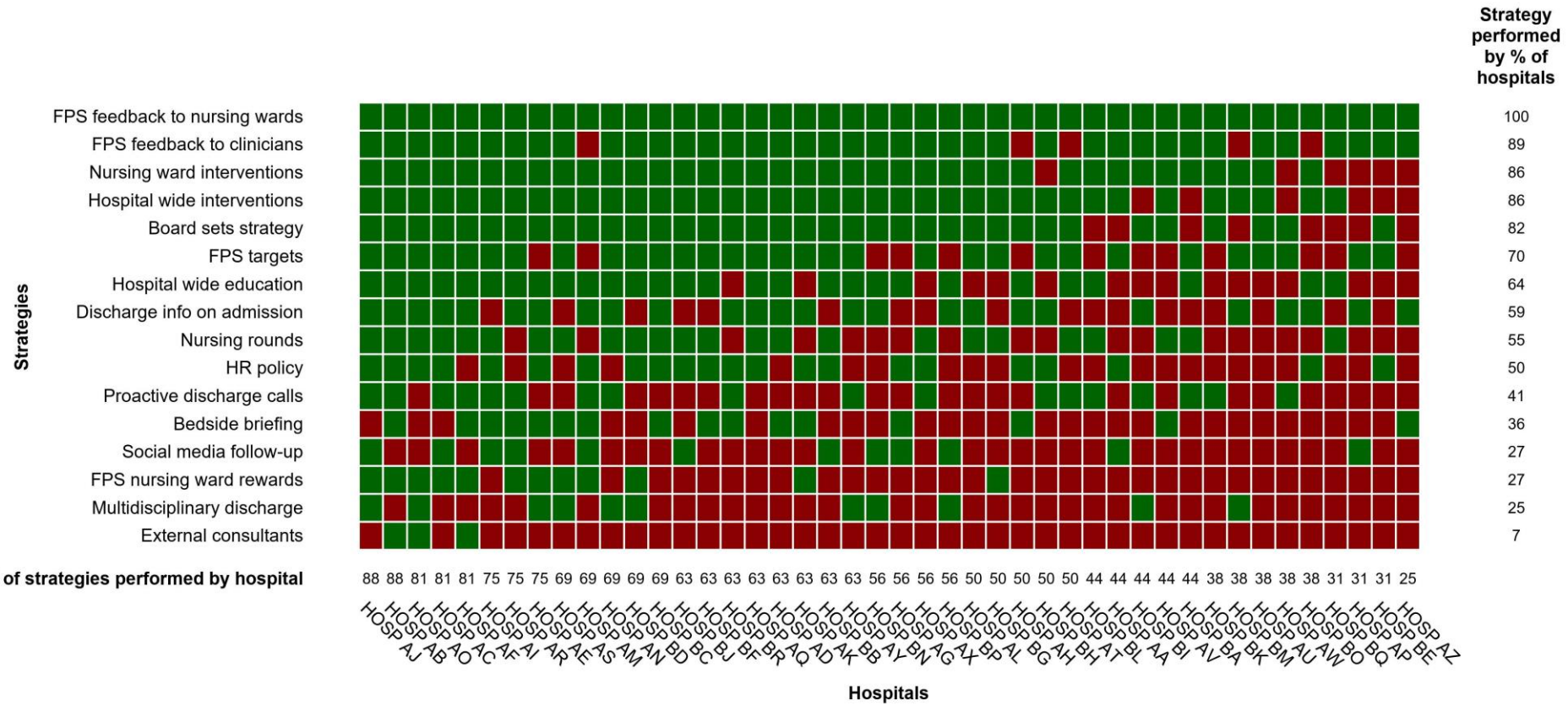


Figure 4.2. Implemented quality improvement strategies to improve patient experiences across hospitals.

Each cell represents a quality improvement strategy in one particular participating hospital (n=44). A green cell represents the strategy being implemented, whereas a red cell represents an unimplemented strategy.

Appendix A.3.1 displays the yearly top-box percentages and the results of the multilevel regression models across time for the two global FPS questions and the averages for the 8 remaining FPS dimensions. Large variation in average percentage top-box scores exists between the 8 dimensions, ranging from 51% to 89% in 2014 and from 53% to 88% in 2019. Assuming linearity, a significant improvement in patient experiences was observed for the two global questions and for all dimension averages except for the dimension discharge. The estimated yearly increases in the percentage of patients rating the hospital 9 or 10 and the percentage of patients definitely recommending the hospital were 1.10 (95% CI: 0.80; 1.40) and 0.39 (95% CI: 0.15; 0.63) respectively. Results from regression models treating year as a categorical variable indicate that improvements are primarily observed in recent measurement periods: compared with 2014, a significant increase in top-box percentages was observed for 2 out of 10 outcomes in 2017, and for 8 out of 10 outcomes in 2019. The largest improvement in patients' experience was observed for the dimension safe care, with 52% of patients answering the top-box score in 2014, improving to 64% in 2019 (β=11.69, 95% CI: 10.03; 13.34). Worsening of patient experiences could be observed in the dimension discharge. However, deteriorations are small and scores remain high (average percentage top-box scores 89% in 2014 and 88% in 2019, β=-0.63, 95% CI: -1.19; -0.08).

Implemented strategies to improve patient experiences

An overview of the surveyed strategies with a description of each strategy is provided in Table 4.1, which includes examples of strategies employed by participating hospitals. Analysis of the binary survey questions on improvement strategies resulted in the heatmap displayed in Figure 4.2. FPS feedback to nursing wards is a strategy implemented by all hospitals (100%, n=44), while direct feedback to clinicians (89%, n=39) is second most common. In a shared third and fourth place come nursing ward interventions (86%, n=38) and hospital wide interventions (86%, n=38). Conversely, hiring external consultants to improve patient experiences is the least explored strategy (7%, n=3). Discharging the patient with a multidisciplinary team (25%, n=11) and both rewarding the best FPS performing nursing ward (27%, n=12) and social media follow-up (27%, n=12) are relatively infrequent as well. A large variation between the number of strategies a hospital implements can be observed, ranging from 4 to 14 out of 16 surveyed initiatives. The number of strategies is independent of hospital size or teaching status. Among the 5 hospitals employing the most strategies for example, both academic (n=2) and general (n=3) hospitals are represented, which are located in 4 of the 5 Flemish provinces and with the number of beds ranging between 271 and 1049.

Table 4.1. Surveyed strategies and their description.

Surveyed strategy	**Description**
FPS feedback to nursing wards	Flemish Patient Survey feedback is received by nursing wards on a regular basis. Feedback can occur on internal data collection as well as on the external benchmark reports released twice a year.
FPS feedback to clinicians	Flemish Patient Survey feedback is received by clinicians on a regular basis. Feedback can occur on internal data collection as well as on the external benchmark reports released twice a year.
Nursing ward interventions	Interventions at the level of the nursing ward are implemented to improve patient experiences. Examples include the introduction of a Magic Table© on geriatrics, interventions on pain management, organizing mealtimes between staff and patients where patients can express their concerns, or

	the introduction of Patient Reported Outcome Measures (PROMs) on specific wards.
Hospital wide interventions	Hospital wide interventions are launched to improve patient experiences. Examples are the implementation of an incident reporting system designed for patients or the organization of consultation hours between hospital staff and management and patients. Additionally, interventions could comprise hospital-wide campaigns aimed at improving the patient's experience. Examples include participation in the internationally renowned 'What Matters to You' campaign, based on Barry and Edgman-Levitan's perspective [27] or campaigns concerning Mangomoments based on research by Vanhaecht *et al.* [28].
Board sets strategy	The hospital board sets the strategy to improve patient experiences. The strategy can e.g. be documented in a charter which is then distributed to all staff.
FPS targets	Specific targets concerning Flemish Patient Survey are premised. A hospital can e.g. choose to aim for more than the required 300 yearly surveys, or can aim for a specific percentage gain in one or more patient experience dimensions.
Hospital wide education	Hospital wide education, like workshops or seminars, to improve patient experiences are organised. For example, hospitals could develop a hospital academy, wherein both online and offline courses are organised for both care professionals and patients. Topics for professionals could include ways of introducing yourself to the patient and techniques on informing patients about their treatment.
Discharge info on admission	Discharge information is provided at the time of a patient's admission.
Nursing rounds	Nursing rounds specifically aiming to improve patient experiences are organised.
HR Policy	Improving patient experiences is an area of concern for human resources management. How an individual care provider scores on his/her patient's experience, can be a topic of a performance appraisal.
Proactive discharge calls	A selection of patients is called proactively after discharge.
Bedside briefing	Briefing of care providers at shift transfer takes place at the patient's bedside.
Social media follow-up	Reviews by patients on online platforms like Facebook, Twitter, Google Reviews, etc. (social media) are systematically followed up on.
FPS nursing ward rewards	Nursing wards receive a reward when scoring excellently on Flemish Patient Survey. The reward can be of a financial nature, but can also e.g. entail a teambuilding outing.
Multidisciplinary discharge	A multidisciplinary team of care providers is present at patient's discharge.
External consultants	A consultancy firm is hired to improve patient experience scores.

Associations between patient experiences and improvement strategies

Associations between the strategies reported by the participating hospitals and the two global patient experience questions for the first semester of 2019 are displayed in Table 4.2. None of the strategies were associated with rating of the hospital, whereas top-box scores for recommendation of the hospital were significantly higher for hospitals having implemented nursing ward interventions and hospital wide education. For both strategies, the difference in percentage definitely recommending the hospital between hospitals with and without the strategy was around 6.6%, but these associations were not significant after Bonferroni correction. At an alpha level of 0.05, significant positive associations were observed for 6 strategy-dimension combinations (Appendix A.3.2), including 3 dimensions for the strategy nursing ward interventions and 2 dimensions for the strategy hospital wide intervention. The dimension discharge, however, was negatively associated with the strategies FPS feedback to clinicians and external consultants. The latter was also negatively associated with the dimension preparing for hospital stay. However, after Bonferroni correction, none of these associations remained significant.

Table 4.2. Associations between quality improvement strategies and top-box scores for global patient experience questions in 2019.

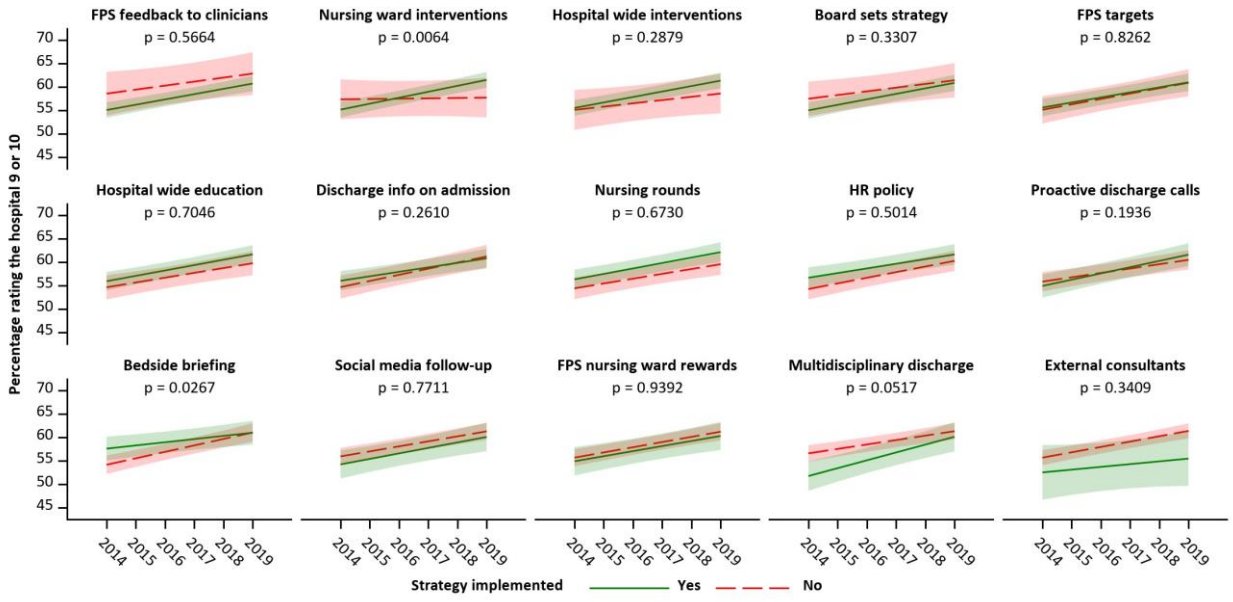
Surveyed quality improvement strategy	**Percentage rating the hospital 9 or 10**		**Percentage definitely recommending the hospital**	
	β[(1)]	(95% CI)	β[(1)]	(95% CI)
FPS feedback to clinicians	-0.64	(-6.61; 5.32)	-2.66	(-9.89; 4.58)
Nursing ward interventions	4.69	(-0.64; 10.01)	6.64	(0.23; 13.05)*
Hospital wide interventions	3.30	(-2.13; 8.72)	5.00	(-1.56; 11.56)
Board sets strategy	-1.06	(-5.98; 3.86)	-0.81	(-6.83; 5.21)
FPS targets	-0.14	(-4.45; 4.16)	1.92	(-3.31; 7.14)
Hospital wide education	2.61	(-1.34; 6.55)	6.69	(2.26; 11.13)**
Discharge info on admission	1.03	(-2.98; 5.05)	3.63	(-1.15; 8.41)
Nursing rounds	2.24	(-1.65; 6.13)	2.45	(-2.31; 7.21)
HR policy	0.08	(-3.87; 4.03)	1.74	(-3.05; 6.53)
Proactive discharge calls	1.60	(-2.36; 5.56)	4.68	(-0.11; 9.48)
Bedside briefing	-0.26	(-4.29; 3.77)	1.74	(-3.15; 6.63)
Social media follow-up	-0.54	(-5.09; 4.02)	0.09	(-5.48; 5.66)
FPS nursing ward rewards	0.39	(-4.03; 4.81)	3.47	(-1.81; 8.76)
Multidisciplinary discharge	0.12	(-4.82; 5.05)	-1.52	(-7.52; 4.49)
External consultants	-6.48	(-13.68; 0.72)	0.21	(-8.94; 9.36)

[(1)] The difference (with 95% confidence interval) in percentage top-box scores between hospitals with and without the improvement strategy.

* Statistically significant at an alpha level of 0.05. ** Statistically significant at an alpha level of 0.01.

None of the estimates were significant after Bonferroni correction.

Associations between strategies and trends in top-box score percentages over time are presented in Figure 4.3 (two global questions) and Appendix A.3.3 (8 remaining dimensions). Significant differences in time trend slopes were observed for the strategy nursing ward interventions: top-box scores for both global questions increased over time in hospitals with nursing ward interventions, whereas patient experiences remained constant (rating the hospital) or deteriorated (recommending the hospital) in hospitals without nursing ward interventions. For recommendation of the hospital, significant differences in time trends were also observed for the strategies board sets strategy, social media follow-up, and multidisciplinary discharge, with hospitals that implemented these strategies showing more positive slopes than hospitals without the strategy. Hospital rating, however, increased more steeply in hospitals without than in hospitals with bedside briefing, but the latter started with higher scores and both ended with similar scores in 2019. Only the association between nursing ward interventions and recommendation of the hospital remained significant after Bonferroni correction. Bonferroni-corrected significant differences in time trends between hospitals with and without nursing ward interventions were also observed in the dimension dealing with patients and collaboration between healthcare providers, with patient experience scores increasing over time in hospitals with nursing ward interventions, but decreasing in hospitals without nursing ward interventions. Patient experience scores in the dimension safe care increased more steeply over time in hospitals with board setting strategy than in hospitals without this strategy (significant after Bonferroni correction).



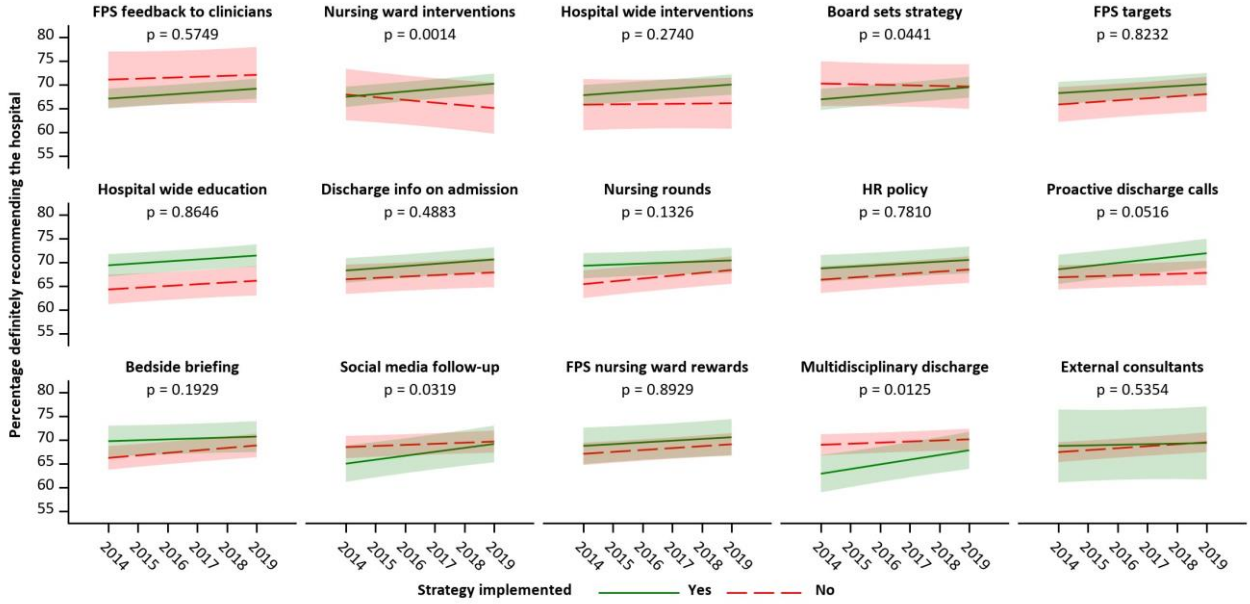


Figure 4.3. Associations between quality improvement strategies and time trends in top-box scores for global patient experience questions (upper panel: rating the hospital; bottom panel: recommending the hospital).

The plotted time trends are the predictions from multilevel regression models containing a binary indicator for strategy implementation, a linear variable for year, and an interaction between these variables. The p-value represents the significance of the interaction term and indicates whether time trends are significantly different between hospitals with and without a given strategy.

4.1.5 Discussion

Although individual results of global FPS questions are already publicly reported from 2014 onwards, this paper provides the first overview of the evolution of FPS results in Flanders across time. The overall improvement, strongest in most recent years, is commendable, yet small. The most recent top-box score of 61% of patients rating the hospital 9 or 10 e.g. is still 11 percentage points lower compared to the average of 73% in the US [29]. The percentage of patients recommending the hospital in 2019 in Flanders (70%) is still 4 percentage points removed from the current US average of 74%.[29] While one cannot unambiguously compare patient experiences across cultures and health care systems,[30] the evidence seems to suggest that Flemish hospitals should keep striving for better achievements. Moreover, our study brought to light a large variability in patient experience scores across both individual hospitals and FPS dimensions. Reducing this variation has long been known as a valuable tool to improve quality of care.[31] While patient experience scores improved in 8 out of 9 dimensions, especially when concerning the safety of care, further opportunities lie in optimizing the discharge process, which seems to have stagnated over time, as well as focusing on the provision of information about both condition and treatment. The latter remain low-scoring dimensions that have shown little improvement over time. From December 2019 onwards, the website https://www.zorgkwaliteit.be has started to also publicly report specific FPS scores of all domains next to the global measures. What the impact of this public reporting on specific FPS scores will be, needs to be studied further.

As demonstrated by our survey concerning improvement strategies, Flemish hospitals have been investing modestly in improving patient experiences. While considerable variation in strategy implementation can be observed between hospitals, it is worth noting that each hospital has implemented more than one strategy. Many strategies described by Aboumatar and colleagues[21] as implemented in top-scoring US hospitals, like nursing ward interventions and hospital wide education, are also frequently implemented in Flemish hospitals. What's more, both nursing ward interventions and hospital wide education were found to be associated with better 2019 FPS results. Additionally, nursing ward interventions in particular were positively associated with improved global patient experiences over time. Flemish hospitals who did not employ nursing ward interventions scored on average 7 percentage points lower on recommendation of the hospital and even decreased across time.

To our knowledge, this is the first assessment of associations between quality improvement strategies and patient experience scores. Despite the positive associations between both nursing ward interventions and hospital wide education and 2019 FPS results and the positive relationship between nursing ward interventions and recommendation of the hospital, improvement strategies were overall not or only weakly associated with patient experience ratings. After Bonferroni correction, only the association between nursing ward interventions and improvements in recommendation remained. Additionally, the relationship with 8 specific patient dimensions is non-existent, apart from a coherent positive influence of nursing ward interventions and strategies by the board on the change in dealing with patients and provision of safe care respectively. A thorough revision of the hospitals' current approach on improving patients' experiences is therefore recommended. Considering its potential, further research into the benefits of nursing ward interventions or a hospital-wide educational program is advised. By researching the evidence-base on the interventions that have shown most promise, we hope future healthcare policy and practice might be altered towards a more unified care, instead of the wide spectrum of sometimes ineffective interventions currently implemented. The examples provided by some participating hospitals such as e.g. mealtimes between staff and patients or the development of hospital-wide courses, suggest a large variety of ways to execute strategies. We thus encourage hospitals to share and learn from both their positive and negative experiences. By focusing on both nursing ward interventions and hospital wide education, a high visibility for the patient as well as a widespread reach of all healthcare staff can be ensured.

Next to the surveyed internal strategies, the external pay-for-performance (P4P) initiative appears to have limited impact on patient experiences at first glance. Implemented In 2018, the federal P4P initiative[32] comprised an adjusted reimbursement based on high-value quality metrics like patient experiences. No strong overall improvement could be observed between FPS results in 2018 and 2019. Today, P4P solely depends on participation in the FPS and is thus not related to hospital results. Only a small portion of hospital payment is currently at stake, i.e. about 5 million on a total budget of 6.4 billion euros for acute-care hospitals. What the impact of larger payments within the P4P scheme, tied to actual FPS results, will be, needs to be studied further. Impact of external evaluations in the form of international accreditation and governmental inspection will be studied in the near future as part of a larger retrospective study of quality improvement initiatives in Flanders.

A number of considerations that merit further attention and highlight a number of limitations to this study needs to be outlined. Firstly, our study might have suffered from recall bias. Secondly, associations between strategies and FPS results need to be interpreted prudently due to multiple testing. However, using a Bonferroni correction controls for this multiplicity issue. Thirdly, we lacked specific information on the quality improvement strategies employed by participating hospitals, like implementation date and detail on how and on what wards the hospitals chose to implement their strategies. Informal conversations with participants showed this information was not always well recorded at the

management level. Often due to high staff turn-over on quality departments, more detail was unavailable for a majority of participating hospitals. Fourthly, no confounding factors like e.g. employment of experience experts or other initiatives were accounted for in this study. The survey sent to every participating hospital left room to fill out additional information in an open-ended question concerning other initiatives taken. Unfortunately, only 50% of participants filled out this question, making it unusable for regression analysis. Lastly, due to the retrospective nature of this research, no causality can be established. Still, with the large representative sample of acute-care Flemish hospitals, we managed to obtain a first overview of current quality improvement strategies and how they have affected patient experience scores.

4.1.6 Conclusion

This study demonstrated how patient experiences across Flemish acute-care hospitals have marginally improved and how hospitals have invested modestly in quality improvement strategies concerning patient experiences. A large variability across hospitals persists, obstructing overall improvement. Beside nursing ward interventions and hospital wide education, which was demonstrated to have potential in further improving patient experiences, no associations between employed strategies and global patient experience scores could be identified. Within the Flemish hospital landscape, the patient's experience remains an area where progress is required. Future healthcare policy will hopefully take the conclusions from this research into account and thus lead the way towards better patient care.

4.2 A comprehensive analysis of temporal trends of between-hospital variation in mortality, readmission and length of stay using logistic regression

4.2.1 Abstract

Despite the benefits of studying multiple patient outcomes together, research on between-hospital variation has often focused on single outcomes or disease-specific study populations. In this study we examined nationwide temporal trends and between-hospital variation in in-hospital mortality, 30-day readmissions and length of stay above the All-Patient-Refined Diagnoses-Related-Group (APR-DRG)-specific 90th percentile (pLOS). We modelled 13,660,187 admissions derived from an administrative database occurring between 2008 and 2018 in 90 (89%) Belgian acute-care hospitals. We applied an APR-DRG-specific logistic regression to study temporal trends in outcomes, hospital-level associations between outcomes, associations of outcomes with hospitals characteristics, and to evaluate how many and which APR-DRGs explained between-hospital variation. Our proposed analytical model managed to achieve novel insights into healthcare quality of care, illustrating the high potential administrative databases can provide. It was revealed that between-hospital variation in outcomes is likely due to systemic hospital factors. This is illustrated by the fact that baseline bottom-performing hospitals remained underperforming throughout the study period and vice versa. APR-DRG-specific between-hospital variation assessments further confirmed this. When hospitals have overall outcome ratios that significantly deviate from the benchmark, this seems to be driven by a considerable number of APR-DRGs, comprising a diverse set of pathologies. This urges a healthcare policy reform wherein longitudinal follow-up and benchmarking of patient outcomes should become the starting point towards targeted quality improvement interventions.

Key words: Temporal Trends; Logistic Regression; Hospital; Mortality ; Length of stay; Readmissions

4.2.2 Introduction

Health policy frontrunners have recognised the routine measurement of quality indicators to reduce patient harm as the stepping stone towards the next era of qualitative care.[33,34] There is a need for hospital-wide research through which policy makers can identify how hospitals are faring in terms of both quality achievement and improvement. A primary set of indicators should include in-hospital mortality as the pinnacle measure of patient safety, 30-day readmissions as an accountability measure, and prolonged length of stay (pLOS) due to its correlations with complications during care and excess costs.[35–38] Mortality, readmissions and pLOS can be considered the 'vital few' patient outcomes among the 'trivial many' to be assessed.[39] Examining the 'vital few' together can help in determining the optimal path to increasing health gains.[35,40,41] What's more, studying combined outcomes can help to expose the existence of perverse relationships between outcomes and uncover potential competing risks between outcomes.[35,42–45] To research the prevalence of hospital-wide patient outcomes on a national level, administrative data developed for financial purposes can potentially provide an interesting dataset solution. However, analyses based on administrative data come with their own set of analytical challenges. In this study, we propose a statistical model that is able to assess temporal trends and between-hospital variation in mortality, readmissions and length of stay for a nationwide dataset.

4.2.3 Literature review

Current evidence-base on temporal trends in patient outcomes often assesses narrow study populations, commonly remaining limited to disease-specific assessments.[41–46] This highlights the need for broader evaluations, as we are proposing within this study. Although multi-outcome studies exist,[35,42,47,48] most often studies assess but one patient outcome.[46,49–51] Furthermore, it remains relatively unknown what pathologies act as potential underlying determinants of patient outcomes.

Most frequently, trends and variation in patient outcomes are studied through means of a logistic regression model.[35,49–51] It is no surprise its use in medical research is popular, as the slope coefficient derived from the regression analyses can conveniently be interpreted as an odds ratio.[52] Use in risk-standardised readmission ratio studies have established logistic regressions are valuable and sensitive to use.[51] Furthermore, it has been demonstrated how regression based standardisation provides more reliable estimates than the direct method when calculations are based on small numbers.[53] Logistic regression can be considered the superior method when compared to for example classification and regression trees, random forest models, or gradient boosting.[54,55] While new approaches such as machine learning provide promise for improvements in risk prediction of patient outcomes, it has been determined they currently offer only limited improvements.[55]

In an effort to close the knowledge gap on multi-outcome hospital-wide temporal trends, we assessed temporal trends in in-hospital mortality, 30-day readmissions and pLOS for a nationwide population between 2008 and 2018 through means of a logistic regression analysis. Additionally, we examined associations between outcomes reciprocally and between outcomes and hospital characteristics. Finally, we explored how many and which All-Patient-Refined Diagnosis-Related-Groups (APR-DRGs) were drivers of overall differences in outcomes between hospitals.

4.2.4 Proposed Model

Data source and study population

We obtained the Belgian Hospital Discharge Set including all inpatient hospitalisations from all 111 Belgian acute-care hospitals for the period 2008-2018, excluding psychiatric stays and one-day clinics. The dataset was provided by the federal health authorities and contains patient demographics, hospital stay characteristics, as well as primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 9-Clinical Modification (ICD-9-CM) up to 2014 and ICD-10-CM from 2016 onwards. Data for 2015 were not included in this study, since registration of diagnoses using ICD was not mandatory in Belgium that year. We excluded data from two hospitals with exclusive specialist care, data from ten hospital mergers during the study period were combined, and nine hospitals were excluded because of data quality issues, so our final sample included 90 hospitals. Data for the year 2014 were excluded for two hospitals because of missing diagnoses information. Using the APR-DRG 31.0 (3M) grouping system, admissions grouped within APR-Major Diagnostic Categories (MDCs) 14 (Pregnancy, childbirth and the puerperium), 15 (Newborns and other neonates), 22 (Burns), and 24 (HIV infections), as well as APR-DRGs with ungroupable hospital stays (APR-DRGs 950 to 956) were excluded. The final study population consisted of 13,660,187 hospital stays within 254 APR-DRGs.

Patient outcomes

We investigated three outcomes: all-cause in-hospital mortality, 30-day readmission and length of stay above the APR-DRG-specific 90th percentile, hereafter referred to as prolonged length of stay (pLOS). We defined a readmission as an all-cause, nonelective admission to the same hospital within 30 days of discharge following the index admission. Readmissions remained restricted to within-hospital, as patient identifiers are specific for each hospital, thus preventing identification of between-hospital readmissions. The index admission was used as the unit of analysis, so each readmission of a patient is again an index admission for a subsequent readmission.[56] Transfers, discharges against medical advice, and admissions ending with the patient's death were not considered as index admissions. Because anonymised patient identifiers are changed each calendar year, readmissions occurring in the next calendar year could not be identified, so all admissions in the month of December were excluded as index admission, resulting in 11,712,289 hospital stays included for readmission analyses.

Patient and hospital characteristics

Patient demographics included sex, age, number of comorbidities, place before admission, and admission type. Age was categorised into 10-year age groups, which were, for each APR-DRG by outcome combination, grouped to contain at least 10 cases in each category. We used the R package ''comorbidity''[57] to obtain the AHRQ version of the Elixhauser comorbidity index.[58] Place before admission was categorised as follows: "Home", "Other hospital", "Nursing home", "On the road" or "Unknown or other". Admission type was defined as "Emergency", "Elective" or "Other". Hospital characteristics included region (Flanders, Wallonia, Brussels), teaching status (academic or general), admission volume, and transfer rate (to other hospital, nursing home or psychiatric home). Both admission volume and transfer rate were calculated by APR-DRG and by year, and were categorised as low or high based on the APR-DRG- and year-specific 75th percentiles.

Statistical analyses

Using SAS software version 9.4, logistic regression models with automated backward variable selection were run for each of the three binary outcomes and for each APR-DRG. The deletion criterion was set at α=0.10 to prevent the unwanted deletion of relevant variables. Hospital-specific risk-standardised ratios and rates were obtained from models including only patient characteristics (model 1): sex, age group, comorbidity index, place before admission, admission type, and year of discharge (coded as a categorical variable). The annual hospital standardised mortality ratio (HSMR) was obtained as the ratio of observed and expected number of deaths across APR-DRGs. Ninety five percent confidence intervals were calculated using Byar's approximation and were used to identify hospitals with mortality significantly lower or higher than expected. Hospital-specific risk-standardised mortality rates were calculated by multiplying the HSMR with the overall crude mortality rate for each year. The same methods were used for readmission and pLOS. For the heatmap visualisation of hospital-specific annual standardised outcomes, rates were categorised into quintiles, using the 20th, 40th, 60th, and 80th percentiles calculated per year. Pearson's correlations were used to assess: 1) associations between hospital-specific standardised outcome rates in the first (2008) and last (2018) year of the study period (Figure 4.6), 2) associations between hospital-specific standardised rates of different outcomes (Figure 4.7), and 3) associations between hospital-specific changes in standardised rates (calculated as the rate difference between 2008 and 2018) for different outcomes (Appendix A.3.6).

Estimates for time trends and associations between standardised outcome rates and hospital characteristics were assessed by using the same outcome- and APR-DRG-specific logistic models as described above, but now also including hospital characteristics in the backward variable selection procedure (model 2). Estimates for time trends were obtained from models in which year of discharge was treated as a categorical variable, whereas associations with hospital characteristics were obtained from models in which year of discharge was treated as a continuous variable.

To explore whether overall (across APR-DRGs) significance of hospital-specific outcome ratios was driven by only a few or by many APR-DRG's, we used the 95% CIs of APR-DRG-specific standardised ratios obtained from model 1 to calculate, across significantly deviating hospitals, the mean, minimum and maximum number of APR-DRGs for which outcomes were significantly higher or lower than expected. To assess which APR-DRGs had high between-hospital variation in outcomes, we calculated the proportion of hospitals significantly deviating from the benchmark for each APR-DRG and outcome combination. To explore potential changes in APR-DRG-specific between-hospital variation over time, this was repeated for the first two years and the last two years of the study period, combining two years of data in order to increase numbers for low-volume APR-DRGs.

An overview of all definitions used for the purpose of this study is provided in Table 4.3.

Table 4.3. Definitions used for the purpose of this study

All Patient Refined – Diagnosis Related Group (APR-DRG)	The APR-DRG methodology classifies hospital inpatients according to their reason for admission, severity of illness and risk of mortality.
Hospital Standardised Mortality Ratio (HSMR)	Annual HSMR was obtained as the ratio of observed and expected number of deaths across all surveyed APR-DRGs. Ninety five percent confidence intervals were calculated using Byar's approximation, an approximation of the exact Poisson distribution which is extremely accurate even with small numbers (Breslow and Day, 1987). The confidence intervals were used to identify hospitals with mortality significantly lower or higher than expected.

Hospital Standardised Prolonged LOS Ratio (HSpLOSR)	Annual HSpLOSR was obtained as the ratio of observed and expected number of prolonged length of stay cases across all surveyed APR-DRGs. Ninety five percent confidence intervals were calculated using Byar's approximation, an approximation of the exact Poisson distribution which is extremely accurate even with small numbers (Breslow and Day, 1987). The confidence intervals were used to identify hospitals with prolonged length of stay significantly lower or higher than expected.
Hospital Standardised Readmission Ratio (HSRR)	Annual HSRR was obtained as the ratio of observed and expected number of readmissions across all surveyed APR-DRGs. Ninety five percent confidence intervals were calculated using Byar's approximation, an approximation of the exact Poisson distribution which is extremely accurate even with small numbers (Breslow and Day, 1987). The confidence intervals were used to identify hospitals with readmissions significantly lower or higher than expected.
Index admission	Every admission of a patient in a hospital that was studied to assess if a readmission has taken place or not. Index admissions are exclusive of transfers, discharges against medical advice and admissions ending with the patient's death.
International Disease Classification (ICD)	ICD-coding is a clinical cataloguing system that provides detailed information for measuring healthcare service quality, safety and efficacy.
Major Diagnostic Categories (MDC)	MDCs are formed by dividing all possible principle diagnoses of ICD-codes into 25 mutually exclusive diagnosis areas. Like diagnosis-related group (DRG) codes, MDC codes are primarily a claims and administrative data element used in reimbursement systems. DRG codes are also mapped into MDC codes. The diagnoses in each MDC correspond to a single organ system or cause and, in general, are associated with a particular medical specialty.
Model 1	Statistical model used in this study to calculate hospital-specific risk-standardised ratios and rates. It includes only patient characteristics: sex, age, group, comorbidity index, place before admission, admission type, year of discharge (as a categorical variable)
Model 2	Statistical model used in this study to calculate time trends and associations between standardised outcome rates and hospital characteristics. It includes both patient characteristics (sex, age, group, comorbidity index, place before admission, admission type, year of discharge (as a categorical variable)) and hospital characteristics (region, teaching status, admission volume, transfer rate)
Mortality	Any death of a patient occurring during their hospital stay, i.e. without any disease or time limitations.
Mortality rate	Hospital-specific risk-standardised mortality ratio (HSMR) multiplied by the overall crude mortality rate for a particular year.
Prolonged length of stay (pLOS)	A patient has a prolonged length of stay when they stay longer in hospital than 90% of patients being admitted for the same diagnosis or procedure within one APR-DRG.
Prolonged length of stay (pLOS) rate	Hospital-specific Risk-standardised prolonged length of stay (HSpLOSR) ratio multiplied by the overall crude pLOS rate for a particular year.
Readmission	A nonelective and all-cause admission to the same hospital within 30 days of discharge following the index admission. Each readmission of a patient is again an index admission for a subsequent readmission. As anonymized patient identifiers are changed each calendar year, readmissions occurring in the next calendar year could not be identified, so all admissions in the month of December were excluded.

Readmission rate	Hospital-specific Risk-standardised readmission ratio (HSRR) multiplied by the overall crude readmission rate for a particular year.

4.2.5 Data and results

Study sample

Of the 90 hospitals included, 43 (47.8%) were located in Flanders, 36 (40.0%) in Wallonia and 11 (12.2%) in Brussels. Seven (7.8%) hospitals were academic and 40 (44.4%) hospitals had more than 500 beds. Appendix A.3.4 shows patient characteristics and crude outcome rates for each study year. Hospital admissions steadily increased from 1,319,661 patient stays in 2008 to 1,410,113 in 2018. The proportion of elderly population expanded across time, in particular those aged 80 and above (16.5% in 2008 and 19.4% in 2008), along with an increase in comorbidity index. The MDC with the highest share of patient stays was MDC 8 (*Musculoskeletal System and Connective Tissue*, 17.1% of patient stays), followed by MDC 5 admissions (*Circulatory System*, 13.9% of patient stays). About six in ten admissions corresponded to medical diagnoses, while surgical procedures accounted for four in ten admissions.

Temporal trends in outcomes and associations between outcomes

Standardised rates of in-hospital mortality, 30-day readmissions and pLOS between 2008 and 2018 are displayed in Figure 4.4. Standardised mortality followed a downward trend across the study period, gradually decreasing from a mean of 3.4% in 2008 to 3.1% in 2018. Similarly, pLOS steadily improved over time, ranging from 10.6% in 2008 to 8.1% in 2018. The average crude LOS was reduced by 1.1 days across the 10-year period. In contrast, standardised readmission rates increased from 4.8% to 5.2%.

Hospital-level standardised rates for 2008 and 2018 are displayed by means of a funnel plot in Figure 4.5. The heatmap displayed in Appendix A.3.5 shows standardised rates categorised according to quintiles for all study years. In the latter figure, the majority of hospitals (n=72) saw an increase in standardised readmissions between 2008 and 2018, while a decrease in mortality and pLOS rates was observed for the preponderance of hospitals (n=58 and n=86 respectively). Large variation among hospitals is noticeable. Only some hospitals (n=10) had made improvements for the three surveyed outcomes, while others (n=4) had worse mortality, readmission and pLOS rates in 2018 than in 2008. Even when large strides were made for one outcome, hospitals could still be underperforming for this outcome when compared to the benchmark. This is exemplified by hospitals no. 21 and 23. Both hospitals saw a reduction in standardised mortality and pLOS over time, yet they still ranked in the bottom 20% of hospitals for these outcomes in 2018 with significantly higher rates than the benchmark. Hospital 13 exhibited the largest reduction in pLOS rate (-7.8%), but still ranked in the bottom 40% of hospitals in 2018, performing significantly worse than the benchmark. In contrast, hospital 1 demonstrated the highest decrease in standardised mortality rates and moved up from the bottom 20% to the top 20% performing hospitals.

Altogether, most hospitals with high outcome rates in 2008 had high rates in 2018 and vice versa, as revealed by Figure 4.6. Pearson correlations between rates in 2008 and rates in 2018 were 0.53, 0.49, and 0.74 for mortality, readmission, and pLOS, respectively.

Except for the significant positive correlation between mortality and pLOS (ρ=0.46), no hospital-level relationship exists between the assessed outcomes in 2018 (Figure 4.7). In 2008, a small negative correlation could additionally be observed between readmissions and pLOS (ρ=-0.21), which disappeared over time. Similarly, the change in mortality rates over time was correlated with the change in pLOS (ρ=0.46), while no other significant correlations between trends in outcomes occurred (Appendix A.3.6).

Summary of APR-DRG-specific time trend estimates and associations with hospital characteristics

Table 4.4 summarises the associations of outcomes with year of discharge and hospital characteristics. The (continuous) variable year of discharge was significant in the majority of models for mortality (186 out of 243 APR-DRGs) and pLOS (220 out of 247 APR-DRGs), with odds ratio estimates being mostly below one (for 181 and 216 APR-DRGs, respectively) and the median odds ratio equal to 0.94 for both outcomes, reflecting improvements in both outcomes over time. For readmission, however, year of discharge was significant for only 77 out of 246 APR-DRGs, and significant improvements (negative odds ratios) were only observed for 30 of these. Notable regional differences in outcomes could be observed, with Brussels and Wallonia often showing higher mortality than Flanders (positive odds ratio estimates for 45 out of 64 and for 76 out of 97 APR-DRGs with significant associations, respectively), and both regions also showing higher pLOS than Flanders (for 142 out of 181 and for 124 out of 166 APR-DRGs with significant odds ratios, respectively). The opposite was observed for readmissions, with Brussels and Wallonia mostly having odds ratios below one compared to Flanders (for 98 out of 101 and for 106 out of 115 APR-DRGs with significant associations, respectively). Academic hospitals showed lower mortality and pLOS than general hospitals for 92 and 118 APR-DRGs (out of 108 and 179 significant associations) respectively, while the odds of readmission were often lower in general hospitals (57 out of 82 APR-DRGs). For APR-DRGs with significant associations with admission volume, higher volume was mostly associated with better performance for all three outcomes. Finally, hospitals that transferred more patients had lower mortality for 122 (out of 127) APR-DRGs, but higher pLOS for 125 (out of 155) APR-DRGs.

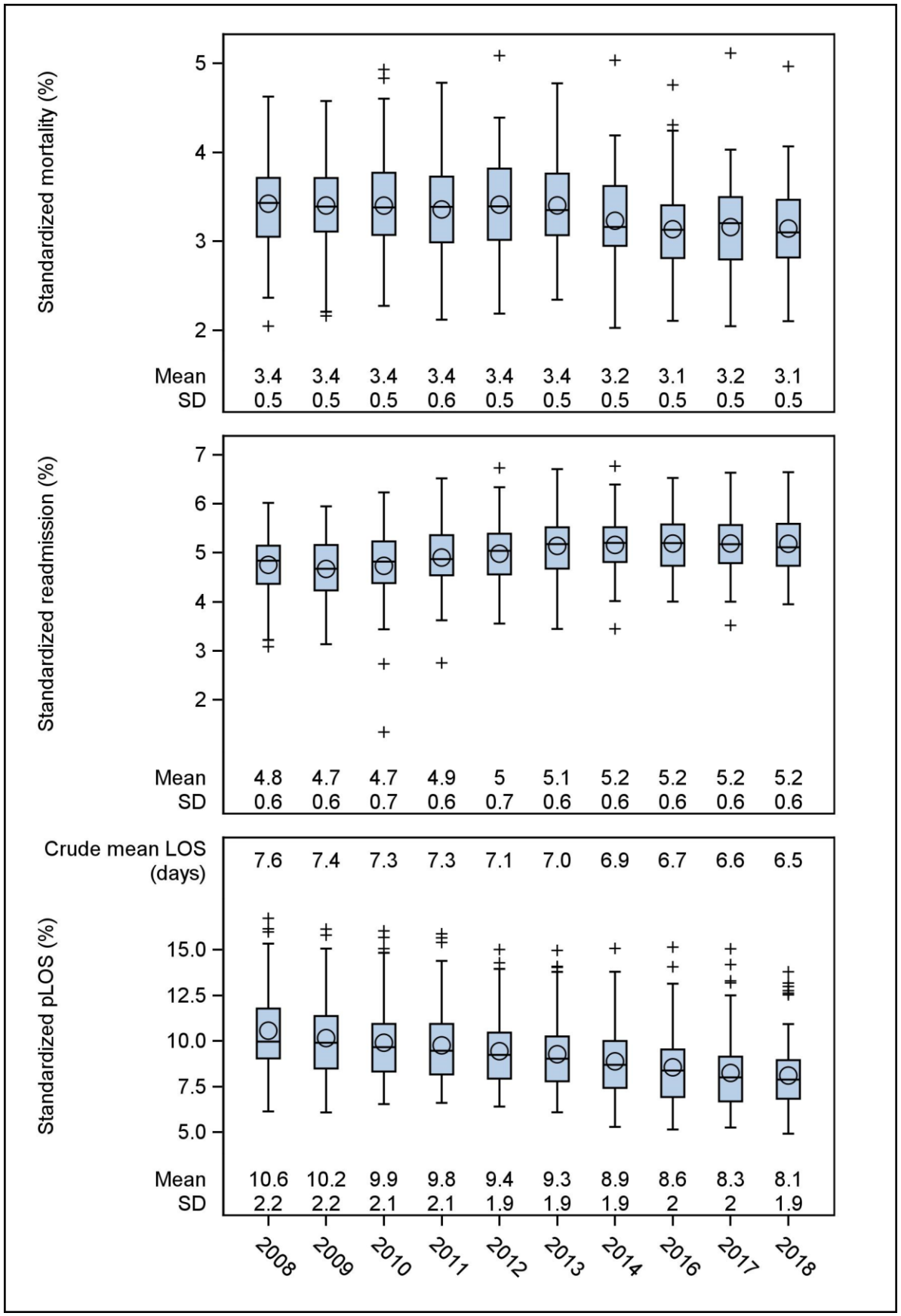


Figure 4.4 Distribution of standardised in-hospital mortality, 30-day readmission, and prolonged length of stay rates in Belgium, 2008-2018.

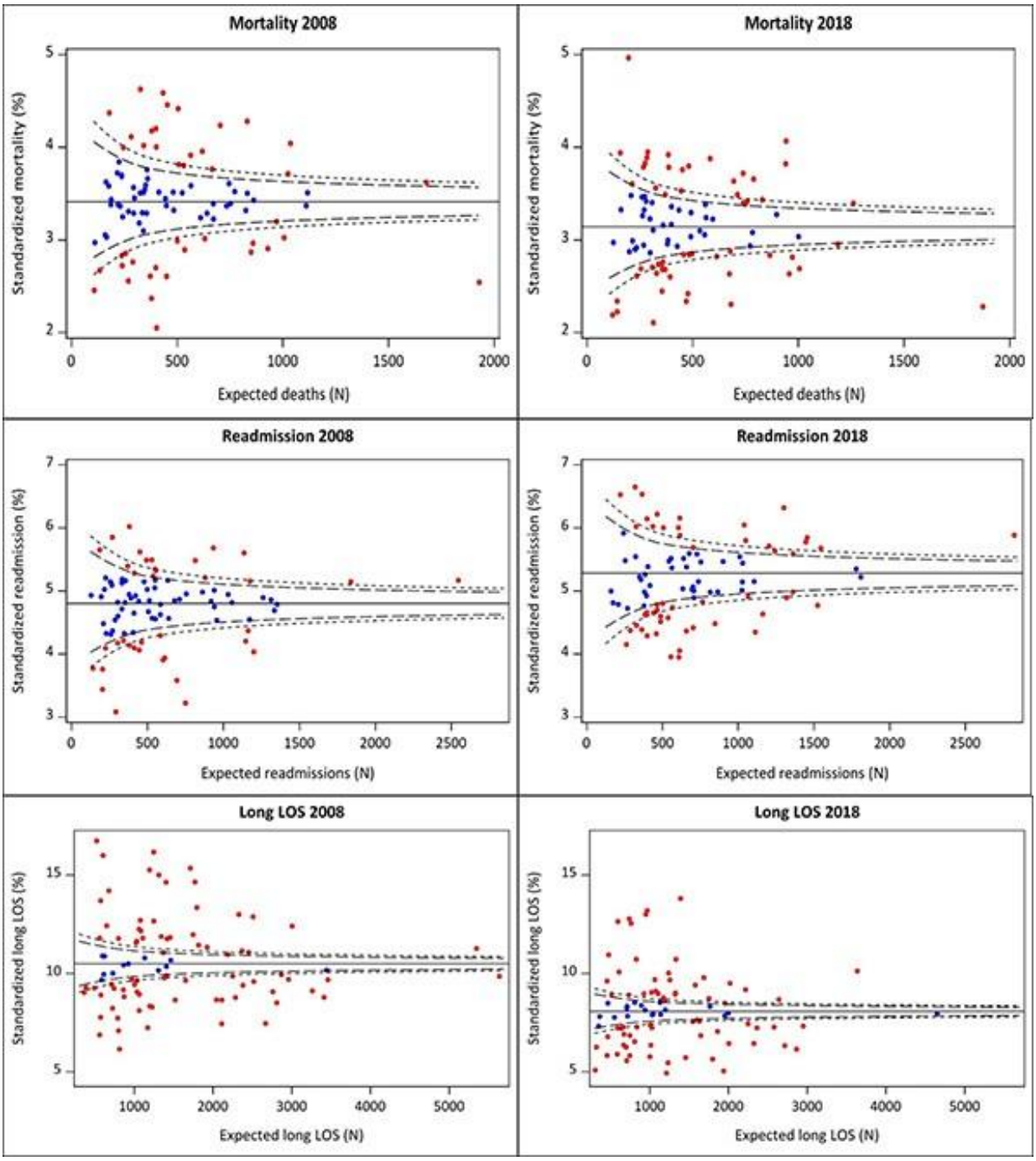


Figure 4.5 Funnel plot of the relationship between the expected number of events and the standardised ratio of mortality, readmissions and long length of stay for the years 2008 and 2018.

The dashed middle lines (top and bottom of the panel) represent respectively the upper and lower 95% confidence limits of the standardised ratios, while the dotted lines (top and bottom of the panel) represent respectively the upper and lower 99% confidence limits of the standardised ratios.

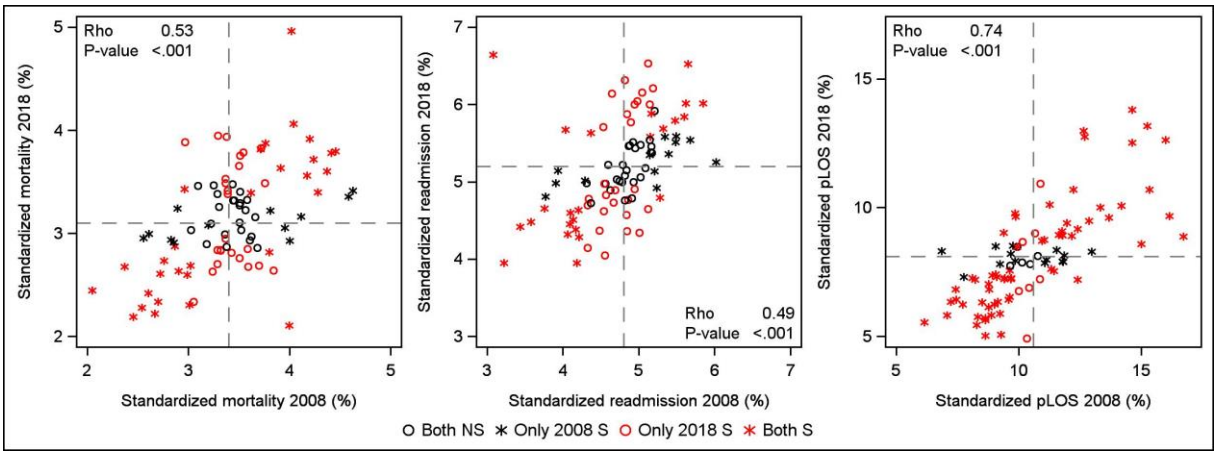


Figure 4.6 Standardised mortality, readmissions, and prolonged length of stay rates for 2018 versus values for 2008, with Pearson correlations (Rho) and significance (P-value).

The dashed lines represent the mean standardised rates in the corresponding years.

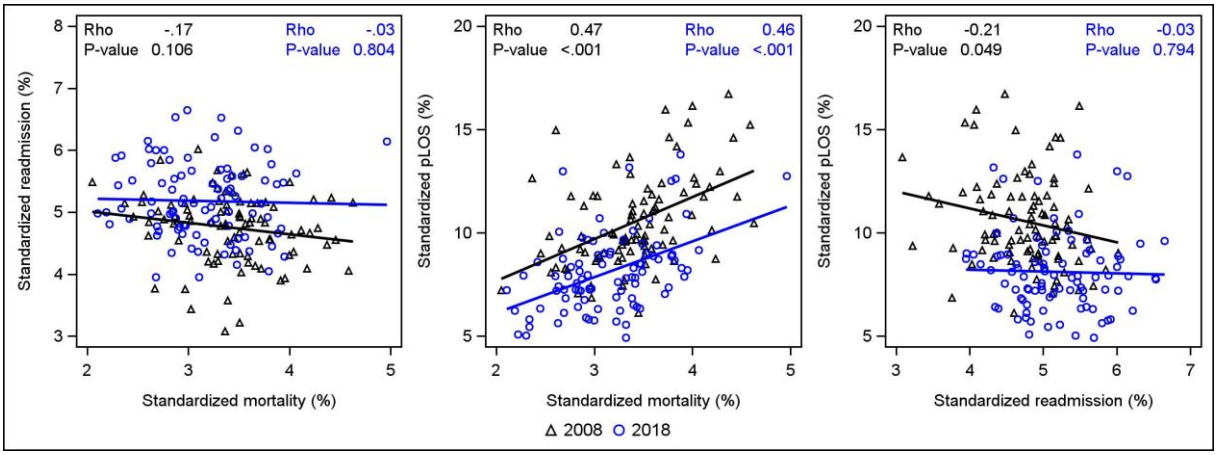


Figure 4.7 Associations between standardised outcomes in 2008 (black triangles) and associations between standardised outcomes in 2018 (blue circles), with Pearson correlations (Rho) and significance (P-value).

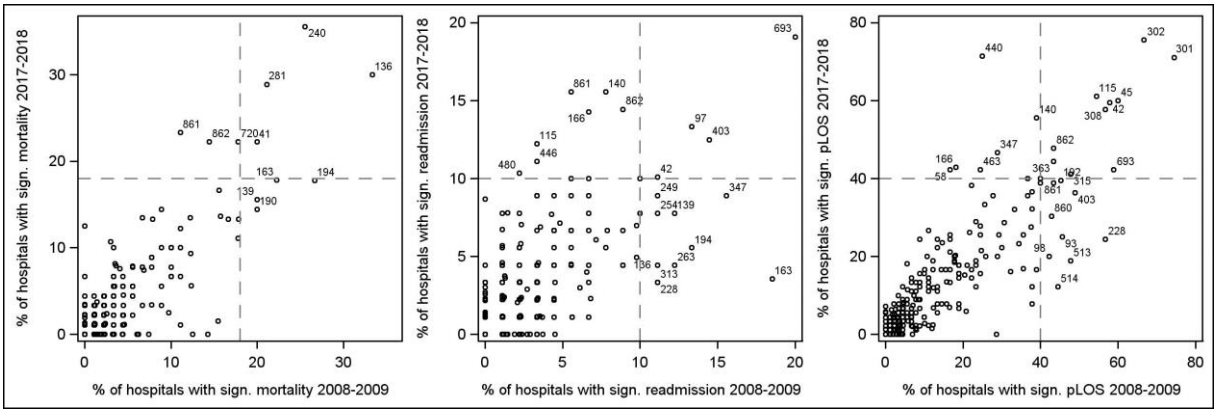


Figure 4.8 APR-DRG specific between-hospital variation in outcomes for the period 2017-2018 (Y-axes) versus values for the period 2008-2009 (X-axes), quantified as the proportion of hospitals with standardised mortality / readmission / prolonged length of stay rates significantly deviating from the benchmark.

APR-DRG codes are shown in case the proportion of hospitals significantly deviating from the benchmark in one or both periods is higher than 18%, 10%, and 40% (roughly corresponding to the middle of the range of values) for mortality, readmission and prolonged length of stay, respectively.

Table 4.4. Associations of outcomes with year of discharge and hospital-level variables, summary of APR-DRG-specific model estimates.

		n APR-DRG[d]			Odds ratio percentiles				
		Significant	**Negative**	**Positive**	**0th**	**25th**	**50th**	**75th**	**100th**
Mortality (n APR-DRG = 243)[a]									
Year of discharge[b]	1-year increase	186	181	5	0.73	0.93	0.94	0.96	1.15
Region[c]	Brussels (vs Flanders)	64	19	45	0.43	0.85	1.22	1.48	3.07
	Wallonia (vs Flanders)	97	21	76	0.12	1.11	1.30	1.49	3.58
Teaching status[c]	General (vs academic)	108	16	92	0.33	1.20	1.36	1.69	6.43
Volume[c]	Low (vs high)	84	17	67	0.19	1.15	1.28	1.59	3.74
Transfer rate[c]	Low (vs high)	127	5	122	0.56	1.22	1.37	1.63	17.53
Readmission (n APR-DRG = 246)[a]									
Year of discharge[b]	1-year increase	75	30	45	0.94	0.99	1.01	1.03	1.06
Region[c]	Brussels (vs Flanders)	101	98	3	0.45	0.71	0.77	0.84	1.20
	Wallonia (vs Flanders)	115	106	9	0.48	0.80	0.85	0.89	1.55
Teaching status[c]	General (vs academic)	82	57	25	0.63	0.77	0.85	1.14	1.91
Volume[c]	Low (vs high)	74	22	52	0.52	0.92	1.15	1.28	2.10
Transfer rate[c]	Low (vs high)	35	17	18	0.60	0.84	1.05	1.16	1.71
prolonged length of stay (pLOS) (n APR-DRG = 247)[a]									
Year of discharge[b]	1-year increase	220	216	4	0.76	0.92	0.94	0.96	1.09
Region[c]	Brussels (vs Flanders)	181	39	142	0.30	1.14	1.31	1.53	5.72
	Wallonia (vs Flanders)	166	42	124	0.45	0.96	1.21	1.43	9.95
Teaching status[c]	General (vs academic)	179	61	118	0.32	0.79	1.31	1.73	6.44
Volume[c]	Low (vs high)	124	51	73	0.29	0.85	1.13	1.38	9.99
Transfer rate[c]	Low (vs high)	155	125	30	0.50	0.76	0.87	0.93	3.21

[a] The final number of models is slightly lower than the total number of APR-DRGs (N=254) because some models did not converge due to low number of cases (N<25).
[b] Estimates from models in which year of discharge was treated as a continuous variable.
[c] Estimates from models in which year of discharge was treated as a categorical variable.
[d] Number of APR-DRGs for which the association was significantly positive or negative (95% confidence interval of odds ratio completely above or below one respectively).

Table 4.5: Number of hospitals with overall (across APR-DRGs) mortality, readmission or prolonged length of stay (pLOS) significantly higher or lower than expected and among these hospitals the mean, minimum and maximum number of APR-DRGs with corresponding outcome significantly higher or lower than expected as well as the percentiles of their APR-DRG-specific outcome ratios (calculated across all APR-DRGs), 2008-2018.

			n APR-DRG with outcome higher than expected			n APR-DRG with outcome lower than expected			Percentiles of APR-DRG-specific standardised outcomes ratios		
Outcome	**Overall (across APR-DRGs)**	**n hospitals**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**25th**	**50th**	**75th**
Mortality	Higher than expected	34	23.9	7	68	4.0	0	12	0.59	1.04	1.40
	Lower than expected	34	6.9	0	21	22.3	6	104	0.34	0.77	1.10
Readmission	Higher than expected	36	22.1	8	60	4.2	0	12	0.83	1.06	1.30
	Lower than expected	39	4.2	0	14	17.3	1	63	0.63	0.87	1.08
Prolonged length of stay	Higher than expected	38	60.5	25	142	18.8	2	74	0.86	1.13	1.44
	Lower than expected	46	15.7	2	45	57.6	19	116	0.58	0.82	1.07

APR-DRGs with pronounced between-hospital variation

When hospitals have overall outcome ratios that significantly deviate from the benchmark, this seems to be driven by a considerable number of APR-DRGs (Table 4.5). Hospitals with an overall mortality ratio (HSMR) higher than expected (n=34), had on average (range) 23.9 (7 to 68) APR-DRGs with significantly higher than expected mortality ratios with the median APR-DRG-specific mortality ratio (SMR) for those hospitals being equal to 1.04. Most distinctly, hospitals with higher than expected overall pLOS (n=38) had on average (range) 60.5 (25 to 142) APR-DRGs with pLOS significantly higher than expected and the median APR-DRG-specific pLOS ratio for these hospitals equalled 1.13.

Figure 4.8 presents the APR-DRG-specific between-hospital variation in outcomes in 2017-2018 (Y-axis) versus in 2007-2008 (X-axis), quantified as the proportion of hospitals significantly deviating from the benchmark for each APR-DRG. APR-DRG numbers are shown when the proportion of significantly deviating hospitals in at least one of the periods was above 18%, 10%, and 40% for mortality, readmission, and pLOS, respectively. These cut-offs roughly correspond to the middle of the range of values in the plots. APR-DRGs 136 (*respiratory malignancy*) and 240 (*digestive malignancy*) showed the highest between-hospital variation for mortality, APR-DRG 693 (*lymphatic & other malignancies & neoplasms of uncertain behaviour*) for readmission and APR-DRGs 301 (*hip joint replacement*) and 302 *(knee joint replacement*) for pLOS. Appendix A.3.7 provides a full overview of the (n=40) APR-DRGs with pronounced between-hospital variation for at least one of the outcomes, i.e. the APR-DRGs for which the proportion of hospitals significantly deviating from the benchmark in at least one of the periods was higher than the cut-off of 18%, 10%, and 40% for mortality, readmission, and pLOS, respectively. Thirteen out of the 40 APR-DRGs showed high between-hospital variation for at least two of the three outcomes, and MDC 8 (Musculoskeletal System and Connective Tissue) and MDC 5 (Circulatory System) were most represented (8 and 7 out of the 40 APR-DRGs, respectively). Five APR-DRGs represent malignancies. For mortality, the APR-DRGs showing the highest between-hospital variation remained relatively constant, with only two APR-DRGs (861 and 862) in the upper left quadrant of the figure that show a clear increase in between-hospital variation over time. For readmission and pLOS, however, the APR-DRGs with high between-hospital variation were less stable over time, with relatively many APR-DRGs in the upper left (increasing variation) and lower right quadrants (decreasing variation) of the figures.

4.2.6 Discussion & conclusions

Summary of key results

This large observational study revealed small yet substantial reductions in overall in-hospital mortality and length of stay in the past decade, while readmission rates have increased over time. Our results are in line with the existing evidence-base on secular trends that have shown reductions in mortality[44,59,60] and length of stay,[44,45,61] while evidence on readmissions is more ambiguous as examples of both increases[44] and decreases[45] can be observed. To our knowledge, this study is the most comprehensive examination of outcome trends to date due to its nationwide all-disease and multi-outcome approach over an extensive study period. Our research is particularly unprecedented for the European continent.

Readmission rates in Belgium were found to be substantially lower than those e.g. observed in the USA.[44,45,61] While the absence of non-index readmissions, which are found to vary between 9 and 14% of total readmission rates,[56,62] might in part help explain the divergences across settings, they don't explain the four-fold differences observed. Nevertheless, the increasing trend in readmissions is

worrisome as readmissions are costly both economically and emotionally.[63] The Belgian healthcare policy introduced in 2014, that reduced a small portion of hospital reimbursements when index readmissions occurred within 10 days after discharge, has thus failed to make a durable impact.[64] The significant relationships of readmissions with hospital region and teaching status suggest learning opportunities and indicate the potential occurrence of structural problems with follow-up care, further solidifying the need for integrated care.[65]

Differences in patient outcomes appear to be driven by systemic hospital factors

In contrast to Chatterjee *et al.*,[59] who argued outcome trends are most likely due to specific diseases, our findings are suggestive of systemic hospital aspects influencing patient outcomes. First, this is illustrated by the fact that significant hospital standardised outcome ratios seem to be driven by more than only a few APR-DRGs. For instance, hospitals with a HSMR higher than expected had on average 24 APR-DRGs with significantly elevated mortality, whereas corresponding numbers for readmission and pLOS were 22 and 60, respectively. Second, APR-DRGs identified to have high between-hospital variation were quite different between outcomes and comprised a diverse set of pathologies. To our knowledge, these analyses based on hospital-wide but APR-DRG-specific models are a novel approach for assessing between-hospital variation. Our results also indicated that baseline poor performers often remained underperforming over time, while top-performers generally kept surpassing other hospitals and this despite often remarkable individual improvements in bottom-performers. Routine longitudinal follow-up and benchmarking of hospitals is therefore crucial to identify those institutions with high-improvement potential as well as those who have managed to achieve superior outcomes. This could be of great value for governmental inspection bodies that aim to prioritise targeted audits. However, benchmarking should not be implemented with the goal of providing hospital rankings,[66,67] as these might lead to perverse hospital responses and attempts to game the system. An illustration of these perverse effects can be found in the impact the Hospital Readmission Reduction program in the US has had on mortality rates.[42,68] Rankings based on composite measures might in part help to reduce these problems, but are in turn characterised by lower distinctive abilities due to lower between-hospital variation.[40] Rather, we would recommend to implement initiatives stimulating collaborative learning with a Safety-II approach,[69,70] which considers patient safety as a consequence of collective efforts that can adapt to dynamic conditions and uncertainty.[71] Collaborative learning between hospitals attempts to distinguish additional hospital contextual factors that contribute to better mortality, readmission and length of stay. It has been established that collaborative learning is an effective way to improve healthcare quality[70,72–75] and evidence even demonstrated improvements in mortality rates in bottom-performing hospitals.[75] This could be beneficial to our studied population, for which an improvement in these bottom-performing centres is lacking. While the Safety-II principle needs further development of practical approaches,[71] research on contextual factors is flourishing.[74,76–78] These contextual factors might in part help explain the systemic differences between hospitals we have observed in this study. Examples of potential contributing factors include leadership characteristics,[76,78] health system alignment with national priorities,[76,78] quality improvement team characteristics,[76,78] quality education[76,78] and an established quality culture.[77,78] Future research into the impact of these factors on patient outcomes is therefore highly recommended.

Promising policy initiatives

Two upcoming policy initiatives might stimulate improvement in the right direction. The first is the introduction of a care bundle with fixed payments for pathology groups that are characterised by high standardisability and low variability between hospitals.[79] As seen from international evidence, a budget system based on APR-DRGs has potential to decrease length of stay.[48] From our analysis on APR-DRG specific variation between outcomes, it was remarkable to observe how some APR-DRGs (e.g. DRGs 301 and 302) that should have high standardisability, continued to have large between-hospitals variation. A policy change targeting this is thus in due time. Secondly, the upcoming reform of the current Pay-for-Performance (P4P) programme in Belgium includes more financial means to encourage high quality hospital care.[80] This creates opportunities to reconsider whether or not to financially reward improvement or achievement of quality outcomes, whereby our presented results can serve as guidance. Remunerations should consider the fact that bottom-performing hospitals have the highest potential for quality gains,[75] as top-performers potentially suffer from ceiling effects.[66] Hospitals that continue to provide high-quality care should not be neglected in financial rewards, so we encourage policymakers to construct a P4P system that stimulates collaboration and peer-learning that aids all hospitals with a quality-mindset financially.[73]

On the use of administrative databases

This paper has demonstrated the potential that administrative databases provide for both policymakers and hospital management alike in their aim to improve quality of care and reduce avoidable harm and costs. Administrative data have the potential for comparisons across hospitals both nationally and internationally due to their shared coding language and provides opportunities for hospital-wide quality assessments with a minimum burden on healthcare workers.[81,82] While we recognise that administrative data have their disadvantages, such as a lack of additional prognostic factors in the form of detailed clinical data and raised concerns about the accuracy and completeness of the data, we consider the results of our analyses as a smoke signal that highlights areas for further thorough investigation.[83] As stated above, we should be cautious in interpreting rankings based on administrative data, especially for lower case volumes.[67] As we examined between-hospital variation on APR-DRG specific models, risk of lower case volumes exists. However, administrative data have proven their potential for systematic screening.[84] Our analyses have revealed novel insights about hospital quality of care, especially through the APR-DRG specific between-hospital variation method and the heatmap that displays individual hospital trends compared to the national benchmark. Other research groups could benefit from our statistical methods to study their own healthcare settings. Today, administrative databases are mainly used for reimbursing purposes. However, their use in the study of healthcare quality proves beneficial due to being inexpensive, readily available, computer readable and encompassing large and comparable populations.[83] In addition, while this study focused on hospital-wide assessments, administrative datasets have possibilities for further in-depth study and can help to determine disease-specific priorities.[85] Despite their increasing availability, disease-specific registries often fail in determining overarching priorities because of their insufficient comparability across a vast array of measuring systems.[81]

Limitations

Several study limitations merit attention. First, we might have suffered from discharge bias as no data was available on post-discharge mortality, which might have been considerable.[40] This could potentially

impact the significant negative association we observed between mortality and transfer rates. We recommend future research to include post-discharge mortality to account for these uncertainties. Second, we were unable to include readmissions occurring in December or readmissions to other hospitals, so readmission rates are likely underestimated. However, non-index readmissions are found to vary between 9 and 14% of total readmission rates.[56,62] indicating we assessed Belgian readmissions to a great extent. Finally, analyses are subject to power issues, with outcomes and APR-DRGs with higher numbers more easily reaching significance, as illustrated by the higher number of significantly deviating observed for pLOS than for other outcomes. Nevertheless, our study encompassed over 13 million patient stays across the majority of the Belgian hospital population and was able to detect nationwide temporal trends in mortality, readmissions and length of stay of the past decade.

Conclusions

This study has demonstrated the potential of using administrative datasets to extract valuable healthcare quality information for policymakers and hospital managers. Our analyses uncovered small improvements in all-cause 30-day mortality and prolonged length of stay in a nationwide study population between 2008 and 2018, while readmission rates increased over time. Differences in outcomes across hospitals are most likely due to systemic hospital factors, urging a healthcare policy reform wherein longitudinal follow-up and benchmarking of these ‘vital few’ outcomes should become the foundation on which to build targeted quality improvement interventions.

4.3 Unwarranted between-hospital variation in mortality, readmission and length of stay of urological admissions: an important trigger for prioritising quality targets

4.3.1 Abstract

Background: Unwarranted between-hospital variation is a persistent healthcare quality issue. It is unknown whether urology patients are prone to this variation.

Objective: To examine between-hospital variation in mortality, readmission and length of stay for all 22 urological All Patient Refined-Diagnosis Related Groups (APR-DRGs).

Design, setting and participants: This study included administrative data from 320,640 urological admissions in 99 (98%) Belgian acute-care hospitals between 2016 and 2018.

Outcome measurements and statistical analysis: We used hierarchical mixed-effects logistic regression models to estimate hospital- and APR-DRG-specific risk-standardised rates for in-hospital mortality, 30-day readmission, and length of stay above the APR-DRG-specific 90th percentile. Between-hospital variation was assessed based on the estimated variance components. Associations of outcomes with patient and hospital characteristics and time trends were examined.

Results and limitations*:* Our analysis revealed important between-hospital variation in mortality, readmission and length of stay for urological pathologies, particularly for medical diagnoses. Significant variation was shown in all three outcomes for kidney & urinary tract infections; other kidney & urinary tract diagnoses; signs & symptoms, urinary stones & acquired upper urinary tract obstruction; and kidney & urinary tract procedures for non-malignancy. Lowering mortality rates in upper-quartile hospitals to the median could potentially save 41.5% of deaths in those hospitals, with the largest absolute gain for kidney & urinary tract infections and kidney & urinary tract malignancy. Limitations included a likely underestimation of readmission rates.

Conclusions*:* Urological patient outcomes are characterised by unwarranted between-hospital variation. We recommend improvement initiatives to prioritise kidney & urinary tract infections because of significant variation across the three outcomes and the largest potential gain in lives saved.

Patient summary: We found notable between-hospital variation in mortality, readmission and length of stay for urological hospital admissions in Belgium. As much as 41.5% of deaths could potentially be avoided if underperforming hospitals improved. Targeting kidney & urinary tract infections could help reduce variation.

Key words: Quality of Care, Hospital, Mortality, Length of stay, Readmission, Urology, Variation

4.3.2 Introduction

The concept of unwarranted healthcare variation was first described over 80 years ago,[86] yet today numerous studies continue to suggest outcomes vary between hospitals.[50,87–94] Between-hospital variation in patient outcomes has been documented to correlate with numerous hospital factors, such as volume,[89,92] teaching status,[95,96] nurse staffing levels[93,94] and geographic region.[90,92] Further monitoring and understanding sources of variation are key steps in supporting effective policies to reduce unwarranted variation, increase health outcomes and reduce expenditures.[90] Subsequently, there is a need to prioritise interventions with the largest potential to reduce variation in patient outcomes.[97] Mortality, readmissions and length of stay (LOS) are often considered as the 'vital few' patient outcomes among the 'trivial many' to be monitored. Despite their acknowledged importance, not many studies exist where all three outcomes are studied simultaneously,[41] with the majority of studies remaining limited to only one[50,91] or two[43,87,88] outcomes and restricted to a select number of diagnoses or procedures.[41,43,50,87,88,91] We hypothesised between-hospital variation in quality of care for urological pathologies is substantial, yet today, little is known about the topic,[98–100] with no overarching research conducted to our knowledge. In order to determine priorities for future quality improvement (QI) initiatives, we examined between-hospital variation in mortality, readmission and LOS rates across Belgian acute-care hospitals for all urological All Patient Refined-Diagnosis Related Groups (APR-DRGs). We also assessed associations between outcomes and patient and hospital characteristics. Finally, we considered whether the number of lives potentially saved, if mortality were to improve, is sizable. As a secondary aim, we looked at trends in urological mortality, readmission and LOS rates over time.

4.3.3 Methods

Data source and study population

We obtained the Belgian Hospital Discharge Set on all inpatient hospitalisations from all 103 Belgian acute-care hospitals for the years 2012-2018, excluding psychiatric stays and one-day clinics. The dataset was provided by the federal health authorities and contains patient demographics, hospital stay characteristics and clinical data, i.e. primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 9-Clinical Modification (ICD-9-CM) up to 2014 and ICD-10-CM from 2016 onwards. In 2015, the registration of diagnoses using ICD was not mandatory in Belgium. We excluded data from two hospitals with exclusive specialist care and data from two hospital mergers during the study period were combined, so our final sample included 99 hospitals.

The APR-DRG 31.0 (3M) grouping system was used to select all 22 urological pathologies (Table 4.6), which fall within Major Diagnostic Category (MDC) 11 (*Kidney and Urinary Tract*) and 12 (*Male Reproductive System*). Of these, 13 are surgical procedures, while 9 involve medical diagnoses. An overview of the majority of diagnoses and procedures that fall under one particular APR-DRG is provided in Appendix A.3.8. We used the three available years with ICD-10-CM data (2016-2018) as main study period, including 320,640 hospital stays. For the assessment of trends over time, we included all 296,766 urological hospital stays registered in the period 2012-2014.

Table 4.6: Overview of the included urological All Patient Refined-Diagnosis Related Groups (APR-DRG)

APR-DRG	Diagnosis description	Abbreviation	Type
440	Kidney transplant	KTr	Surgical
441	Major bladder procedures	MBP	Surgical
442	Kidney & urinary tract procedures for malignancy	UTM	Surgical
443	Kidney & urinary tract procedures for non-malignancy	UTNM	Surgical
444	Renal dialysis access device procedure only	DIAL	Surgical
445	Other bladder procedures	OBl	Surgical
446	Urethral & transurethral procedures	TUP	Surgical
447	Other kidney, urinary tract & related procedures	OUT	Surgical
460	Renal failure	RF	Medical
461	Kidney & urinary tract malignancy	UTMD	Medical
462	Nephritis & nephrosis	NEPH	Medical
463	Kidney & urinary tract infections	UTI	Medical
465	Urinary stones & acquired upper urinary tract obstruction	USO	Medical
466	Malfunction, reaction, complication of genitourinary device or procedure	DEV	Medical
468	Other kidney & urinary tract diagnoses, signs & symptoms	OUTD	Medical
480	Major male pelvic procedures	MMPP	Surgical
481	Penis procedures	PENP	Surgical
482	Transurethral prostatectomy	TURP	Surgical
483	Testes & scrotal procedures	TSP	Surgical
484	Other male reproductive system & related procedures	OMRP	Surgical
500	Malignancy, male reproductive system	MMRSD	Medical
501	Male reproductive system diagnoses except malignancy	MRSD	Medical

Outcomes and patient and hospital characteristics

We investigated three outcomes: all-cause in-hospital mortality, 30-day readmission, and length of stay (LOS) above the APR-DRG-specific 90th percentile, hereafter referred to as pLOS. We opted for the latter as the overall urological 90th percentile was set at 13 days, a patient stay generally accepted as long.[101] A readmission was defined as an all-cause, nonelective admission to the same hospital within 30 days of discharge following the index admission. Readmissions remained limited to within-hospital, as patient identifiers are specific for each hospital, thus preventing research of between-hospital readmissions. The index admission was used as the unit of analysis, so each readmission of a patient is again an index admission for a subsequent readmission. Transfers, discharges against medical advice and admissions ending with the patient's death were not considered as index admissions. Because anonymised patient identifiers are changed each calendar year, readmissions occurring in the next calendar year could not be identified, so all admissions in the month of December were excluded as index admission.

Patient demographics included sex, age, the number of comorbidities, place before admission, and admission type. Age was categorised as 10-year age groups which were, for each APR-DRG*outcome combination, grouped to contain at least 10 cases in each category. We used the R package "comorbidity"[57] to obtain the (unweighted) number of Elixhauser-comorbidities, categorised as zero, one to four and five or more comorbidities. Place before admission was defined as home, other hospital or nursing home and on the road or other. Admission type was categorised as elective or emergency. Hospital characteristics included region (Flanders, Wallonia, Brussels), hospital type (academic or general), and urological volume. Urological volume was calculated for each hospital as the average annual number of admissions for the 22 selected APR-DRGs and was categorised into tertiles: <700

admissions (low volume), 700-1100 admissions (medium volume) and ≥1100 admissions (high volume).

Statistical analyses

Using the SAS-GLIMMIX procedure, we fitted logistic hierarchal linear models with a random intercept for each hospital to account for hospital-level clustering. APR-DRG-specific models were run for each of the three binary outcomes. In a first set of models, only patient characteristics were included as fixed effects, whereas a second set of models also included hospital characteristics. For each APR-DRG, hospital-specific risk-standardised mortality rates were calculated as the ratio of predicted and expected deaths (estimated by the model including only patient characteristics), multiplied by the overall crude mortality rate for that APR-DRG. The predicted number of deaths was obtained as the hospital-specific prediction from the logistic hierarchical linear model including both the fixed effects and the hospital-specific random intercept (i.e. the best linear unbiased predictor), whereas the expected number of deaths is the prediction including only the fixed effects. Hospitals for which the random intercept estimate was significantly higher (or lower) than zero were identified as hospitals with significantly higher (or lower) than expected mortality. Significance of the between-hospital variation in mortality risk was based on a Wald test for the random hospital effect, and the variation was quantified by means of the median odds ratio (MOR).[102] If one were to repeatedly sample at random two subjects with the same covariates (i.e. same fixed effects) from different hospitals, then the MOR is the median odds of mortality for the patient in the high-risk hospital compared to the patient in the low-risk hospital. The same methods were used for readmission and pLOS.

4.3.4 Results

Descriptives

Of the 99 included hospitals, 52 are located in Flanders, 36 in Wallonia, and 11 in Brussels. Seven hospitals are academic. The majority of included APR-DRGs occurred in all included hospitals (Table 4.7), while *Kidney transplant* (KTr) occurs in only seven hospitals, as this procedure occurred exclusively in academic centres. The most frequent APR-DRG was *Kidney & urinary tract infections* (UTI), representing nearly 20% of all urological hospital admissions, whereas KTr was least frequent (0.5% of admissions). Highest mortality rates were observed in two cancer APR-DRGs, i.e. *Malignancy of the male reproductive system* (MMRSD) and *Kidney & urinary tract malignancy* (UTMD) (21.9% and 17.1% mortality respectively). Readmission rates ranged from 2.6% (*Testes & scrotal procedures* [TSP]) to 12.6% (*Major bladder procedures* [MBP]). The latter also caused the longest LOS, with 10% of patients staying 28 days or longer.

Between-hospital variation in patient outcomes

Figure 4.9 shows that, after adjusting for patient characteristics, significant variation in between-hospital risk for all three outcomes was observed for three medical APR-DRGs (UTI; *Other kidney & urinary tract diagnoses, signs & symptoms* [OUTD]; *Urinary stones & acquired upper urinary tract obstruction* [USO]) and one surgical APR-DRG (*Kidney & urinary tract procedures for non-malignancy* [UTNM]). Significant variation in risk for two out of three outcomes was found for MMRSD, *Renal failure* (RF),

Kidney & urinary tract procedures for malignancy (UTM) and *Malfunction, reaction, complication of genitourinary device or procedure* (DEV) (mortality and pLOS), and for *Major male pelvic procedures* (MMPP), *Urethral & transurethral procedures* (TUP), *Male reproductive system diagnoses except malignancy* (MRSD) and *Transurethral prostatectomy* (TURP) (readmission and pLOS). UTI ranked highest based on significance of the variation in risk (P<0.001 for the three outcomes). For mortality, the MOR was nearly twofold higher (Appendix A.3.9) for UTMD at a high-risk hospital as compared to a low-risk hospital. Additionally, six hospitals had significantly worse and 16 significantly better mortality than expected for this APR-DRG. For both readmission and pLOS, MMPP showed the highest MOR (1.67 and 3.08 respectively).

Associations with patient and hospital characteristics

In general, odds of mortality and readmission were higher for men than for women (Appendix A.3.10), whereas odds of pLOS were lower for men. For the three outcomes, odds were higher for higher number of comorbidities and for emergency admissions. Patients admitted from nursing homes or other hospitals often had higher odds of mortality and pLOS than patients admitted from home. In most APR-DRGs, the risk of mortality and readmission was not significantly associated with year of discharge, but the odds of pLOS significantly decreased over time.

Overall, a higher number of significant associations with hospital characteristics (Table 4.8) was observed in medical (14 significant associations for mortality, 5 for readmissions and 19 for pLOS) compared to surgical APR-DRGs (5, 5 and 13 significant associations for mortality, readmissions and pLOS, respectively). Flanders showed significantly higher odds of readmission compared to Brussels or Wallonia for 6 APR-DRGs. For pLOS, however, Flanders often outperformed Brussels (12 APR-DRGs) or Wallonia (8 APR-DRGs). Significant associations of hospital type with mortality, readmission and pLOS were observed for 7, 1, and 8 APR-DRGs, respectively, with odds always lower for academic hospitals, except for the readmission association. Low urological volume was associated with lower mortality for 5 APR-DRGs, of which four are medical (RF, UTMD, UTI, DEV), and with higher mortality for *Other kidney, urinary tract & related procedures* (OUT). For readmission (n=1) and pLOS (n=3), significant odds ratios showed worse outcomes for low volume.

Potential lives saved

If APR-DRG-specific risk-standardised mortality rates in upper-quartile hospitals would be reduced to the median values, a total of 412 urological deaths per year, or 41.5% of observed urological deaths in those hospitals, could be avoided (Figure 4.10). The largest absolute gain was observed for UTI and UTMD (92 and 73 lives saved respectively) and the largest relative gain was observed for USO and *Nephritis & nephrosis* (NEPH) (67.3 and 66.5% of observed deaths, respectively).

Table 4.7. Characteristics of urological hospital admissions in Belgium, 2016-2018

APR-DRG	N hosp.	Admissions		Mort. %	Readm. %	LOS P90	Age, mean ± SD	Sex	Nr. of co-morbidities		Place before admission		Type of admission
		Total N	Yearly N per hospital, median (IQR)					Male, %	1-4, %	≥5, %	Other hospital or nursing home %	Other %	Emergency %
Total	99	320,640	1,271 (874-1,967)	2.2	7.8	13	63±21	66.8	41.5	8.1	5.5	1.7	50.7
440-Kidney transplant	7	1,468	63 (51-89)	0.3	9.3	24	53±14	64.2	79.6	8.4	0.7	0.4	72.5
441-Major bladder procedures	99	4,743	12 (6-21)	2.4	12.6	28	67±16	71.1	57.5	8.3	1.7	0.6	9.6
442-Kidney & urinary tract procedures for malignancy	99	6,553	16 (9-32)	1.7	6.8	13	67±13	66.2	56.9	6.6	0.9	0.2	6.3
443-Kidney & urinary tract procedres for non-malignancy	99	25,496	61 (34-107)	0.8	7.6	10	57±20	57.1	36.8	4.0	2.4	1.2	31.2
444-Renal dialysis access device procedures only	82	2,881	10 (4-18)	0.3	6.4	4	66±15	64.8	76.3	11.	1.1	0.5	5.8
445-Other bladder procedures	99	4,234	10 (5-17)	0.6	6.4	9	67±17	66.1	38.7	4.6	3.4	0.6	24.2
446-Urethral & transurethral procedures	99	41,197	115 (70-185)	0.3	6.6	4	64±17	73.6	32.4	2.2	1.0	1.0	26.1
447-Other kidney, urinary tract & related procedures	96	2,180	6 (3-11)	4.6	6.6	25	65±17	55.1	57.1	16.	4.5	1.4	26.2
460-Renal failure	99	12,773	38 (19-58)	11.0	9.4	24	72±17	54.3	58.8	32.	12.5	2.4	71.0
461-Kidney & urinary tract malignancy	99	5,747	16 (10-26)	17.1	10.0	19	73±14	71.4	61.1	12.	6.4	1.1	40.0
462-Nephritis & nephrosis	99	2,480	6 (2-13)	1.5	6.3	13	45±27	59.3	46.9	9.0	5.0	1.4	41.4
463-Kidney & urinary tract infections	99	62,464	182 (133-274)	3.0	8.0	18	61±29	30.0	47.5	13.	14.9	2.3	90.6
465-Urinary stones & acquired upper UT obstruction	99	35,260	106 (73-153)	0.1	8.9	3	51±17	68.5	21.4	0.9	1.1	3.3	81.7
466-Malfunction, reaction, compl. of genitourinary device or	99	7,650	17 (10-32)	2.1	11.5	14	66±19	67.0	55.0	13.	11.0	2.5	72.2
468-Other kidney & UT diagnoses, signs & symptoms	99	34,281	86 (61-140)	2.2	9.2	13	69±18	66.7	49.8	13.	6.5	2.4	56.6
480-Major male pelvic procedures	97	12,158	22 (10-53)	0.2	5.4	8	66±7	100.0	43.2	1.2	0.3	0.1	0.9
481-Penis procedures	98	3,335	5 (2-12)	0.0	3.3	5	42±28	100.0	21.6	1.0	1.2	0.6	9.8
482-Transurethral prostatectomy	99	24,337	63 (37-100)	0.2	8.1	6	71±9	100.0	37.2	2.3	0.7	0.2	4.3
483-Testes & scrotal procedures	99	6,483	18 (9-31)	0.1	2.6	2	41±24	100.0	21.5	1.1	0.8	2.0	26.8
484-Other male reproductive system & related proc.	99	5,747	13 (7-28)	0.4	6.6	9	70±10	100.0	37.4	2.4	0.6	0.4	6.3
500-Malignancy, male reproductive system	99	3,899	11 (6-18)	21.9	11.3	23	75±13	100.0	66.1	14.	8.0	1.3	48.7
501-Male reproductive system diagnoses except malignancy	99	15,274	43 (27-66)	0.7	6.0	10	64±20	100.0	37.7	6.3	4.3	2.7	77.8

Abbreviations: APR-DRG, All Patient Refined-Diagnosis Related Groups; hosp., hospitals; Mort., mortality; Readm., readmission; LOS, length of stay; P90, 90th percentile; SD, standard deviation; proc., procedure; UT, urinary tract; compl., complication

Grey indicates a surgical APR-DRG;

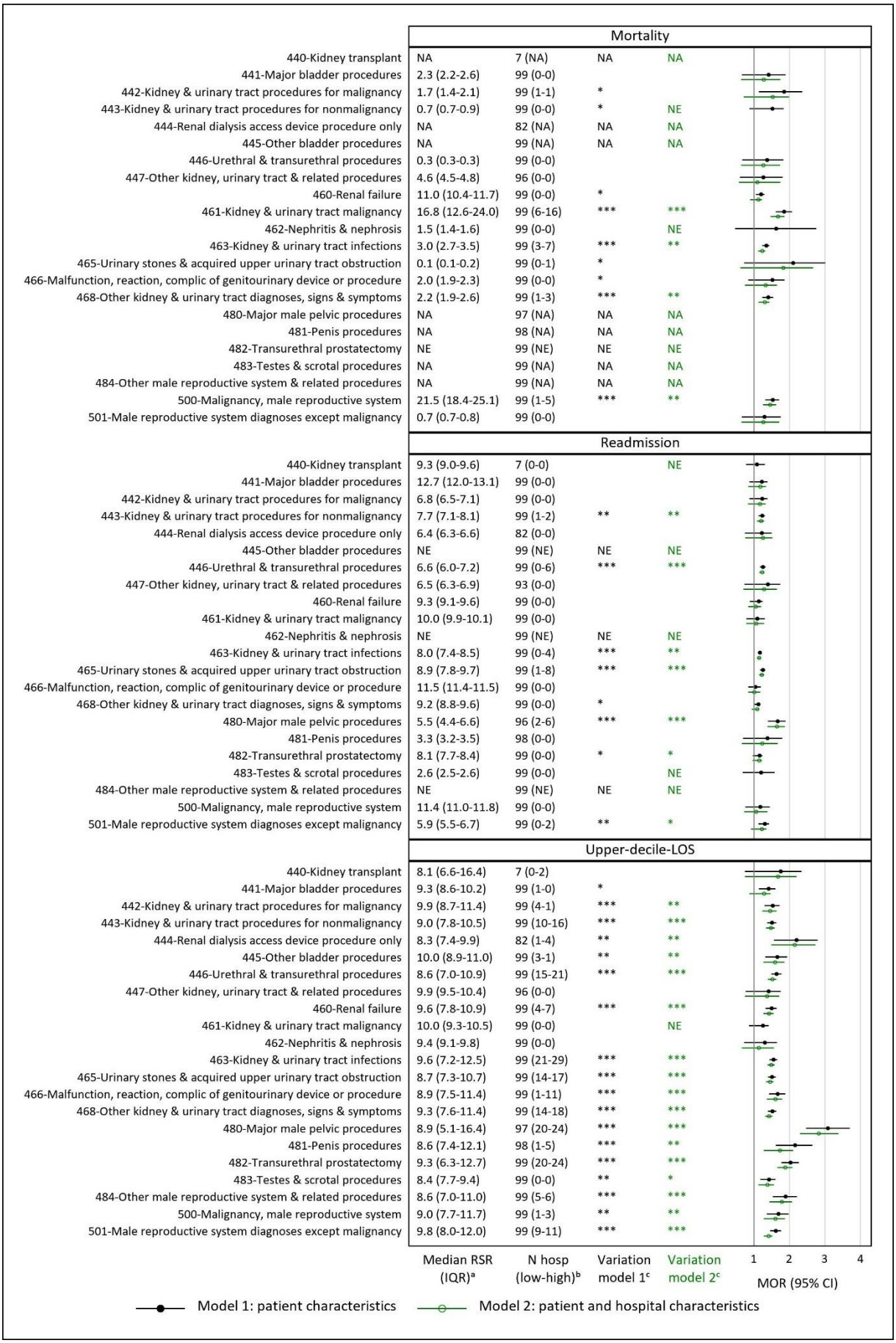

Mortality
440-Kidney transplant NA 7 (NA) NA NA
441-Major bladder procedures 2.3 (2.2-2.6) 99 (0-0)
442-Kidney & urinary tract procedures for malignancy 1.7 (1.4-2.1) 99 (1-1) *
443-Kidney & urinary tract procedures for nonmalignancy 0.7 (0.7-0.9) 99 (0-0) * NE
444-Renal dialysis access device procedure only NA 82 (NA) NA NA
445-Other bladder procedures NA 99 (NA) NA NA
446-Urethral & transurethral procedures 0.3 (0.3-0.3) 99 (0-0)
447-Other kidney, urinary tract & related procedures 4.6 (4.5-4.8) 96 (0-0)
460-Renal failure 11.0 (10.4-11.7) 99 (0-0) *
461-Kidney & urinary tract malignancy 16.8 (12.6-24.0) 99 (6-16) *** ***
462-Nephritis & nephrosis 1.5 (1.4-1.6) 99 (0-0) NE
463-Kidney & urinary tract infections 3.0 (2.7-3.5) 99 (3-7) *** **
465-Urinary stones & acquired upper urinary tract obstruction 0.1 (0.1-0.2) 99 (0-1) *
466-Malfunction, reaction, complic of genitourinary device or procedure 2.0 (1.9-2.3) 99 (0-0) *
468-Other kidney & urinary tract diagnoses, signs & symptoms 2.2 (1.9-2.6) 99 (1-3) *** **
480-Major male pelvic procedures NA 97 (NA) NA NA
481-Penis procedures NA 98 (NA) NA NA
482-Transurethral prostatectomy NE 99 (NE) NE NE
483-Testes & scrotal procedures NA 99 (NA) NA NA
484-Other male reproductive system & related procedures NA 99 (NA) NA NA
500-Malignancy, male reproductive system 21.5 (18.4-25.1) 99 (1-5) *** **
501-Male reproductive system diagnoses except malignancy 0.7 (0.7-0.8) 99 (0-0)
Readmission
440-Kidney transplant 9.3 (9.0-9.6) 7 (0-0) NE
441-Major bladder procedures 12.7 (12.0-13.1) 99 (0-0)
442-Kidney & urinary tract procedures for malignancy 6.8 (6.5-7.1) 99 (0-0)
443-Kidney & urinary tract procedures for nonmalignancy 7.7 (7.1-8.1) 99 (1-2) ** **
444-Renal dialysis access device procedure only 6.4 (6.3-6.6) 82 (0-0)
445-Other bladder procedures NE 99 (NE) NE NE
446-Urethral & transurethral procedures 6.6 (6.0-7.2) 99 (0-6) *** ***
447-Other kidney, urinary tract & related procedures 6.5 (6.3-6.9) 93 (0-0)
460-Renal failure 9.3 (9.1-9.6) 99 (0-0)
461-Kidney & urinary tract malignancy 10.0 (9.9-10.1) 99 (0-0)
462-Nephritis & nephrosis NE 99 (NE) NE NE
463-Kidney & urinary tract infections 8.0 (7.4-8.5) 99 (0-4) *** **
465-Urinary stones & acquired upper urinary tract obstruction 8.9 (7.8-9.7) 99 (1-8) *** ***
466-Malfunction, reaction, complic of genitourinary device or procedure 11.5 (11.4-11.5) 99 (0-0)
468-Other kidney & urinary tract diagnoses, signs & symptoms 9.2 (8.8-9.6) 99 (0-0) *
480-Major male pelvic procedures 5.5 (4.4-6.6) 96 (2-6) *** ***
481-Penis procedures 3.3 (3.2-3.5) 98 (0-0)
482-Transurethral prostatectomy 8.1 (7.7-8.4) 99 (0-0) * *
483-Testes & scrotal procedures 2.6 (2.5-2.6) 99 (0-0) NE
484-Other male reproductive system & related procedures NE 99 (NE) NE NE
500-Malignancy, male reproductive system 11.4 (11.0-11.8) 99 (0-0)
501-Male reproductive system diagnoses except malignancy 5.9 (5.5-6.7) 99 (0-2) ** *
Upper-decile-LOS
440-Kidney transplant 8.1 (6.6-16.4) 7 (0-2)
441-Major bladder procedures 9.3 (8.6-10.2) 99 (1-0) *
442-Kidney & urinary tract procedures for malignancy 9.9 (8.7-11.4) 99 (4-1) *** **
443-Kidney & urinary tract procedures for nonmalignancy 9.0 (7.8-10.5) 99 (10-16) *** ***
444-Renal dialysis access device procedure only 8.3 (7.4-9.9) 82 (1-4) ** **
445-Other bladder procedures 10.0 (8.9-11.0) 99 (3-1) ** **
446-Urethral & transurethral procedures 8.6 (7.0-10.9) 99 (15-21) *** ***
447-Other kidney, urinary tract & related procedures 9.9 (9.5-10.4) 96 (0-0)
460-Renal failure 9.6 (7.8-10.9) 99 (4-7) *** ***
461-Kidney & urinary tract malignancy 10.0 (9.3-10.5) 99 (0-0) NE
462-Nephritis & nephrosis 9.4 (9.1-9.8) 99 (0-0)
463-Kidney & urinary tract infections 9.6 (7.2-12.5) 99 (21-29) *** ***
465-Urinary stones & acquired upper urinary tract obstruction 8.7 (7.3-10.7) 99 (14-17) *** ***
466-Malfunction, reaction, complic of genitourinary device or procedure 8.9 (7.5-11.4) 99 (1-11) *** ***
468-Other kidney & urinary tract diagnoses, signs & symptoms 9.3 (7.6-11.4) 99 (14-18) *** ***
480-Major male pelvic procedures 8.9 (5.1-16.4) 97 (20-24) *** ***
481-Penis procedures 8.6 (7.4-12.1) 98 (1-5) *** **
482-Transurethral prostatectomy 9.3 (6.3-12.7) 99 (20-24) *** ***
483-Testes & scrotal procedures 8.4 (7.7-9.4) 99 (0-0) ** *
484-Other male reproductive system & related procedures 8.6 (7.0-11.0) 99 (5-6) *** ***
500-Malignancy, male reproductive system 9.0 (7.7-11.7) 99 (1-3) ** **
501-Male reproductive system diagnoses except malignancy 9.8 (8.0-12.0) 99 (9-11) *** ***
Median RSR (IQR)a
N hosp (low-high)b
Variation model 1c
Variation model 2c
1 2 3 4
MOR (95% CI)
Model 1: patient characteristics
Model 2: patient and hospital characteristics

Figure 4.9. Hospital variation in APR-DRG-specific urological in-hospital mortality, 30-day readmissions, and prolonged length of stay, with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

APR-DRGs are ordered by decreasing variation (based on the significance of the variation in model 1) across the 3 outcomes.

Abbreviations: LOS, length of stay; RSR, risk-standardised rate; IQR, interquartile range; NA, not applicable; NE, not estimable; MOR, median odds ratio; CI, confidence interval

[a]Based on the model including only patient characteristics (model 1)

[b]Total number of hospitals (number with RSR significantly lower than expected - number with RSR significantly higher than expected), based on model 1.

[c]Significance of the variation in risk across hospitals (testing whether the random hospital effect differs from zero): * P<0.05, ** P<0.01, *** P<0.001

Note: Results are not presented for models with <30 cases (indicated as NA) and for models in which the random hospital effect was estimated to be zero (indicated as NE).

Table 4.8. Adjusted odds ratios (95% confidence intervals) for hospital characteristics from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length of stay[a]

APR-DRG[b]	Mortality					Readmission					Prolonged length of stay				
	Region (reference = Flanders)		Hospital type	Annual volume (reference = high)		Region (reference = Flanders)		Hospital type	Annual volume (reference = high)		Region (reference = Flanders)		Hospital type	Annual volume (reference = high)	
	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium
KTr						0.77 (0.51-1.15)	0.55 (0.27-1.11)				0.93 (0.34-2.53)	0.50 (0.11-2.18)			
MBP	1.14 (0.57-2.29)	1.07 (0.68-1.68)	0.76 (0.39-1.48)	1.46 (0.83-2.58)	0.84 (0.50-1.44)	1.07 (0.78-1.49)	0.82 (0.65-1.04)	0.83 (0.60-1.15)	0.95 (0.69-1.31)	0.91 (0.70-1.18)	**1.53 (1.05-2.24)**	0.84 (0.63-1.11)	**0.60 (0.40-0.90)**	1.13 (0.79-1.61)	0.82 (0.60-1.11)
UTM	**2.67 (1.33-5.34)**	1.19 (0.72-1.97)	**0.41 (0.18-0.91)**	1.49 (0.84-2.64)	**0.52 (0.29-0.94)**	1.20 (0.82-1.76)	1.15 (0.90-1.48)	0.76 (0.53-1.08)	1.26 (0.90-1.76)	0.98 (0.74-1.29)	**1.57 (1.03-2.40)**	1.12 (0.84-1.49)	0.88 (0.55-1.40)	**1.53 (1.08-2.18)**	1.09 (0.80-1.51)
UTNM	1.31 (0.84-2.04)	0.79 (0.57-1.11)	**0.39 (0.24-0.62)**	0.85 (0.55-1.32)	0.78 (0.53-1.14)	0.83 (0.66-1.04)	0.87 (0.75-1.02)	0.96 (0.76-1.20)	0.96 (0.79-1.16)	0.93 (0.79-1.11)	1.07 (0.77-1.50)	0.81 (0.65-1.01)	1.05 (0.72-1.54)	0.89 (0.68-1.16)	0.91 (0.70-1.17)
DIAL						0.84 (0.48-1.48)	1.21 (0.81-1.81)	1.38 (0.77-2.49)	0.78 (0.42-1.43)	0.87 (0.57-1.35)	0.64 (0.27-1.54)	0.87 (0.47-1.60)	1.53 (0.61-3.86)	0.77 (0.34-1.78)	1.12 (0.57-2.21)
OBI						0.81 (0.51-1.30)	0.81 (0.58-1.12)	0.73 (0.47-1.13)	1.07 (0.71-1.62)	1.13 (0.81-1.56)	1.17 (0.68-2.02)	1.29 (0.88-1.89)	0.59 (0.32-1.10)	0.97 (0.61-1.55)	0.82 (0.54-1.24)
TUP	0.46 (0.20-1.08)	0.97 (0.62-1.52)	1.30 (0.64-2.63)	1.24 (0.74-2.10)	1.25 (0.77-2.02)	0.89 (0.71-1.11)	**0.79 (0.68-0.92)**	0.97 (0.76-1.25)	1.06 (0.90-1.26)	0.90 (0.77-1.06)	**2.11 (1.51-2.94)**	**1.53 (1.23-1.90)**	0.80 (0.53-1.20)	1.03 (0.80-1.32)	0.89 (0.69-1.14)
OUT	1.61 (0.84-3.11)	1.07 (0.65-1.77)		**1.89 (1.02-3.48)**	0.74 (0.41-1.31)	0.77 (0.38-1.54)	0.65 (0.40-1.04)	0.98 (0.52-1.84)	1.05 (0.53-2.08)	1.08 (0.64-1.80)	0.77 (0.38-1.54)	1.18 (0.77-1.80)	0.96 (0.52-1.78)	1.33 (0.73-2.40)	0.89 (0.54-1.46)
RF	1.02 (0.82-1.26)	0.91 (0.78-1.05)	**0.67 (0.52-0.85)**	1.02 (0.86-1.22)	**0.83 (0.70-0.97)**	0.91 (0.73-1.12)	**0.81 (0.69-0.94)**	1.16 (0.95-1.42)			**1.62 (1.16-2.26)**	1.14 (0.91-1.42)	0.73 (0.49-1.10)	**1.31 (1.00-1.71)**	0.98 (0.75-1.26)
UTMD	0.88 (0.56-1.38)	**0.62 (0.46-0.84)**	**0.35 (0.20-0.62)**	**0.69 (0.48-0.99)**	0.73 (0.52-1.03)	1.14 (0.84-1.53)	1.04 (0.82-1.31)	1.16 (0.87-1.54)			**1.32 (1.02-1.73)**	**0.76 (0.62-0.95)**	**0.57 (0.41-0.78)**	1.09 (0.85-1.40)	0.88 (0.70-1.10)
NEPH	0.85 (0.27-2.71)	1.65 (0.78-3.47)	1.15 (0.47-2.82)	1.20 (0.40-3.55)	0.81 (0.33-1.96)	0.91 (0.51-1.65)	1.11 (0.74-1.67)	0.62 (0.37-1.03)	0.58 (0.26-1.25)	1.00 (0.65-1.56)	1.38 (0.84-2.27)	**1.46 (1.02-2.10)**	0.96 (0.61-1.50)	1.23 (0.71-2.14)	1.06 (0.70-1.59)
UTI	**1.41 (1.12-1.78)**	**1.41 (1.22-1.64)**	**0.69 (0.52-0.91)**	**0.79 (0.66-0.95)**	**0.81 (0.68-0.96)**	0.86 (0.74-1.00)	0.95 (0.86-1.05)	**1.23 (1.04-1.45)**	0.97 (0.86-1.09)	0.98 (0.88-1.10)	**1.47 (1.08-2.00)**	1.15 (0.95-1.40)	**0.53 (0.36-0.79)**	1.04 (0.83-1.31)	1.08 (0.86-1.36)
USO	2.22 (0.79-6.23)	1.09 (0.52-2.29)	0.34 (0.08-1.49)	1.04 (0.42-2.58)	0.98 (0.44-2.20)	0.82 (0.66-1.02)	**0.87 (0.76-0.99)**	1.06 (0.83-1.36)	1.16 (0.99-1.36)	1.06 (0.91-1.23)	**1.48 (1.09-2.02)**	**1.32 (1.09-1.61)**	0.86 (0.59-1.26)	1.25 (1.00-1.58)	1.03 (0.82-1.30)
DEV	0.63 (0.35-1.14)	0.86 (0.57-1.30)	**0.51 (0.28-0.92)**	**0.54 (0.30-0.97)**	0.93 (0.60-1.45)	0.93 (0.72-1.19)	0.92 (0.76-1.11)	1.02 (0.83-1.27)	0.91 (0.71-1.16)	0.86 (0.69-1.06)	**1.64 (1.05-2.57)**	**1.38 (1.01-1.90)**	0.97 (0.59-1.58)	0.82 (0.55-1.21)	0.81 (0.56-1.16)
OUTD	1.02 (0.72-1.44)	1.03 (0.83-1.28)	**0.54 (0.36-0.81)**	1.10 (0.85-1.43)	1.16 (0.91-1.47)	**0.82 (0.70-0.96)**	0.93 (0.84-1.03)	1.05 (0.91-1.23)	0.96 (0.84-1.09)	0.94 (0.84-1.06)	**1.58 (1.18-2.11)**	1.15 (0.95-1.39)	**0.57 (0.40-0.81)**	**1.30 (1.04-1.62)**	1.07 (0.86-1.33)
MMPP						1.36 (0.81-2.29)	1.10 (0.77-1.55)	1.06 (0.62-1.83)	0.89 (0.57-1.41)	1.02 (0.69-1.49)	2.20 (0.98-4.95)	**1.71 (1.01-2.89)**	0.61 (0.23-1.64)	1.52 (0.81-2.86)	0.87 (0.47-1.60)
PENP						0.57 (0.28-1.16)	0.77 (0.46-1.30)	0.90 (0.55-1.49)			**3.03 (1.62-5.66)**	**2.68 (1.64-4.36)**	0.97 (0.50-1.87)	0.92 (0.47-1.80)	1.16 (0.69-1.98)
TURP	2.23 (0.89-5.57)	0.80 (0.34-1.88)	0.44 (0.09-2.04)	1.09 (0.49-2.40)	0.54 (0.22-1.32)	0.86 (0.70-1.06)	0.90 (0.78-1.03)	1.08 (0.85-1.38)	0.96 (0.82-1.12)	0.98 (0.85-1.14)	**2.09 (1.28-3.42)**	**1.76 (1.28-2.43)**	**0.53 (0.28-1.00)**	1.00 (0.69-1.45)	0.99 (0.68-1.43)
TSP						**0.49 (0.28-0.87)**	**0.63 (0.43-0.91)**	1.34 (0.77-2.31)	**1.70 (1.07-2.70)**	1.44 (0.95-2.20)	1.27 (0.85-1.89)	0.89 (0.67-1.18)	**0.57 (0.36-0.90)**	0.81 (0.57-1.14)	0.79 (0.58-1.08)
OMRP						0.99 (0.68-1.44)	**1.29 (1.00-1.66)**	1.18 (0.78-1.78)	0.98 (0.71-1.36)	0.88 (0.67-1.16)	1.20 (0.67-2.16)	1.25 (0.85-1.84)	0.60 (0.28-1.26)	1.33 (0.85-2.09)	0.87 (0.56-1.35)
MMRSD	0.75 (0.51-1.11)	**0.74 (0.57-0.97)**	0.65 (0.41-1.04)	0.91 (0.67-1.25)	0.86 (0.64-1.16)	1.07 (0.75-1.54)	0.89 (0.66-1.19)	1.00 (0.65-1.53)	1.27 (0.91-1.78)	1.32 (0.97-1.80)	0.91 (0.54-1.53)	0.91 (0.64-1.30)	**0.46 (0.24-0.90)**	1.06 (0.71-1.59)	0.91 (0.61-1.36)
MRSD	0.63 (0.31-1.28)	1.02 (0.66-1.58)	1.19 (0.61-2.31)	0.99 (0.55-1.79)	1.33 (0.82-2.15)	1.10 (0.83-1.45)	**0.72 (0.59-0.88)**	0.87 (0.64-1.20)	1.16 (0.92-1.46)	1.10 (0.89-1.36)	**2.56 (1.86-3.52)**	**1.65 (1.33-2.05)**	**0.55 (0.37-0.82)**	1.09 (0.84-1.42)	1.03 (0.81-1.32)

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge; Bold indicates significance p<0.05; Grey indicates a surgical APR-DRG

[b]APR-DRG code abbreviations: KTR: 440-Kidney transplant; MBP: 441-Major bladder procedures; UTM: 442-Kidney & urinary tract procedures for malignancy; UTNM: 443-Kidney & urinary tract procedures for non-malignancy; DIAL: 444-Renal dialysis access device procedure only; OBI: 445-Other bladder procedures; TUP: 446-Urethral & transurethral procedures; OUT: 447-Other kidney, urinary tract & related procedures; RF: 460-Renal failure; UTMD: 461-Kidney & urinary tract malignancy; NEPH: 462-Nephritis & nephrosis; UTI: 463-Kidney & urinary tract infections; USO: 465-Urinary stones & acquired upper urinary tract obstruction; DEV: 466-Malfunction, reaction, complication of genitourinary device or procedure; OUTD: 468-Other kidney & urinary tract diagnoses, signs & symptoms; MMPP: 480-Major male pelvic procedures; PENP: 481-Penis procedures; TURP: 482-Transurethral prostatectomy; TSP: 483-Testes & scrotal procedures; OMRP: 484-Other male reproductive system & related procedures; MMRSD: 500-Malignancy, male reproductive system; MRSD: 501-Male reproductive system diagnoses except malignancy

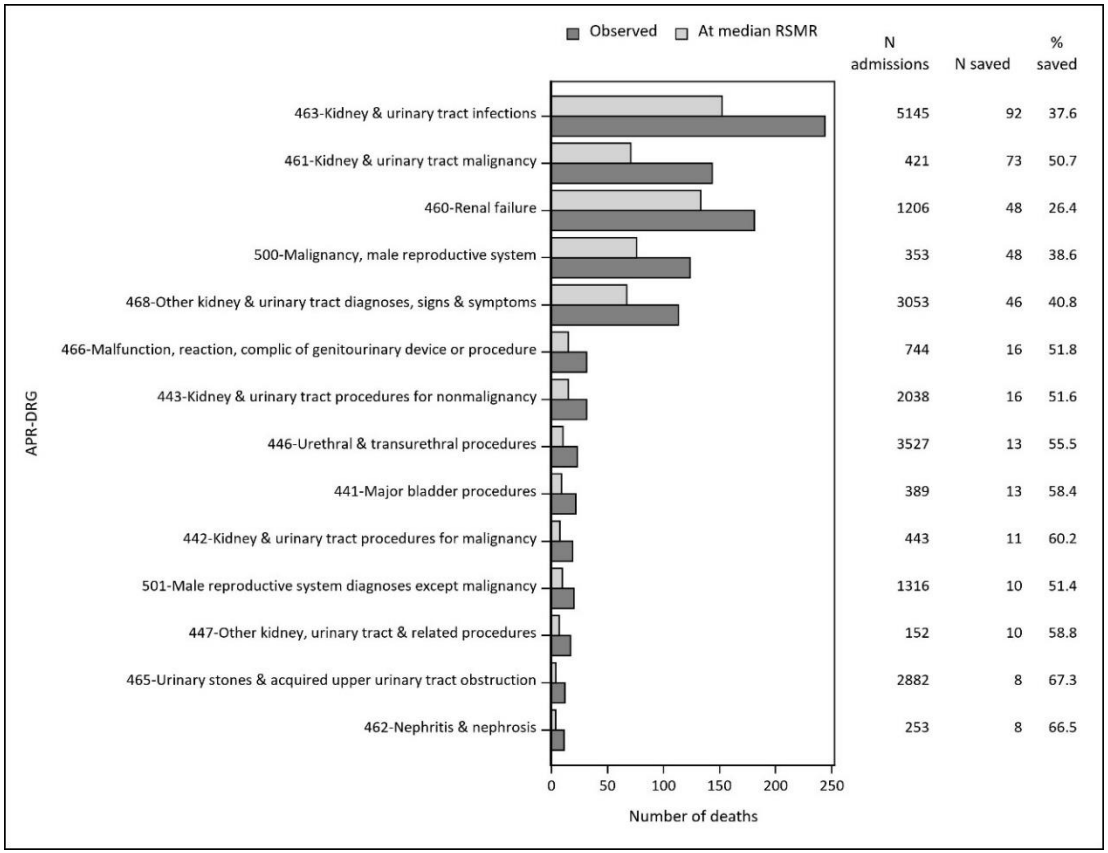


Figure 4.10. Annual number of observed deaths and estimated deaths among urological APR-DRGs if mortality in hospitals with risk-standardised mortality rates in the upper quartile would be reduced to the median value.

Results are based on the risk-standardised mortality distribution estimated by the model including only patient characteristics. Numbers at the bottom of the figure represent the annual APR-DRG-specific number of admissions and lives saved in hospitals with risk-standardised mortality in the upper quartile. The percentage of lives saved is calculated relative to the number of observed deaths in those hospitals.

Note: Results are not presented for 7 APR-DRGs with <30 deaths and for 1 APR-DRG~~s~~ for which the random hospital effect was estimated to be zero.

Abbreviations: RSMR, risk-standardised-mortality rate

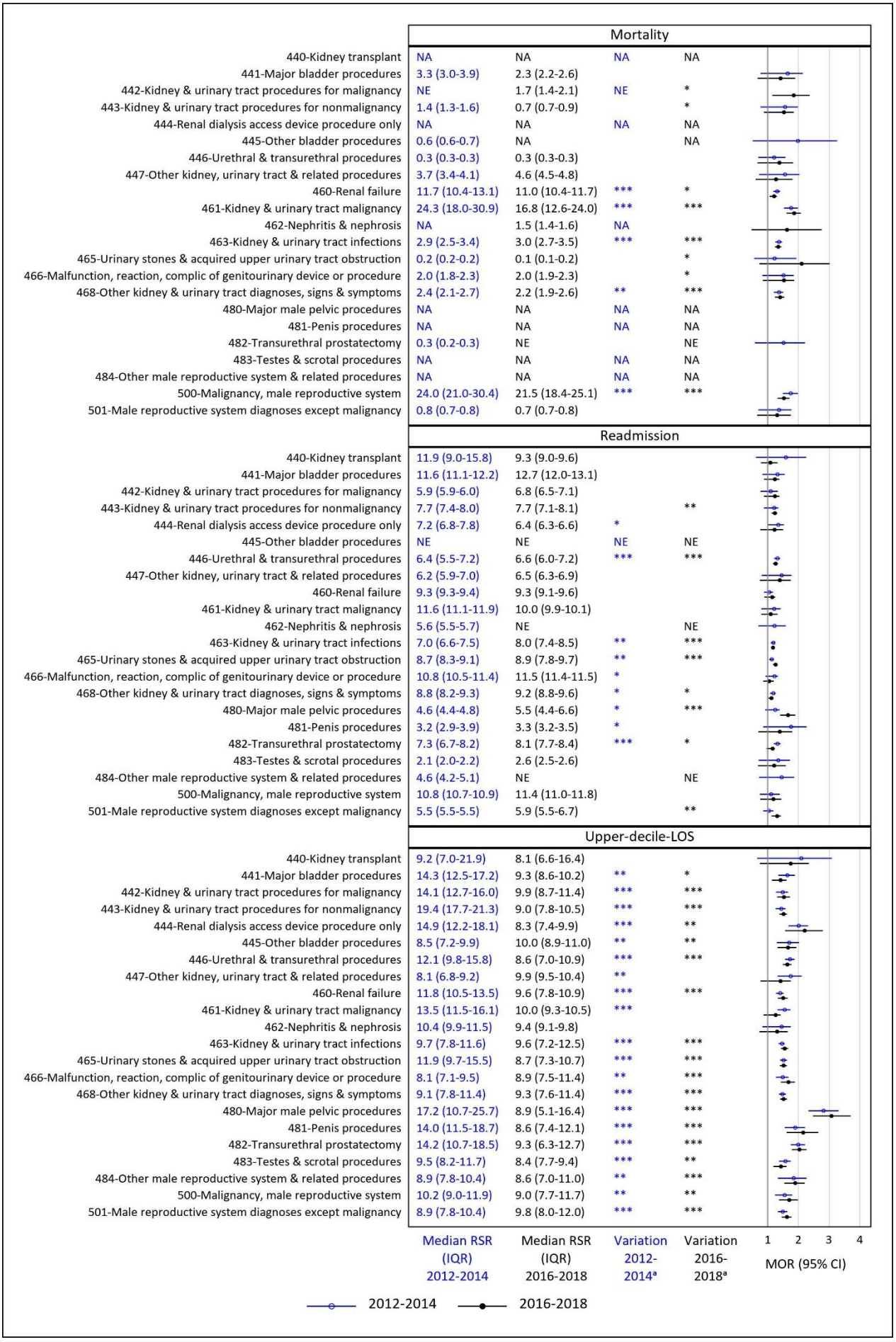

Mortality
440-Kidney transplant NA NA NA NA
441-Major bladder procedures 3.3 (3.0-3.9) 2.3 (2.2-2.6)
442-Kidney & urinary tract procedures for malignancy NE 1.7 (1.4-2.1) NE *
443-Kidney & urinary tract procedures for nonmalignancy 1.4 (1.3-1.6) 0.7 (0.7-0.9) *
444-Renal dialysis access device procedure only NA NA NA NA
445-Other bladder procedures 0.6 (0.6-0.7) NA NA
446-Urethral & transurethral procedures 0.3 (0.3-0.3) 0.3 (0.3-0.3)
447-Other kidney, urinary tract & related procedures 3.7 (3.4-4.1) 4.6 (4.5-4.8)
460-Renal failure 11.7 (10.4-13.1) 11.0 (10.4-11.7) *** *
461-Kidney & urinary tract malignancy 24.3 (18.0-30.9) 16.8 (12.6-24.0) *** ***
462-Nephritis & nephrosis NA 1.5 (1.4-1.6) NA
463-Kidney & urinary tract infections 2.9 (2.5-3.4) 3.0 (2.7-3.5) *** ***
465-Urinary stones & acquired upper urinary tract obstruction 0.2 (0.2-0.2) 0.1 (0.1-0.2) *
466-Malfunction, reaction, complic of genitourinary device or procedure 2.0 (1.8-2.3) 2.0 (1.9-2.3) *
468-Other kidney & urinary tract diagnoses, signs & symptoms 2.4 (2.1-2.7) 2.2 (1.9-2.6) ** ***
480-Major male pelvic procedures NA NA NA NA
481-Penis procedures NA NA NA NA
482-Transurethral prostatectomy 0.3 (0.2-0.3) NE NE
483-Testes & scrotal procedures NA NA NA NA
484-Other male reproductive system & related procedures NA NA NA NA
500-Malignancy, male reproductive system 24.0 (21.0-30.4) 21.5 (18.4-25.1) *** ***
501-Male reproductive system diagnoses except malignancy 0.8 (0.7-0.8) 0.7 (0.7-0.8)
Readmission
440-Kidney transplant 11.9 (9.0-15.8) 9.3 (9.0-9.6)
441-Major bladder procedures 11.6 (11.1-12.2) 12.7 (12.0-13.1)
442-Kidney & urinary tract procedures for malignancy 5.9 (5.9-6.0) 6.8 (6.5-7.1)
443-Kidney & urinary tract procedures for nonmalignancy 7.7 (7.4-8.0) 7.7 (7.1-8.1) **
444-Renal dialysis access device procedure only 7.2 (6.8-7.8) 6.4 (6.3-6.6) *
445-Other bladder procedures NE NE NE NE
446-Urethral & transurethral procedures 6.4 (5.5-7.2) 6.6 (6.0-7.2) *** ***
447-Other kidney, urinary tract & related procedures 6.2 (5.9-7.0) 6.5 (6.3-6.9)
460-Renal failure 9.3 (9.3-9.4) 9.3 (9.1-9.6)
461-Kidney & urinary tract malignancy 11.6 (11.1-11.9) 10.0 (9.9-10.1)
462-Nephritis & nephrosis 5.6 (5.5-5.7) NE NE
463-Kidney & urinary tract infections 7.0 (6.6-7.5) 8.0 (7.4-8.5) ** ***
465-Urinary stones & acquired upper urinary tract obstruction 8.7 (8.3-9.1) 8.9 (7.8-9.7) ** ***
466-Malfunction, reaction, complic of genitourinary device or procedure 10.8 (10.5-11.4) 11.5 (11.4-11.5) *
468-Other kidney & urinary tract diagnoses, signs & symptoms 8.8 (8.2-9.3) 9.2 (8.8-9.6) * *
480-Major male pelvic procedures 4.6 (4.4-4.8) 5.5 (4.4-6.6) * ***
481-Penis procedures 3.2 (2.9-3.9) 3.3 (3.2-3.5) *
482-Transurethral prostatectomy 7.3 (6.7-8.2) 8.1 (7.7-8.4) *** *
483-Testes & scrotal procedures 2.1 (2.0-2.2) 2.6 (2.5-2.6)
484-Other male reproductive system & related procedures 4.6 (4.2-5.1) NE NE
500-Malignancy, male reproductive system 10.8 (10.7-10.9) 11.4 (11.0-11.8)
501-Male reproductive system diagnoses except malignancy 5.5 (5.5-5.5) 5.9 (5.5-6.7) **
Upper-decile-LOS
440-Kidney transplant 9.2 (7.0-21.9) 8.1 (6.6-16.4)
441-Major bladder procedures 14.3 (12.5-17.2) 9.3 (8.6-10.2) ** *
442-Kidney & urinary tract procedures for malignancy 14.1 (12.7-16.0) 9.9 (8.7-11.4) *** ***
443-Kidney & urinary tract procedures for nonmalignancy 19.4 (17.7-21.3) 9.0 (7.8-10.5) *** ***
444-Renal dialysis access device procedure only 14.9 (12.2-18.1) 8.3 (7.4-9.9) *** **
445-Other bladder procedures 8.5 (7.2-9.9) 10.0 (8.9-11.0) ** **
446-Urethral & transurethral procedures 12.1 (9.8-15.8) 8.6 (7.0-10.9) *** ***
447-Other kidney, urinary tract & related procedures 8.1 (6.8-9.2) 9.9 (9.5-10.4) **
460-Renal failure 11.8 (10.5-13.5) 9.6 (7.8-10.9) *** ***
461-Kidney & urinary tract malignancy 13.5 (11.5-16.1) 10.0 (9.3-10.5) ***
462-Nephritis & nephrosis 10.4 (9.9-11.5) 9.4 (9.1-9.8)
463-Kidney & urinary tract infections 9.7 (7.8-11.6) 9.6 (7.2-12.5) *** ***
465-Urinary stones & acquired upper urinary tract obstruction 11.9 (9.7-15.5) 8.7 (7.3-10.7) *** ***
466-Malfunction, reaction, complic of genitourinary device or procedure 8.1 (7.1-9.5) 8.9 (7.5-11.4) ** ***
468-Other kidney & urinary tract diagnoses, signs & symptoms 9.1 (7.8-11.4) 9.3 (7.6-11.4) *** ***
480-Major male pelvic procedures 17.2 (10.7-25.7) 8.9 (5.1-16.4) *** ***
481-Penis procedures 14.0 (11.5-18.7) 8.6 (7.4-12.1) *** ***
482-Transurethral prostatectomy 14.2 (10.7-18.5) 9.3 (6.3-12.7) *** ***
483-Testes & scrotal procedures 9.5 (8.2-11.7) 8.4 (7.7-9.4) *** **
484-Other male reproductive system & related procedures 8.9 (7.8-10.4) 8.6 (7.0-11.0) ** ***
500-Malignancy, male reproductive system 10.2 (9.0-11.9) 9.0 (7.7-11.7) ** **
501-Male reproductive system diagnoses except malignancy 8.9 (7.8-10.4) 9.8 (8.0-12.0) *** ***
Median RSR (IQR) 2012-2014
Median RSR (IQR) 2016-2018
Variation 2012-2014a
Variation 2016-2018a
1 2 3 4
MOR (95% CI)
2012-2014
2016-2018

Figure 4.11. Comparison of hospital variation in APR-DRG-specific urological in-hospital mortality, 30-day readmissions, and prolonged length of stay between the main study period (2016-2018) and the three years before (2012-2014), with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

Results are based on models including only patient characteristics. APR-DRGs are ordered by decreasing variation (based on the significance of the variation in the model for 2016-2018) across the 3 outcomes. Abbreviations: LOS, length of stay; RSR, risk-standardised rate; IQR, interquartile range; NA, not applicable; NE, not estimable; MOR, median odds ratio; CI, confidence interval
[a]Significance of the variation in risk across hospitals (testing whether the random hospital effect differs from zero): * P<0.05, ** P<0.01, *** P<0.001

Trends over time

For APR-DRGs that allowed a comparison between the main study period (2016-2018) and the three years prior (2012-2014), mortality rates decreased over time by one third or more for UTNM, UTMD and USO (Figure 4.11). The largest (absolute) decrease in mortality (from 24.3% to 16.8%) was observed for UTMD. Both UTI, DEV and OUT demonstrated increasing mortality rates, with a remarkable surge in OUT (25% increase). pLOS rates decreased for most APR-DRGs (except for OUTD, DEV, MRSD, *Other bladder procedures* [OBI] and OUT), with approximately a halving of rates observed for UTNM and MMPP. Readmission rates, however, increased for 16 out of 19 comparable APR-DRGs.

As for the main study period, UTI ranked highest based on significance of risk variation across the three outcomes (P<0.01). The mortality variation for USO, UTNM and DEV was significant in the main study period, but not in earlier years, with a remarkable increase in MOR for USO, which also showed an increase in readmission variation over time. The significant variation in readmission in the main study period for UTNM and MRSD was not significant for 2012-2014. A remarkable increase in readmission MOR was observed for MMPP, for which the (already high) MOR for pLOS also increased. Contrastingly, the significance of readmission variation for DEV, *Penis procedures* (PENP) and *Renal dialysis access device procedure only* (DIAL) disappeared over time. For pLOS, variation for APR-DRGs UTMD and OUT was significant in 2012-2014, but not in 2016-2018.

4.3.5 Discussion

Significant between-hospital variation in at least two of three measured outcomes was observed for 7 out of 9 medical and 5 out of 13 surgical APR-DRGs, suggesting larger inequalities in urological quality of care for medical than for surgical admissions. This might be related to past QI initiatives having mainly been directed towards surgical patients, with e.g. implementation of safe-surgery-checklists[103,104] and technological advances such as robotics.[105] The European Association of Urology has invested significantly in the development of guidelines and standards[106] for urological care since many years with high acceptance among the urological community. These guidelines are produced after a rigorous methodological process using analysis of all published clinical trials, with expert opinion avoided as much as possible. Adherence to guidelines might be higher for oncology because clinical practice guidelines are based on a large amount of clinical trials, whereas the limited number of trials for non-oncological diseases could represent a problem for obtaining high-quality recommendations.[107]

With significant variation in each of the three outcomes, and representing nearly 20% of urological hospital admissions, our research revealed UTI should become a priority for future QI interventions. Improving mortality in bottom-performing hospitals could potentially save 92 patients annually for this APR-DRG, a substantial amount considering its relatively low, yet increasing, mortality rate. A high number of lives potentially saved (73 p.a.) was also observed for UTMD, which also showed the highest significant mortality variation (based on the MOR). The highest relative gain in lives saved (67.3%) and highest MOR for mortality (2.11), although not significant, was observed for USO. MORs for APR-DRGs with significant between-hospital variation were often higher than odds ratios for hospital characteristics, indicating between-hospital variation exceeds variation explained by hospitals characteristics. With 41.5% of deaths potentially being avoided in bottom-performing hospitals if they were to improve to the median, reducing variation would be highly beneficial for urological patients.

To mitigate this unwarranted variation, we encourage urological associations to further invest into the development and implementation of clinical guidelines and standardisation. While surgical and oncological standards have received abundant attention in the past,[106,108] it is now time to switch focus to medical conditions such as antibiotic stewardship[109] for urological infections. Secondly, systematic collation and benchmarking of outcomes and variation on a national and international level is required to ensure future focus on the right priorities.[97] Thirdly, collaborative learning on a local level has shown promise to improve patient outcomes[110] and should be expanded from existing initiatives.[111]

In line with previous work,[50,87,88] we found certain hospital characteristics, e.g. region or teaching status, are associated with mortality, readmission and LOS. Remarkably, our study discovered medical diagnoses with low admission volume are often associated with a lower risk of mortality, which seems contradictive of the existing evidence-base on surgical volume.[89] The mechanism behind this finding is currently uncertain and therefore requires further research. Inclusion of hospital factors into the statistical model only minimally helped explain between-hospital variation, suggesting the need for additional research on hospital contextual factors contributing to this variation. Strategies for improving hospital performance should be customised based on key hospital attributes as well as on individual performance profiles.

In this study, we formally evaluated between-hospital variation in patient outcomes at APR-DRG-level. The methods presented in this paper are easily transferrable to other disease groups besides urology, allowing priority setting across the healthcare spectrum. However, several study limitations merit attention. First, we were unable to include readmissions occurring in December, nor readmissions to other hospitals, so readmission rates are likely underestimated. Second, we did not obtain results for some outcome-APR-DRG combinations because the random component was estimated to be zero, which could indicate low between-hospital variation, but could also result from a model misspecification, especially in case of low numbers. We did not encounter this problem for pLOS, probably because of the higher number of cases (10% by definition). This is also the outcome for which significant between-hospital variation was observed most often, suggesting a potential lack of power in some mortality and readmission models. Nevertheless, our study comprised the preponderance of the Belgian urological population and was able to identify urological APR-DRGs with important variation for mortality, readmission and LOS.

4.3.6 Conclusions

Urological care is characterised by notable between-hospital variation in mortality, readmission and length of stay, in particular for medical pathologies. Future quality improvement interventions could target this variation by prioritising kidney & urinary tract infections, which was found to have significant variation in the three outcomes and could potentially save the largest number of lives if improvements were made.

4.4 Call for action to target inter-hospital variation in cardiovascular mortality, readmissions and length of stay: results of a national population analysis

4.4.1 Abstract

Aims: Excessive inter-hospital variation threatens healthcare quality. Data on variation in patient outcomes across the entire cardiovascular patient population are lacking. We aimed to examine inter-hospital variability for 28 cardiovascular All Patient Refined-Diagnosis Related Groups (APR-DRGs) in Belgium.

Methods and results*:* We studied 521,166 cardiovascular admissions in 99 (98%) Belgian acute-care hospitals between 2016 and 2018. Using generalised linear mixed models, we estimated hospital-specific and APR-DRG-specific risk-standardised rates for in-hospital mortality, 30-day readmissions and length of stay above the APR-DRG-specific 90th percentile, controlling for patient characteristics. Inter-hospital variation was assessed based on estimated variance components and time trends were examined. There was strong evidence on inter-hospital variation, with statistically significant inter-hospital variation across all three outcomes for five APR-DRGs taking patient and hospital factors into account: *percutaneous cardiovascular procedures with acute myocardial infarction, heart failure, hypertension, angina pectoris* and *arrhythmia.* Medical diagnoses that are often treated within interdisciplinary teams, with in particular *heart failure, hypertension, angina pectoris* and *cardiac arrest,* showed strongest variability. Overall, should hospitals target this variability by improving hospitals with upper-quartile risk-standardised rates to the median level, an annual 633 deaths, 322 readmissions and 1578 extended hospital stays could potentially be avoided.

Conclusions: Analysis of inter-hospital variation highlights important differences in patient outcomes between hospitals that are not explained by known patient or hospital characteristics. Targeting variation is therefore a promising strategy to improve cardiovascular care. We recommend policy makers and hospital management to prioritise interventions to improve guideline implementation for *heart failure, hypertension, cardiac arrest* and *angina pectoris*.

Key words: Healthcare Quality, Hospital, Mortality, Length of stay, Readmission, Cardiology

4.4.2 Introduction

Despite developments and implementation of a wide range of evidence-based preventive and treatment approaches, cardiovascular disease remains the most common cause of death in Europe.[112] With cardiovascular disease accounting for 42.5% of all deaths or more than 2.8 million deaths per year across Europe,[112] novel strategies to reduce the disease burden are urgently required. One such approach could be the examination and reduction in excessive healthcare variation, which poses a threat to quality, equity and patient safety.[113,114] Unwarranted variation in utilisation of cardiovascular care has been documented across many countries.[115,116] Furthermore, numerous studies suggest disparities in patient outcomes between hospitals, such as variability in mortality,[43,117,118] readmissions[43,88] or length of stay.[119] However, this evidence on cardiovascular care variation remains limited to a restricted patient sample of a select set of diagnoses or procedures.[43,88,117–121] To our knowledge, no data are available on variation in patient outcomes across the entire cardiovascular patient spectrum and across multiple patient outcomes. Monitoring and understanding such overarching variability can provide critically important information and insights for policy makers, healthcare professionals, managers and patient organisations.[122] Knowing which diagnoses or procedures are most prone to inter-hospital variation can help to prioritise future interventions that have the largest potential to improve cardiovascular care.

The primary aim of our study was to examine inter-hospital variability across all cardiovascular All Patient Refined-Diagnosis Related Groups (APR-DRGs) for all Belgian acute-care hospitals. We studied variability in in-hospital mortality, unplanned 30-day readmissions and prolonged length of hospital stay (pLOS), measures which are available from routinely collected data and which are strongly correlated with healthcare quality and spending.[36–38] Studies examining all three outcomes together are rare[40,41,123] and are, to the best of our knowledge, lacking within cardiology. Yet, considering combined outcomes can help uncover potential competing risks between them.[43,124–126] Additionally, we assessed associations between outcomes and patient and hospital characteristics and estimated the number of outcomes potentially avoidable, if successful variation-reducing policies could be established. Our secondary aim was to study trends in cardiovascular mortality, readmission and pLOS rates over time.

4.4.3 Methods

Data source and study population

We exploited the Belgian Hospital Discharge Set on all inpatient hospitalisations from all 99 Belgian acute-care hospitals for the years 2012-2018, excluding psychiatric stays and one-day clinics as well as hospitals with exclusive specialist care that are dedicated to only one or a few related medical specialties. The dataset contains patient demographics, hospital stay characteristics and clinical data, i.e. primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 9-Clinical Modification (ICD-9-CM) up to 2014 and ICD-10-CM from 2016 onwards. Data from 2015 were excluded as the registration of diagnoses using ICD was not mandatory during this ICD transition period.

The APR-DRG 31.0 (3M) grouping system was used to select 28 cardiovascular pathologies (Appendix A.3.11), falling within Major Diagnostic Category (MDC) 5 (*Diseases and Disorders of the Circulatory System*). These encompass the majority (84.4%) of all cardiovascular care in Belgium. A limited set of APR-DRGs were excluded, either because they were too infrequent (APR-DRG 160-*Major cardiothoracic repair of heart anomaly*) or because they covered a heterogenous array of diagnoses and

procedures that made clinical interpretation difficult (APR-DRGs 167-*Other cardiothoracic procedures*, 173-*Other vascular procedures*, and 180-*Other circulatory system procedures*). One APR-DRG, i.e. 207-*Other circulatory system diagnoses*, was adapted to include only diagnoses of pericarditis. Of the included APR-DRGs, 12 are mapped under surgical APR-DRGs, while 16 reflect medical diagnoses. An overview of the most frequent diagnoses and per APR-DRG is provided in Appendix A.3.12. We used the three available years with ICD-10-CM data (2016-2018) as main study period, including a total of 521,166 hospital stays. For the assessment of trends over time, we also studied 511,833 cardiovascular hospital stays registered in the period 2012-2014.

Outcomes and patient and hospital characteristics

We investigated three outcomes: all-cause in-hospital mortality, 30-day readmission, and length of stay (LOS) above the APR-DRG-specific 90th percentile, hereafter referred to as prolonged LOS (pLOS). A readmission was defined as an all-cause, nonelective admission to the same hospital within 30 days of discharge following the index admission. Readmissions remained limited to within-hospital, as patient identifiers are specific to each hospital. The index admission was used as the unit of analysis, so each readmission is again an index admission for a subsequent readmission. Transfers, discharges against medical advice and admissions ending with the patient's death were not considered as index admissions. Because anonymised patient identifiers are changed each calendar year, readmissions occurring in the next calendar year could not be identified, so all admissions in the month of December were excluded as index admission.

Patient demographics included sex, age, the number of comorbidities, place before admission ('home', 'other hospital or nursing home' or 'in transit or other'), and admission type (elective or emergency). Age was categorised in 10-year age groups which were, for each APR-DRG*outcome combination, grouped to contain at least 10 cases in each category. We used the R package "comorbidity"[57,127] to obtain the (unweighted) number of Elixhauser-comorbidities, categorised as zero, one to four and five or more comorbidities. Hospital characteristics included region (Flanders, Wallonia, Brussels), teaching status (academic or general) and cardiovascular volume. The latter was calculated by APR-DRG for each hospital as the average annual number of admissions.

Statistical analyses

Using the SAS GLIMMIX procedure, we fitted generalised linear mixed models with a binary response distribution and logit link function. All models were corrected for patient characteristics and included a random intercept for hospital to account for hospital-level clustering. APR-DRG-specific models were run for each of the three binary outcomes separately. Hospital-specific risk-standardised mortality rates were calculated as the ratio of predicted and expected deaths (estimated by the model including only patient characteristics) multiplied by the overall crude mortality rate by APR-DRG. The predicted number of deaths was obtained as the hospital-specific prediction from the model including both the fixed effects and the hospital-specific random intercept (i.e. the best linear unbiased predictor), whereas the expected number of deaths is the prediction including only the fixed effects. Hospitals for which the random intercept estimate was significantly higher (or lower) than zero were identified as hospitals with significantly higher (or lower) than expected mortality. Significance of the between-hospital variation in mortality risk was based on a Wald test for the random hospital effect, and the variation was quantified by means of the median odds ratio (MOR).[102] The MOR describes the likelihood that patients with similar covariates would have different outcomes at randomly chosen hospitals by repeatedly sampling

at random two subjects with the same fixed patient effects but from different hospitals. A MOR of 1 suggests that no statistically significant variation in mortality across hospitals can be observed, whereas e.g. a MOR of 1.5 suggests that the odds of a patient dying at that hospital are 1.5 times the odds of a similar patient dying at another randomly identified hospital. Between-hospital variation (significance and MOR) was reassessed after additional adjustment for hospital characteristics in the model, in order to evaluate whether between-hospital variation can be explained by those characteristics. The same methods were used for readmission and pLOS.

4.4.4 Results

Descriptives

Of the 99 included hospitals, 52 are located in Flanders, 36 in Wallonia, and 11 in Brussels. Seven hospitals are academic teaching hospitals. The majority of included APR-DRGs occurred in all hospitals (Table 4.9), except for APR-DRGs 161 to 166, involving defibrillator implants, cardiac valve procedures and coronary bypass procedures, which are restricted to designated hospitals. The most frequent APR-DRG was percutaneous cardiovascular procedures without acute myocardial infarction (*PCI without AMI*), representing over 15% of all cardiovascular admissions, whereas endocarditis was least frequent (0.1% of admissions). The highest in-hospital mortality rate was observed in *cardiac arrest* patients (82.5%), while only 0.2% of patients admitted for cardiac pacemaker & defibrillator device replacement (*pacemaker replacement*) or for chest pain *(CP)* died during their hospital stay. Readmission rates ranged from 2.2% *(catheterization for ischemic heart disease)* to 13.1% *(heart failure [HF])*, while the longest LOS was observed for *endocarditis*, with 10% of patients staying 47 days or longer.

Between-hospital variation in patient outcomes

Adjusting for patient characteristics, statistically significant between-hospital variation in risk for all three outcomes was observed for four surgical procedures *(bypass without catheterization; major thoracic & abdominal procedures; PCI with AMI; PCI without AMI)* and five medical diagnoses *(catheterization without ischemic heart disease; HF; angina pectoris & coronary atherosclerosis (angina pectoris); hypertension; arrhythmia & conduction disorders)* (Figure 4.12). Statistically significant variation in risk for two out of three outcomes was found for eight APR-DRGs, among which three surgical procedures *(valve procedures without catheterization; bypass with catheterization; pacemaker without AMI/HF/shock)* and five medical diagnoses *(AMI; catheterization for ischemic heart disease; peripheral disorders; structural & valvular disorders; syncope & collapse [S&C])*. Additional adjustments for hospital characteristics on top of the included patient factors resulted in minimal reductions in statistically significant variation. Statistically significant variation across all three outcomes was observed in five APR-DRGs *(PCI without AMI; HF; angina pectoris; hypertension; arrhythmia & conduction disorders)*, while statistically significant variation across two outcomes was observed in nine APR-DRGs *(valve procedures without catheterization; bypass with catheterization; major thoracic & abdominal procedures; pacemaker without AMI/HF/shock; PCI with AMI; AMI; catheterization without ischemic heart disease; catheterization for ischemic heart disease; peripheral disorders)*.

Table 4.9. Characteristics of cardiovascular hospital admissions in Belgium, 2016-2018

APR-DRG	N Hospitals	Admissions		Mortality, (%)	Readmissions (%)	LOS P90 (days)	Age, mean ± SD	Sex	Number of comorbidities		Place before admission		Type of admission
		N Admissions	Yearly admissions per hospital, median (IQR)					Male (%)	1-4	≥5	Other hospital or nursing home	Other	Emergency (%)
Total	99	521166	2822 (1412-4761)	4,0	6,1	14	70±16	58,5	54,0	16,6	7,9	3,9	55,0
161-Cardiac defibrillator & heart assist implant	51	5097	36 (2-64)	0,6	3,9	17	63±13	78,2	65,4	17,3	10,4	3.0	21,4
162-Cardiac valve procedures with cardiac catheterization	29	2020	13 (7-23)	7,3	8,1	45	71±12	60,3	58,4	32,9	8,1	2,6	29,9
163-Cardiac valve procedures without cardiac catheterization	30	10188	76 (36-181)	3,5	6,3	24	69±15	61,6	62,7	20,6	5,3	0,4	6,1
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	31	5119	49 (29-68)	3,8	6,2	27	68±10	79,1	59,6	16,3	13,1	3,5	45,1
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	30	11728	123 (54-192)	1,2	4,3	17	68±9	81,3	60,1	10,8	10,8	0,6	6,5
169-Major thoracic & abdominal vascular procedures	98	11197	19 (10-38)	5,4	5,7	21	65±14	70,3	59,9	9,8	4,3	1,3	19,1
170-Permanent cardiac pacemaker implant with acute myocardial infarction, heart failure or shock	93	1012	3 (1-5)	2,6	10,1	26	79±9	53,2	59,2	38,4	7,8	1,7	58,9
171-Permanent cardiac pacemaker implant without acute myocardial infarction, heart failure or shock	98	19681	54 (31-89)	0,8	5,5	12	77±11	57,4	61,1	13,3	4,4	2,9	39,9
174-Percutaneous cardiovascular procedures with acute myocardial infarction	94	26857	68 (11-176)	4,2	6,9	10	66±13	73,8	55,6	10,3	16,2	6,4	86,7
175-Percutaneous cardiovascular procedures without acute myocardial infarction	89	81293	150 (18-445)	0,7	3,7	5	65±14	67,7	49,1	7,1	3,5	0,9	14,1
176-Cardiac pacemaker & defibrillator device replacement	97	7371	14 (6-28)	0,2	3,2	4	75±15	60,6	56,7	10,8	2,6	0,7	8,4

177-Cardiac pacemaker & defibrillator revision except device replacement	96	2328	4 (2-12)	0,9	5,2	10	71±15	60,2	59,0	13,5	5,9	1,2	22,0
190-Acute myocardial infarction	99	21437	69 (46-95)	11,0	9,0	14	72±14	61,5	55,5	17,9	26,6	4,0	80,0
191-Cardiac catheterization with circulatory disorders except ischemic heart disease	97	35627	70 (27-157)	1,4	4,1	11	67±15	56,4	54,8	17,6	3,8	2,5	35,9
192-Cardiac catheterization for ischemic heart disease	91	48668	108 (45-303)	0,2	2,2	3	68±11	62,4	53,6	6,4	2,0	1,4	20,1
193-Acute & subacute endocarditis	93	640	2 (1-4)	17,3	12,3	47	69±18	66,5	54,3	35,7	17,0	3,3	72,7
194-Heart failure	99	69685	194 (138-308)	11,9	13,1	23	81±11	47,4	49,4	48,2	15,1	2,5	86,3
196-Cardiac arrest	98	3008	7 (4-13)	82,5	10,5	8	71±17	59,4	45,3	12,9	11,7	15,2	98,1
197-Peripheral & other vascular disorders	99	16322	42 (29-73)	7,2	6,3	18	69±18	51,9	56,4	15,1	9,7	3,1	62,5
198-Angina pectoris & coronary atherosclerosis	99	13691	39 (27-55)	2,5	6,6	9	70±14	63,0	56,3	14,8	11,6	4,3	81,3
199-Hypertension	99	8144	24 (16-36)	1,4	5,3	12	69±17	34,6	55,7	8,0	5,3	3,7	87,4
200-Cardiac structural & valvular disorders	99	3646	9 (5-15)	8,0	8,0	19	76±18	41,9	54,8	29,5	15,1	3,3	61,8
201-Cardiac arrhythmia & conduction disorders	99	59159	157 (112-268)	2,3	7,1	11	71±16	49,7	56,7	13,1	5,0	5,1	82,1
203-Chest pain	99	14776	41 (23-64)	0,2	3,8	5	60±19	52,5	47,1	4,4	3,4	6,8	96,6
204-Syncope & collapse	99	32499	86 (50-145)	0,8	5,0	13	67±23	47,6	54,4	10,6	5,6	18,1	93,7
205-Cardiomyopathy	97	1206	4 (2-6)	6,7	10,1	19	66±19	61,0	58,1	30,6	10,4	4,6	70,3
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	99	3870	8 (4-17)	3,6	9,4	17	65±18	58,0	62,0	15,5	7,2	2,8	57,7
207*-Pericarditis	99	4898	13 (7-22)	1,0	8,6	10	53±20	64,3	46,3	6,7	3,8	4,2	90,9

Abbreviations: APR-DRG, All Patient Refined-Diagnosis Related Groups; hosp., hospitals; Mort., mortality; Readm., readmission; LOS, length-of-stay; P90, 90th percentile; SD, standard deviation; proc., procedure;

Grey indicates a surgical APR-DRG

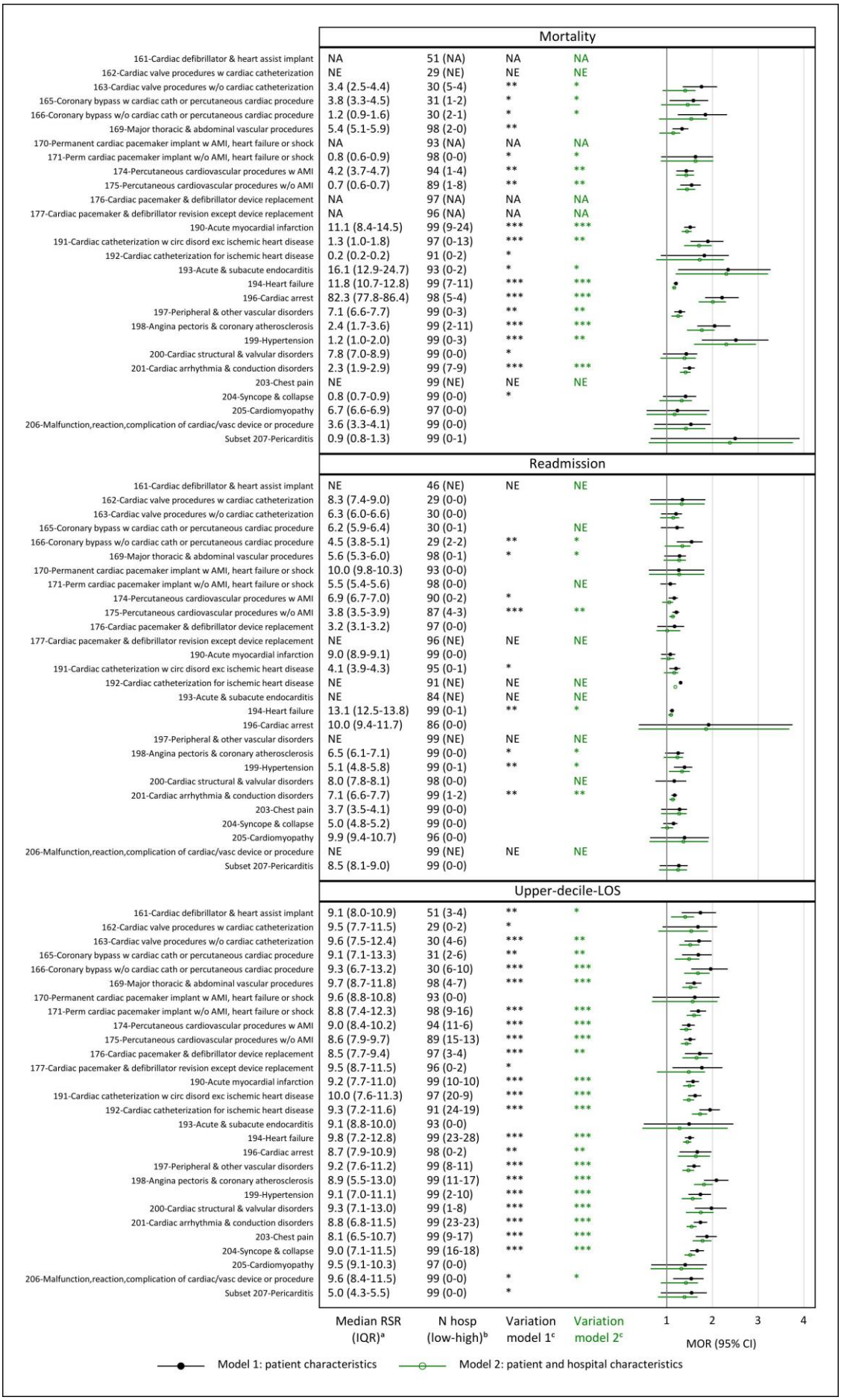

Mortality
161-Cardiac defibrillator & heart assist implant NA 51 (NA) NA NA
162-Cardiac valve procedures w cardiac catheterization NE 29 (NE) NE NE
163-Cardiac valve procedures w/o cardiac catheterization 3.4 (2.5-4.4) 30 (5-4) ** *
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 3.8 (3.3-4.5) 31 (1-2) * *
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 1.2 (0.9-1.6) 30 (2-1) * *
169-Major thoracic & abdominal vascular procedures 5.4 (5.1-5.9) 98 (2-0) **
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock NA 93 (NA) NA NA
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 0.8 (0.6-0.9) 98 (0-0) * *
174-Percutaneous cardiovascular procedures w AMI 4.2 (3.7-4.7) 94 (1-4) ** **
175-Percutaneous cardiovascular procedures w/o AMI 0.7 (0.6-0.7) 89 (1-8) ** **
176-Cardiac pacemaker & defibrillator device replacement NA 97 (NA) NA NA
177-Cardiac pacemaker & defibrillator revision except device replacement NA 96 (NA) NA NA
190-Acute myocardial infarction 11.1 (8.4-14.5) 99 (9-24) *** ***
191-Cardiac catheterization w circ disord exc ischemic heart disease 1.3 (1.0-1.8) 97 (0-13) *** **
192-Cardiac catheterization for ischemic heart disease 0.2 (0.2-0.2) 91 (0-2) *
193-Acute & subacute endocarditis 16.1 (12.9-24.7) 93 (0-2) * *
194-Heart failure 11.8 (10.7-12.8) 99 (7-11) *** ***
196-Cardiac arrest 82.3 (77.8-86.4) 98 (5-4) *** ***
197-Peripheral & other vascular disorders 7.1 (6.6-7.7) 99 (0-3) ** **
198-Angina pectoris & coronary atherosclerosis 2.4 (1.7-3.6) 99 (2-11) *** ***
199-Hypertension 1.2 (1.0-2.0) 99 (0-3) *** **
200-Cardiac structural & valvular disorders 7.8 (7.0-8.9) 99 (0-0) *
201-Cardiac arrhythmia & conduction disorders 2.3 (1.9-2.9) 99 (7-9) *** ***
203-Chest pain NE 99 (NE) NE NE
204-Syncope & collapse 0.8 (0.7-0.9) 99 (0-0) *
205-Cardiomyopathy 6.7 (6.6-6.9) 97 (0-0)
206-Malfunction,reaction,complication of cardiac/vasc device or procedure 3.6 (3.3-4.1) 99 (0-0)
Subset 207-Pericarditis 0.9 (0.8-1.3) 99 (0-1)
Readmission
161-Cardiac defibrillator & heart assist implant NE 46 (NE) NE NE
162-Cardiac valve procedures w cardiac catheterization 8.3 (7.4-9.0) 29 (0-0)
163-Cardiac valve procedures w/o cardiac catheterization 6.3 (6.0-6.6) 30 (0-0)
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 6.2 (5.9-6.4) 30 (0-1) NE
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 4.5 (3.8-5.1) 29 (2-2) ** *
169-Major thoracic & abdominal vascular procedures 5.6 (5.3-6.0) 98 (0-1) * *
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock 10.0 (9.8-10.3) 93 (0-0)
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 5.5 (5.4-5.6) 98 (0-0) NE
174-Percutaneous cardiovascular procedures w AMI 6.9 (6.7-7.0) 90 (0-2) *
175-Percutaneous cardiovascular procedures w/o AMI 3.8 (3.5-3.9) 87 (4-3) *** **
176-Cardiac pacemaker & defibrillator device replacement 3.2 (3.1-3.2) 97 (0-0)
177-Cardiac pacemaker & defibrillator revision except device replacement NE 96 (NE) NE NE
190-Acute myocardial infarction 9.0 (8.9-9.1) 99 (0-0)
191-Cardiac catheterization w circ disord exc ischemic heart disease 4.1 (3.9-4.3) 95 (0-1) *
192-Cardiac catheterization for ischemic heart disease NE 91 (NE) NE NE
193-Acute & subacute endocarditis NE 84 (NE) NE NE
194-Heart failure 13.1 (12.5-13.8) 99 (0-1) ** *
196-Cardiac arrest 10.0 (9.4-11.7) 86 (0-0)
197-Peripheral & other vascular disorders NE 99 (NE) NE NE
198-Angina pectoris & coronary atherosclerosis 6.5 (6.1-7.1) 99 (0-0) * *
199-Hypertension 5.1 (4.8-5.8) 99 (0-1) ** *
200-Cardiac structural & valvular disorders 8.0 (7.8-8.1) 98 (0-0) NE
201-Cardiac arrhythmia & conduction disorders 7.1 (6.6-7.7) 99 (1-2) ** **
203-Chest pain 3.7 (3.5-4.1) 99 (0-0)
204-Syncope & collapse 5.0 (4.8-5.2) 99 (0-0)
205-Cardiomyopathy 9.9 (9.4-10.7) 96 (0-0)
206-Malfunction,reaction,complication of cardiac/vasc device or procedure NE 99 (NE) NE NE
Subset 207-Pericarditis 8.5 (8.1-9.0) 99 (0-0)
Upper-decile-LOS
161-Cardiac defibrillator & heart assist implant 9.1 (8.0-10.9) 51 (3-4) ** *
162-Cardiac valve procedures w cardiac catheterization 9.5 (7.7-11.5) 29 (0-2) *
163-Cardiac valve procedures w/o cardiac catheterization 9.6 (7.5-12.4) 30 (4-6) *** **
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 9.1 (7.1-13.3) 31 (2-6) ** **
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 9.3 (6.7-13.2) 30 (6-10) *** ***
169-Major thoracic & abdominal vascular procedures 9.7 (8.7-11.8) 98 (4-7) *** ***
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock 9.6 (8.8-10.8) 93 (0-0)
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 8.8 (7.4-12.3) 98 (9-16) *** ***
174-Percutaneous cardiovascular procedures w AMI 9.0 (8.4-10.2) 94 (11-6) *** ***
175-Percutaneous cardiovascular procedures w/o AMI 8.6 (7.9-9.7) 89 (15-13) *** ***
176-Cardiac pacemaker & defibrillator device replacement 8.5 (7.7-9.4) 97 (3-4) *** **
177-Cardiac pacemaker & defibrillator revision except device replacement 9.5 (8.7-11.5) 96 (0-2) *
190-Acute myocardial infarction 9.2 (7.7-11.0) 99 (10-10) *** ***
191-Cardiac catheterization w circ disord exc ischemic heart disease 10.0 (7.6-11.3) 97 (20-9) *** ***
192-Cardiac catheterization for ischemic heart disease 9.3 (7.2-11.6) 91 (24-19) *** ***
193-Acute & subacute endocarditis 9.1 (8.8-10.0) 93 (0-0)
194-Heart failure 9.8 (7.2-12.8) 99 (23-28) *** ***
196-Cardiac arrest 8.7 (7.9-10.9) 98 (0-2) ** **
197-Peripheral & other vascular disorders 9.2 (7.6-11.2) 99 (8-11) *** ***
198-Angina pectoris & coronary atherosclerosis 8.9 (5.5-13.0) 99 (11-17) *** ***
199-Hypertension 9.1 (7.0-11.1) 99 (2-10) *** ***
200-Cardiac structural & valvular disorders 9.3 (7.1-13.0) 99 (1-8) *** ***
201-Cardiac arrhythmia & conduction disorders 8.8 (6.8-11.5) 99 (23-23) *** ***
203-Chest pain 8.1 (6.5-10.7) 99 (9-17) *** ***
204-Syncope & collapse 9.0 (7.1-11.5) 99 (16-18) *** ***
205-Cardiomyopathy 9.5 (9.1-10.3) 97 (0-0)
206-Malfunction,reaction,complication of cardiac/vasc device or procedure 9.6 (8.4-11.5) 99 (0-0) * *
Subset 207-Pericarditis 5.0 (4.3-5.5) 99 (0-0) *
Median RSR (IQR)a
N hosp (low-high)b
Variation model 1c
Variation model 2c
1
2
3
4
MOR (95% CI)
Model 1: patient characteristics
Model 2: patient and hospital characteristics

Figure 4.12. Hospital variation in APR-DRG-specific cardiovascular in-hospital mortality, 30-day readmissions, and prolonged length-of-stay, with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

APR-DRGs are ordered by APR-DRG number.

Abbreviations: LOS, length of stay; RSR, risk-standardised rate; IQR, interquartile range; NA, not applicable; NE, not estimable; MOR, median odds ratio; CI, confidence interval

[a]Based on the model including only patient characteristics (model 1)

[b]Total number of hospitals (number with RSR significantly lower than expected - number with RSR significantly higher than expected), based on model 1.

[c]Significance of the variation in risk across hospitals (based on a Wald test for the random hospital effect): * P<0.05, ** P<0.01, *** P<0.001

Note: Results are not presented for models with <30 cases (indicated as NA) and for models in which the random hospital effect was estimated to be zero (indicated as NE).

The median odds ratio for mortality exceeded 2 in four medical diagnoses *(endocarditis, cardiac arrest (CA), angina pectoris, hypertension),* with the highest MOR observed for *hypertension* (2.51) (Figure 4.12, numerical MOR values supplied in Appendix A.3.13). After correction for hospital characteristics the median odds ratio for *hypertension* mortality remained high (2.30), as well as for all other included pathologies, indicating that the between-hospital variation cannot be explained by the studied hospital characteristics. For readmissions, the highest MOR could be observed for *bypass without catheterization* (1.54), while *angina pectoris* patients had the highest MOR for pLOS (2.09).

Associations of mortality, readmissions and pLOS with patient and hospital characteristics

In general, the odds of mortality were higher for men than for women (Appendix A.3.14), whereas the odds of readmissions after surgical procedures and pLOS were lower for men. For the three outcomes, the odds were mainly higher for patients with a higher number of comorbidities and emergency admissions. Patients admitted from other hospitals or nursing homes often had higher odds of mortality and pLOS than patients admitted from home, whereas the opposite was true for readmissions.

The odds of mortality and pLOS were often lower in Flanders than in the other Belgian regions (for 10 and 16 APR-DRGs, respectively), while a reverse relationship could be detected for readmissions (nine APR-DRGs) (Table 4.10). Academic hospitals showed a lower odds of readmissions (two APR-DRGs) and pLOS (six medical APR-DRGs). However, increased odds of mortality in academic hospitals could be observed in three APR-DRGs: *major thoracic & abdominal procedures; catheterizations without ischemic heart disease* and *angina pectoris*. Finally, a higher cardiovascular admission volume was associated with a lower odds of mortality in one APR-DRG *(major thoracic & abdominal procedures),* with a lower odds of readmissions in four APR-DRGs and lower odds of pLOS in six APR-DRGs. On the other hand, higher volume was associated with increased odds of readmission in two APR-DRGs (*endocarditis; syncope & collapse)* and increased odds of pLOS in one APR-DRG *(complication of device or procedure).*

Table 4.10. Adjusted odds ratios (95% confidence intervals) for hospital characteristics from hierarchical logistic regression analyses of cardiovascular in-hospital mortality, 30-day readmission, and prolonged length-of-stay[a]

APR-DRG[b]	Mortality					Readmission					Prolonged Length of stay				
	Region (reference = Flanders)		Teaching status	Annual volume (reference = high)		Region (reference = Flanders)		Teaching status	Annual volume (reference = high)		Region (reference = Flanders)		Teaching status	Annual volume (reference = high)	
	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium
161						1.01 (0.61-1.67)	1.18 (0.79-1.76)	0.86 (0.57-1.30)	1.33 (0.85-2.10)	0.82 (0.55-1.24)	0.72 (0.41-1.27)	**0.54 (0.34-0.85)**	**2.15 (1.34-3.46)**	**2.06 (1.17-3.65)**	**2.20 (1.30-3.71)**
162	1.08 (0.61-1.93)	1.22 (0.81-1.84)	1.01 (0.60-1.70)	1.43 (0.87-2.34)	1.30 (0.74-2.29)			1.04 (0.53-2.06)	0.96 (0.48-1.92)	0.83 (0.38-1.81)	1.27 (0.62-2.61)	0.77 (0.42-1.42)	0.69 (0.34-1.38)	1.88 (0.84-4.24)	1.35 (0.53-3.44)
163	1.67 (0.90-3.10)	**2.53 (1.51-4.23)**	0.72 (0.41-1.27)	1.15 (0.55-2.40)	1.33 (0.64-2.79)	0.76 (0.52-1.12)	0.82 (0.59-1.15)	0.85 (0.60-1.21)	1.07 (0.69-1.64)	0.92 (0.60-1.39)	**2.02 (1.12-3.66)**	1.05 (0.62-1.78)	0.69 (0.40-1.20)	1.35 (0.64-2.87)	1.29 (0.60-2.78)
165	1.02 (0.53-1.99)	1.64 (0.95-2.82)	1.19 (0.62-2.28)	1.93 (0.88-4.25)	1.83 (0.81-4.15)	0.86 (0.54-1.35)	**0.70 (0.50-0.97)**	0.94 (0.62-1.43)	0.68 (0.45-1.01)	0.70 (0.48-1.01)	1.42 (0.81-2.48)	1.07 (0.66-1.74)	0.63 (0.36-1.13)	**2.66 (1.28-5.52)**	**2.82 (1.31-6.07)**
166	1.47 (0.64-3.41)	**2.49 (1.24-5.01)**	0.93 (0.47-1.81)	1.50 (0.59-3.79)	1.54 (0.74-3.23)	0.91 (0.54-1.56)	0.95 (0.60-1.49)	0.75 (0.49-1.16)	**2.17 (1.19-3.96)**	1.52 (0.94-2.46)	**2.06 (1.02-4.17)**	**1.87 (1.00-3.48)**	0.63 (0.34-1.15)	1.54 (0.66-3.55)	1.73 (0.88-3.44)
169	1.04 (0.74-1.47)	**1.40 (1.13-1.74)**	**1.42 (1.01-1.99)**	**2.05 (1.39-3.02)**	1.38 (0.98-1.93)	0.94 (0.64-1.38)	0.92 (0.72-1.19)	1.08 (0.72-1.61)	1.10 (0.69-1.76)	1.07 (0.71-1.61)	1.21 (0.80-1.84)	1.25 (0.96-1.63)	1.42 (0.86-2.35)	**2.43 (1.31-4.50)**	**2.22 (1.25-3.96)**
170								0.88 (0.36-2.14)	1.11 (0.47-2.63)	0.87 (0.39-1.92)	1.20 (0.50-2.90)	1.43 (0.82-2.49)			
171			0.97 (0.49-1.89)			**0.73 (0.56-0.95)**	0.87 (0.75-1.01)	0.87 (0.69-1.11)	1.11 (0.92-1.34)	1.03 (0.87-1.22)	**1.62 (1.07-2.45)**	**1.43 (1.11-1.84)**	0.86 (0.54-1.37)	1.26 (0.85-1.86)	0.92 (0.63-1.34)
174	0.82 (0.54-1.26)	1.29 (0.97-1.69)	1.25 (0.82-1.90)	0.86 (0.53-1.38)	1.13 (0.75-1.71)	0.84 (0.68-1.05)	**0.82 (0.71-0.94)**	**0.76 (0.62-0.92)**	0.87 (0.71-1.08)	0.86 (0.72-1.02)	1.22 (0.86-1.74)	1.04 (0.82-1.31)	1.00 (0.68-1.48)	1.52 (0.99-2.33)	1.22 (0.82-1.80)
175	1.11 (0.70-1.74)	**1.56 (1.10-2.20)**	1.56 (0.95-2.56)	0.85 (0.53-1.39)	1.04 (0.61-1.78)	0.92 (0.77-1.10)	**0.70 (0.61-0.81)**	**0.73 (0.60-0.89)**	**1.25 (1.06-1.48)**	**1.25 (1.03-1.51)**	1.31 (0.95-1.82)	**1.41 (1.12-1.77)**	1.34 (0.90-2.01)	1.35 (0.93-1.96)	1.05 (0.68-1.62)
176						1.10	**0.68**	0.79	1.18	1.13	1.32	1.33	1.50	1.54	1.33

						(0.68-1.77)	**(0.48-0.97)**	(0.51-1.20)	(0.77-1.80)	(0.77-1.65)	(0.73-2.39)	(0.89-2.00)	(0.85-2.64)	(0.84-2.81)	(0.74-2.40)
177						1.45 (0.76-2.79)	1.00 (0.63-1.58)	0.92 (0.47-1.82)	1.30 (0.62-2.76)	1.28 (0.69-2.37)	1.23 (0.61-2.45)	**2.27 (1.47-3.52)**	1.72 (0.87-3.42)	1.21 (0.58-2.52)	1.24 (0.65-2.34)
190	**1.59 (1.14-2.22)**	**1.37 (1.12-1.67)**	1.27 (0.88-1.83)	1.07 (0.80-1.42)	1.03 (0.79-1.34)	0.85 (0.67-1.08)	0.91 (0.79-1.04)	0.89 (0.71-1.11)			1.35 (0.94-1.95)	0.95 (0.76-1.18)	**0.62 (0.41-0.94)**	**1.40 (1.03-1.92)**	1.08 (0.81-1.45)
191	0.93 (0.51-1.69)	**1.65 (1.12-2.43)**	**2.23 (1.18-4.22)**	0.89 (0.44-1.80)	1.61 (0.85-3.08)	0.90 (0.71-1.14)	0.86 (0.73-1.02)	1.06 (0.82-1.36)	**1.33 (1.03-1.73)**	1.13 (0.90-1.44)	1.38 (0.98-1.93)	**1.36 (1.09-1.70)**	1.29 (0.83-2.01)	**2.04 (1.28-3.25)**	1.22 (0.78-1.91)
192	1.32 (0.58-3.03)	1.48 (0.82-2.65)	1.24 (0.54-2.81)	1.43 (0.60-3.42)	1.82 (0.81-4.09)	0.84 (0.63-1.11)	**0.79 (0.66-0.95)**	0.86 (0.66-1.13)	**1.39 (1.10-1.77)**	0.99 (0.79-1.25)	1.11 (0.71-1.74)	0.98 (0.73-1.31)	0.65 (0.38-1.09)	**2.21 (1.37-3.56)**	1.11 (0.68-1.82)
193	0.71 (0.25-1.97)	1.01 (0.50-2.04)	0.78 (0.26-2.38)	0.94 (0.34-2.55)	0.90 (0.36-2.30)	2.58 (0.90-7.39)	1.19 (0.52-2.71)	0.80 (0.31-2.07)	**0.27 (0.09-0.85)**	0.46 (0.18-1.14)	1.88 (0.84-4.22)	1.36 (0.71-2.59)		1.01 (0.43-2.38)	1.08 (0.51-2.28)
194	0.99 (0.85-1.14)	**1.18 (1.08-1.29)**	0.89 (0.76-1.06)	1.08 (0.95-1.23)	1.02 (0.90-1.16)	0.89 (0.79-1.00)	**0.88 (0.82-0.94)**	0.95 (0.84-1.08)	0.96 (0.87-1.06)	1.00 (0.92-1.10)	**1.59 (1.19-2.12)**	1.11 (0.93-1.33)	**0.60 (0.42-0.84)**	0.94 (0.72-1.25)	0.83 (0.63-1.09)
196	**2.09 (1.06-4.10)**	**1.99 (1.28-3.08)**	0.96 (0.47-1.95)	0.73 (0.36-1.45)	1.24 (0.63-2.44)			0.75 (0.23-2.47)			0.79 (0.44-1.42)	0.68 (0.45-1.04)	0.89 (0.48-1.66)	1.11 (0.61-2.02)	1.09 (0.61-1.92)
197	1.06 (0.80-1.39)	1.19 (1.00-1.43)	0.84 (0.58-1.22)	0.80 (0.58-1.09)	0.98 (0.73-1.32)	0.84 (0.66-1.06)	0.89 (0.76-1.05)	0.77 (0.57-1.03)	1.09 (0.84-1.40)	1.00 (0.79-1.27)	**1.41 (1.00-1.98)**	**1.32 (1.05-1.65)**	**0.49 (0.29-0.83)**	1.11 (0.72-1.72)	1.13 (0.73-1.74)
198	**2.08 (1.16-3.73)**	**1.84 (1.25-2.71)**	**2.00 (1.07-3.76)**	1.38 (0.77-2.45)	1.08 (0.63-1.86)	1.14 (0.82-1.57)	1.04 (0.84-1.29)	0.94 (0.67-1.30)	0.97 (0.72-1.30)	1.11 (0.86-1.44)	**2.67 (1.61-4.42)**	**2.00 (1.45-2.77)**	0.61 (0.33-1.10)	1.39 (0.84-2.32)	1.25 (0.77-2.04)
199	2.18 (0.80-5.98)	1.80 (0.94-3.44)	0.21 (0.04-1.24)	0.66 (0.26-1.69)	0.98 (0.42-2.24)	1.11 (0.73-1.67)	0.86 (0.65-1.13)	0.64 (0.37-1.12)	0.79 (0.55-1.14)	0.95 (0.68-1.31)	**1.90 (1.23-2.95)**	**1.77 (1.34-2.35)**	0.71 (0.40-1.24)	0.98 (0.66-1.45)	0.96 (0.66-1.39)
200	0.96 (0.56-1.63)	1.24 (0.91-1.70)	1.04 (0.61-1.78)	1.10 (0.65-1.85)	1.08 (0.67-1.75)	0.70 (0.42-1.18)	**0.73 (0.53-1.00)**	0.68 (0.42-1.11)	0.78 (0.48-1.27)	1.09 (0.72-1.65)	**2.75 (1.54-4.92)**	1.37 (0.93-2.00)	**0.44 (0.21-0.89)**	1.39 (0.70-2.76)	1.33 (0.70-2.54)
201	**1.69 (1.21-2.37)**	**1.47 (1.19-1.82)**	0.90 (0.61-1.31)	0.96 (0.71-1.30)	0.90 (0.67-1.21)	0.87 (0.74-1.04)	**0.81 (0.73-0.90)**	1.07 (0.90-1.26)	0.94 (0.82-1.08)	0.94 (0.83-1.06)	**2.13 (1.51-3.02)**	**1.65 (1.34-2.05)**	**0.56 (0.37-0.84)**	1.22 (0.88-1.71)	0.96 (0.69-1.33)
203						1.04	1.15	1.14	0.95	0.95	1.60	**1.47**	0.67	1.26	1.17

						(0.66-1.65)	(0.89-1.50)	(0.77-1.70)	(0.68-1.33)	(0.71-1.27)	(0.94-2.74)	**(1.05-2.06)**	(0.37-1.19)	(0.76-2.09)	(0.73-1.89)
204	0.75 (0.38-1.49)	0.97 (0.66-1.44)	0.53 (0.27-1.04)	1.17 (0.72-1.90)	1.20 (0.81-1.78)				**0.67 (0.58-0.79)**	0.91 (0.80-1.03)	**2.70 (1.87-3.91)**	**1.81 (1.41-2.32)**	**0.52 (0.35-0.78)**	0.75 (0.51-1.08)	0.91 (0.65-1.28)
205	1.31 (0.60-2.87)	0.86 (0.51-1.46)	0.62 (0.25-1.53)			0.82 (0.36-1.90)	1.04 (0.62-1.75)	0.92 (0.37-2.30)	1.03 (0.46-2.29)	0.95 (0.46-1.99)	1.14 (0.55-2.37)	1.31 (0.81-2.10)	0.53 (0.21-1.31)	0.78 (0.37-1.66)	0.84 (0.43-1.63)
206	1.01 (0.50-2.02)	1.12 (0.71-1.76)				0.92 (0.62-1.37)	1.01 (0.76-1.34)	0.58 (0.21-1.57)	0.47 (0.17-1.34)	0.54 (0.20-1.45)	1.58 (0.98-2.56)	1.09 (0.78-1.53)	0.30 (0.08-1.08)	**0.21 (0.05-0.79)**	**0.27 (0.08-0.97)**
207*	1.10 (0.27-4.40)	1.70 (0.72-4.02)	1.21 (0.34-4.26)	0.83 (0.27-2.62)	0.62 (0.23-1.70)	0.93 (0.59-1.46)	0.94 (0.69-1.27)	0.91 (0.60-1.39)	0.82 (0.56-1.20)	0.90 (0.67-1.23)	**2.77 (1.64-4.68)**	**1.65 (1.13-2.41)**	0.87 (0.50-1.50)	1.21 (0.73-2.01)	0.91 (0.59-1.40)

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge; Bold indicates significance $p<0.05$; Grey indicates a surgical APR-DRG

[b]APR-DRG codes: 161-Cardiac defibrillator & heart assist implant; 162-Cardiac valve procedures with cardiac catheterization; 163-Cardiac valve procedures without cardiac catheterization; 165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure; 166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure; 169-Major thoracic & abdominal vascular procedures; 170-Permanent cardiac pacemaker implant with acute myocardial infarction, heart failure or shock; 171-Perm cardiac pacemaker implant without acute myocardial infarction, heart failure or shock; 174-Percutaneous cardiovascular procedures with acute myocardial infarction; 175-Percutaneous cardiovascular procedures without acute myocardial infarction; 176-Cardiac pacemaker & defibrillator device replacement; 177-Cardiac pacemaker & defibrillator revision except device replacement; 190-Acute myocardial infarction; 191-Cardiac catheterization with circulatory disorder except ischemic heart disease; 192-Cardiac catheterization for ischemic heart disease; 193-Acute & subacute endocarditis; 194-Heart failure; 196-Cardiac arrest; 197-Peripheral & other vascular disorders; 198-Angina pectoris & coronary atherosclerosis; 199-Hypertension; 200-Cardiac structural & valvular disorders; 201-Cardiac arrhythmia & conduction disorders; 203-Chest pain; 204-Syncope & collapse; 205-Cardiomyopathy; 206-Malfunction,reaction,complication of cardiac/vascular device or procedure; 207*-Pericard

Potential deaths, readmissions and long patient stays avoided

To quantify the potential gain of reducing between-hospital variation, we calculated the number of cases that could theoretically be avoided if APR-DRG-specific risk-standardised mortality, readmission and pLOS rates in upper-quartile (i.e. lowest performing) hospitals would be reduced to the median values. A total of 633 cardiovascular deaths per year, or 26.4% of observed mortality in those hospitals could possibly be avoided (Figure 4.13a). Moreover, 322 (11.8%) readmissions and 1,578 (33.3%) long patient stays could be avoided in those upper-quartile hospitals. The highest absolute gain could be made in *HF* patients, with 122 deaths, 62 readmissions and 277 pLOS potentially avoidable (Figure 4.13b). The highest relative gain in mortality would be observed in *hypertension* patients, with 76.2% of deaths that could be avoided in the upper-quartile hospitals. *Cardiac arrest* patients had the highest potential for improving 30-day readmissions, with 38.9% potential cases avoided, while pLOS could be avoided 50.1% of patients admitted for *angina pectoris.*

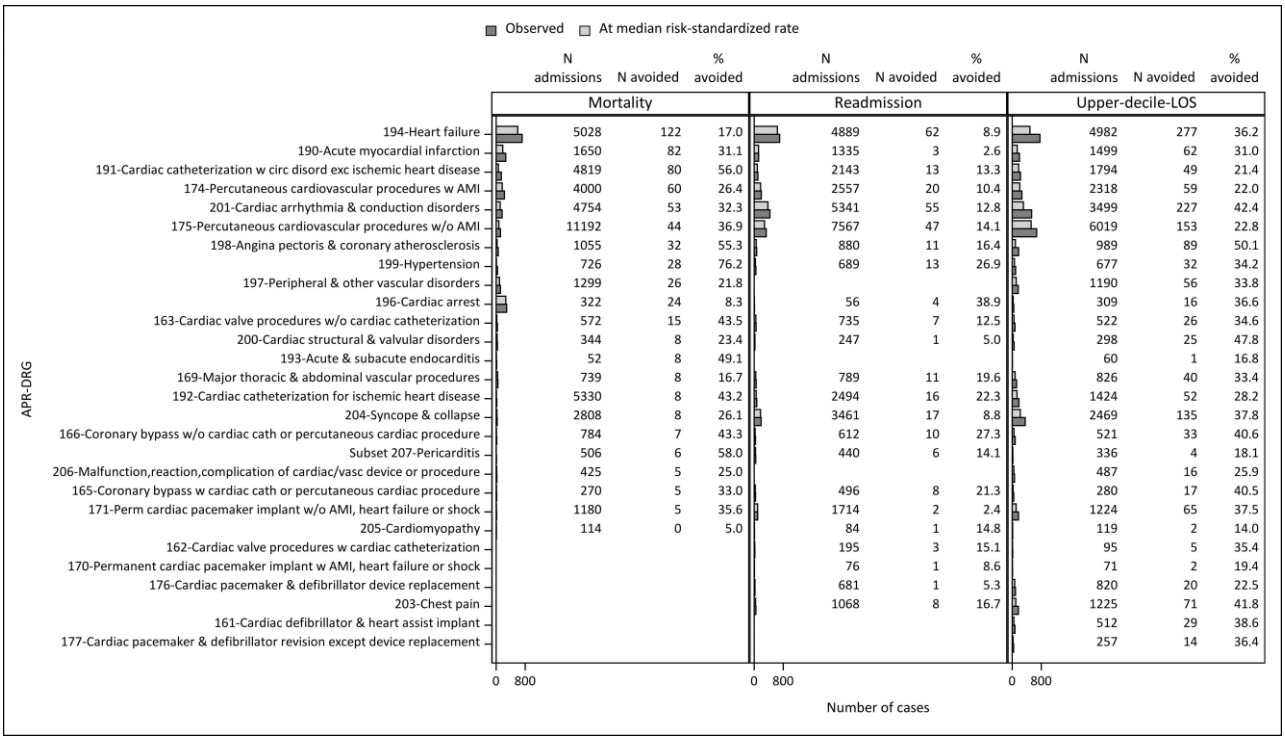


Figure 4.13a. Annual number of observed deaths, readmissions and prolonged length of stay and estimated deaths, readmissions and prolonged length-of-stay (pLOS) among cardiovascular APR-DRGs if outcomes in hospitals with risk-standardised outcome rates in the upper quartile would be reduced to the median value.

Results are based on the risk-standardised mortality, readmission and pLOS distribution estimated by the model including only patient characteristics. Numbers at the bottom of the figure represent the annual APR-DRG-specific number of admissions and cases saved in hospitals with risk-adjusted mortality, readmission and pLOS, respectively in the upper quartile. The percentage of cases saved is calculated relative to the number of risk-adjusted observed deaths, readmissions and pLOS in those hospitals.

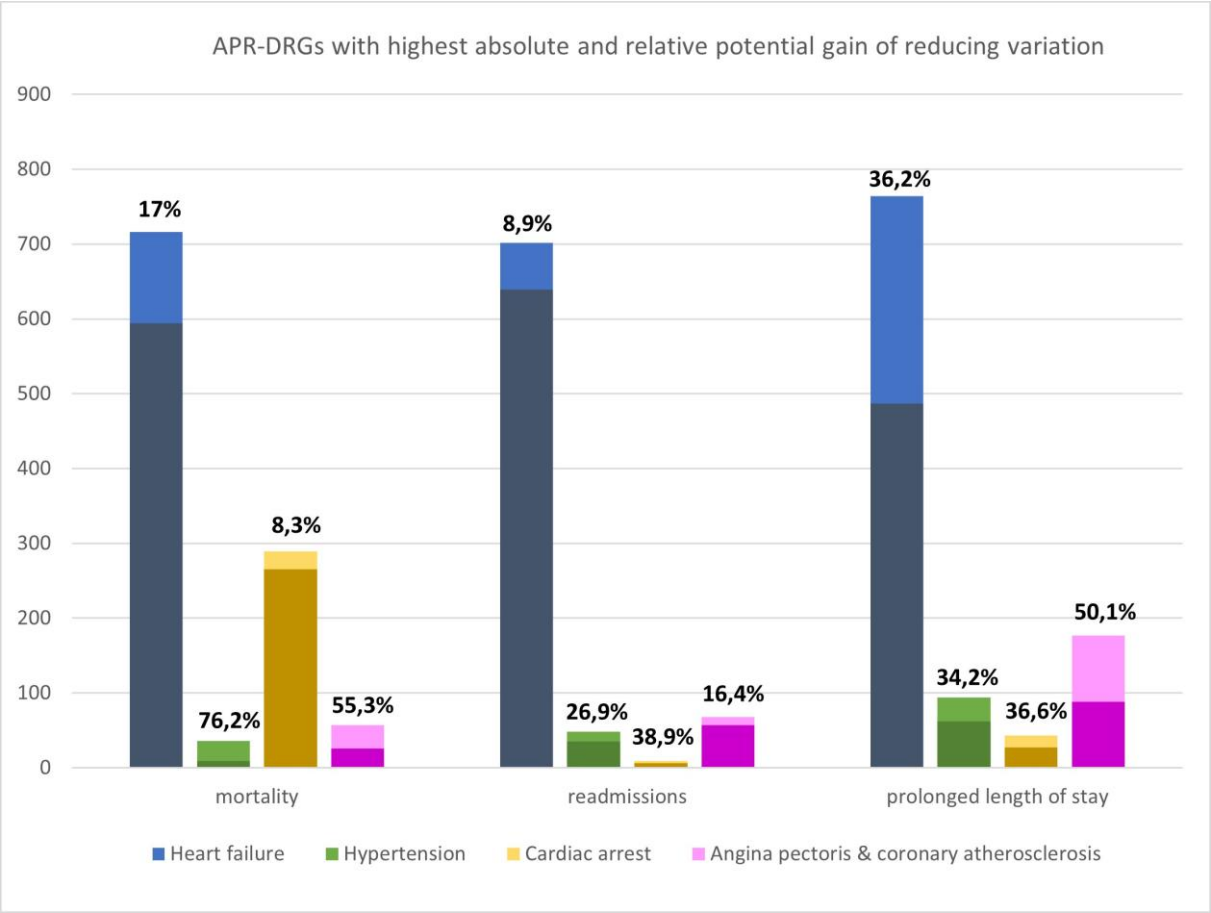


Figure 4.13b. APR-DRGs with highest absolute and relative potential gain of reducing inter-hospital variation.

The y-axis displays the number of cases in the upper-quartile (i.e. worst-performing) hospitals, with a lighter colour indicating the number of observed cases and a darker colour indicating the number of cases when reduced to the median risk-standardised rate. Numbers above the bar indicate the % of cases avoided. Heart failure displays the largest absolute potential across outcomes, hypertension the largest relative potential for mortality, cardiac arrest the largest relative potential for readmissions and angina pectoris & coronary atherosclerosis the largest relative potential for prolonged length-of-stay.

Trends over time

Overall patient outcome rate changes were relatively small between 2012 and 2018 (Figure 4.14). *Major thoracic & abdominal procedures* saw the highest reduction in pLOS, with an improvement of five percentage points (14.7% to 9.7%) over time. Across all APR-DRGs, pLOS most frequently improved, with improvements observed in 18 APR-DRGs. For mortality, risk-adjusted rates improved in eight APR-DRGs (e.g. *major thoracic & abdominal procedures, cardiac arrest, HF)*, while rates for another eight deteriorated (e.g. *hypertension, cardiomyopathy*). Readmission rates mainly worsened, with increases observed in 13 APR-DRGs and declines in only two APR-DRGs.

Statistically significant between-hospital variation became more frequent in more recent years compared to the 2012-2014 period. For mortality for instance, variation was statistically significant in 2016-2018 but not in 2012-2014 in three APR-DRGs (*bypass without catheterization; hypertension; structural & valvular disorders*). Four APR-DRGs displayed a higher level of statistical significance (i.e. lower p-values) for between-hospital variation in mortality in the most recent period (*catheterization without*

ischemic heart disease; CA; peripheral disorders; angina pectoris). Similarly, MORs for mortality over time increased for those APR-DRGs, with a remarkable increase in MOR for hypertension from below 1.5 to over 2.5. Like for mortality, the level of significance and MORs increased for a*ngina pectoris* and *hypertension* for both readmissions and pLOS. For readmissions, a total of three APR-DRGs displayed statistically significant between-hospital variation in 2016-2018 but not in 2012-2014 (*bypass with catheterization; angina pectoris; hypertension)*, while between-hospital variation in *complication of device or procedure* became significant for pLOS. Only five APR-DRGs showed improvements over time, with higher levels of statistically significant variation in 2012-2014 compared to 2016-2018, i.e. *pacemaker without AMI/HF/shock* for mortality, *catheterization without ischemic heart disease, HF* and *arrhythmia & conduction disorders* for readmissions and *pacemaker with AMI/HF/shock* for pLOS.

4.4.5 Discussion

Summary of key results

Cardiovascular care in Belgium is characterised by extensive variation in patient outcomes between acute-care hospitals. Adjusting for patient characteristics, statistically significant between-hospital variation in risk for all three outcomes was observed for four surgical procedures *(bypass without catheterization; major thoracic & abdominal procedures; PCI with AMI; PCI without AMI)* and five medical diagnoses *(catheterization without ischemic heart disease; HF; angina pectoris & coronary atherosclerosis (angina pectoris); hypertension; arrhythmia & conduction disorders).* Additional adjustments for hospital characteristics helped explain some of the observed inter-hospital variation, but only minimally, resulting in five out of 28 APR-DRGs with statistically significant inter-hospital variation in mortality, readmissions and pLOS: *PCI without AMI, heart failure, hypertension, angina pectoris and arrhythmia.* Overall, the observed variation increased over time, with statistically significant between-hospital variation observed in a larger number of APR-DRGs in the 2016-2018 period compared to 2012-2014. Should hospitals target this variability by improving the upper-quartile performing hospitals to the median level of care, an annual 633 deaths, 322 readmissions and 1578 extended hospital stays could potentially be avoided. Not only could this positively impact patient safety, reducing variation in readmission and pLOS could also reduce economical and societal costs.[63,128]

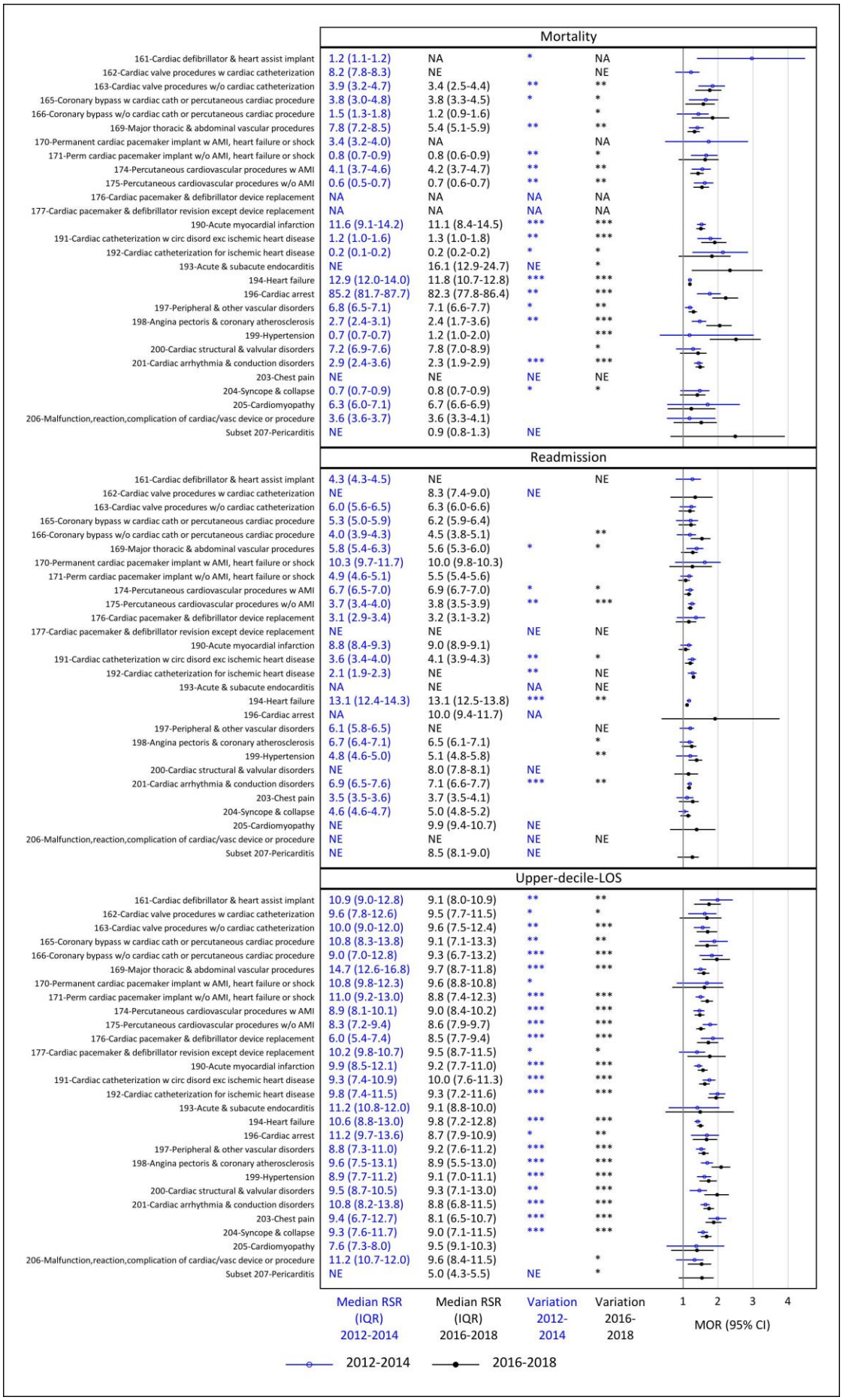

Mortality
161-Cardiac defibrillator & heart assist implant 1.2 (1.1-1.2) NA * NA
162-Cardiac valve procedures w cardiac catheterization 8.2 (7.8-8.3) NE NE
163-Cardiac valve procedures w/o cardiac catheterization 3.9 (3.2-4.7) 3.4 (2.5-4.4) ** **
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 3.8 (3.0-4.8) 3.8 (3.3-4.5) * *
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 1.5 (1.3-1.8) 1.2 (0.9-1.6) *
169-Major thoracic & abdominal vascular procedures 7.8 (7.2-8.5) 5.4 (5.1-5.9) ** **
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock 3.4 (3.2-4.0) NA NA
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 0.8 (0.7-0.9) 0.8 (0.6-0.9) ** *
174-Percutaneous cardiovascular procedures w AMI 4.1 (3.7-4.6) 4.2 (3.7-4.7) ** **
175-Percutaneous cardiovascular procedures w/o AMI 0.6 (0.5-0.7) 0.7 (0.6-0.7) ** **
176-Cardiac pacemaker & defibrillator device replacement NA NA NA NA
177-Cardiac pacemaker & defibrillator revision except device replacement NA NA NA NA
190-Acute myocardial infarction 11.6 (9.1-14.2) 11.1 (8.4-14.5) *** ***
191-Cardiac catheterization w circ disord exc ischemic heart disease 1.2 (1.0-1.6) 1.3 (1.0-1.8) ** ***
192-Cardiac catheterization for ischemic heart disease 0.2 (0.1-0.2) 0.2 (0.2-0.2) * *
193-Acute & subacute endocarditis NE 16.1 (12.9-24.7) NE *
194-Heart failure 12.9 (12.0-14.0) 11.8 (10.7-12.8) *** ***
196-Cardiac arrest 85.2 (81.7-87.7) 82.3 (77.8-86.4) ** ***
197-Peripheral & other vascular disorders 6.8 (6.5-7.1) 7.1 (6.6-7.7) * **
198-Angina pectoris & coronary atherosclerosis 2.7 (2.4-3.1) 2.4 (1.7-3.6) ** ***
199-Hypertension 0.7 (0.7-0.7) 1.2 (1.0-2.0) ***
200-Cardiac structural & valvular disorders 7.2 (6.9-7.6) 7.8 (7.0-8.9) *
201-Cardiac arrhythmia & conduction disorders 2.9 (2.4-3.6) 2.3 (1.9-2.9) *** ***
203-Chest pain NE NE NE NE
204-Syncope & collapse 0.7 (0.7-0.9) 0.8 (0.7-0.9) * *
205-Cardiomyopathy 6.3 (6.0-7.1) 6.7 (6.6-6.9)
206-Malfunction,reaction,complication of cardiac/vasc device or procedure 3.6 (3.6-3.7) 3.6 (3.3-4.1)
Subset 207-Pericarditis NE 0.9 (0.8-1.3) NE
Readmission
161-Cardiac defibrillator & heart assist implant 4.3 (4.3-4.5) NE NE
162-Cardiac valve procedures w cardiac catheterization NE 8.3 (7.4-9.0) NE
163-Cardiac valve procedures w/o cardiac catheterization 6.0 (5.6-6.5) 6.3 (6.0-6.6)
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 5.3 (5.0-5.9) 6.2 (5.9-6.4)
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 4.0 (3.9-4.3) 4.5 (3.8-5.1) **
169-Major thoracic & abdominal vascular procedures 5.8 (5.4-6.3) 5.6 (5.3-6.0) * *
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock 10.3 (9.7-11.7) 10.0 (9.8-10.3)
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 4.9 (4.6-5.1) 5.5 (5.4-5.6)
174-Percutaneous cardiovascular procedures w AMI 6.7 (6.5-7.0) 6.9 (6.7-7.0) * *
175-Percutaneous cardiovascular procedures w/o AMI 3.7 (3.4-4.0) 3.8 (3.5-3.9) ** ***
176-Cardiac pacemaker & defibrillator device replacement 3.1 (2.9-3.4) 3.2 (3.1-3.2)
177-Cardiac pacemaker & defibrillator revision except device replacement NE NE NE NE
190-Acute myocardial infarction 8.8 (8.4-9.3) 9.0 (8.9-9.1)
191-Cardiac catheterization w circ disord exc ischemic heart disease 3.6 (3.4-4.0) 4.1 (3.9-4.3) ** *
192-Cardiac catheterization for ischemic heart disease 2.1 (1.9-2.3) NE ** NE
193-Acute & subacute endocarditis NA NE NA NE
194-Heart failure 13.1 (12.4-14.3) 13.1 (12.5-13.8) *** **
196-Cardiac arrest NA 10.0 (9.4-11.7) NA
197-Peripheral & other vascular disorders 6.1 (5.8-6.5) NE NE
198-Angina pectoris & coronary atherosclerosis 6.7 (6.4-7.1) 6.5 (6.1-7.1) *
199-Hypertension 4.8 (4.6-5.0) 5.1 (4.8-5.8) **
200-Cardiac structural & valvular disorders NE 8.0 (7.8-8.1) NE
201-Cardiac arrhythmia & conduction disorders 6.9 (6.5-7.6) 7.1 (6.6-7.7) *** **
203-Chest pain 3.5 (3.5-3.6) 3.7 (3.5-4.1)
204-Syncope & collapse 4.6 (4.6-4.7) 5.0 (4.8-5.2)
205-Cardiomyopathy NE 9.9 (9.4-10.7) NE
206-Malfunction,reaction,complication of cardiac/vasc device or procedure NE NE NE NE
Subset 207-Pericarditis NE 8.5 (8.1-9.0) NE
Upper-decile-LOS
161-Cardiac defibrillator & heart assist implant 10.9 (9.0-12.8) 9.1 (8.0-10.9) ** **
162-Cardiac valve procedures w cardiac catheterization 9.6 (7.8-12.6) 9.5 (7.7-11.5) * *
163-Cardiac valve procedures w/o cardiac catheterization 10.0 (9.0-12.0) 9.6 (7.5-12.4) ** ***
165-Coronary bypass w cardiac cath or percutaneous cardiac procedure 10.8 (8.3-13.8) 9.1 (7.1-13.3) ** **
166-Coronary bypass w/o cardiac cath or percutaneous cardiac procedure 9.0 (7.0-12.8) 9.3 (6.7-13.2) *** ***
169-Major thoracic & abdominal vascular procedures 14.7 (12.6-16.8) 9.7 (8.7-11.8) *** ***
170-Permanent cardiac pacemaker implant w AMI, heart failure or shock 10.8 (9.8-12.3) 9.6 (8.8-10.8) *
171-Perm cardiac pacemaker implant w/o AMI, heart failure or shock 11.0 (9.2-13.0) 8.8 (7.4-12.3) *** ***
174-Percutaneous cardiovascular procedures w AMI 8.9 (8.1-10.1) 9.0 (8.4-10.2) *** ***
175-Percutaneous cardiovascular procedures w/o AMI 8.3 (7.2-9.4) 8.6 (7.9-9.7) *** ***
176-Cardiac pacemaker & defibrillator device replacement 6.0 (5.4-7.4) 8.5 (7.7-9.4) *** ***
177-Cardiac pacemaker & defibrillator revision except device replacement 10.2 (9.8-10.7) 9.5 (8.7-11.5) * *
190-Acute myocardial infarction 9.9 (8.5-12.1) 9.2 (7.7-11.0) *** ***
191-Cardiac catheterization w circ disord exc ischemic heart disease 9.3 (7.4-10.9) 10.0 (7.6-11.3) *** ***
192-Cardiac catheterization for ischemic heart disease 9.8 (7.4-11.5) 9.3 (7.2-11.6) *** ***
193-Acute & subacute endocarditis 11.2 (10.8-12.0) 9.1 (8.8-10.0)
194-Heart failure 10.6 (8.8-13.0) 9.8 (7.2-12.8) *** ***
196-Cardiac arrest 11.2 (9.7-13.6) 8.7 (7.9-10.9) * **
197-Peripheral & other vascular disorders 8.8 (7.3-11.0) 9.2 (7.6-11.2) *** ***
198-Angina pectoris & coronary atherosclerosis 9.6 (7.5-13.1) 8.9 (5.5-13.0) *** ***
199-Hypertension 8.9 (7.7-11.2) 9.1 (7.0-11.1) *** ***
200-Cardiac structural & valvular disorders 9.5 (8.7-10.5) 9.3 (7.1-13.0) ** ***
201-Cardiac arrhythmia & conduction disorders 10.8 (8.2-13.8) 8.8 (6.8-11.5) *** ***
203-Chest pain 9.4 (6.7-12.7) 8.1 (6.5-10.7) *** ***
204-Syncope & collapse 9.3 (7.6-11.7) 9.0 (7.1-11.5) *** ***
205-Cardiomyopathy 7.6 (7.3-8.0) 9.5 (9.1-10.3)
206-Malfunction,reaction,complication of cardiac/vasc device or procedure 11.2 (10.7-12.0) 9.6 (8.4-11.5) *
Subset 207-Pericarditis NE 5.0 (4.3-5.5) NE *
Median RSR (IQR) 2012-2014
Median RSR (IQR) 2016-2018
Variation 2012-2014
Variation 2016-2018
1 2 3 4
MOR (95% CI)
2012-2014
2016-2018

Figure 4.14. Comparison of hospital variation in APR-DRG-specific cardiovascular in-hospital mortality, 30-day readmissions, and prolonged length of stay between the main study period (2016-2018) and the three years before (2012-2014), with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

Results are based on models including only patient characteristics. APR-DRGs are ordered by decreasing variation (based on the significance of the variation in the model for 2016-2018) across the 3 outcomes.

Abbreviations: LOS, length of stay; RSR, risk-standardised rate; IQR, interquartile range; NA, not applicable; NE, not estimable; MOR, median odds ratio; CI, confidence interval

[a]Significance of the variation in risk across hospitals (based on a Wald test for the random hospital effect): * P<0.05, ** P<0.01, *** P<0.001

Across our analyses, medical diagnoses appear to be more prone to inter-hospital variation than surgical procedures. Four medical diagnoses that stand out should be prioritised by policy makers in future quality improvement initiatives. First, *heart failure* is a large driver of inter-hospital variation and continues to be the largest contributor to in-hospital mortality with over 82% of patients dying during their admission. As such, it has the largest potential in terms of absolute numbers of deaths, readmissions and pLOS that could be avoided when the worst performing hospitals would improve their outcomes to the median level of care. Second, while on average only 1.2% of patients admitted for *hypertension* pass away during their hospital stay, *hypertension* displayed distinctive inter-hospital variation across the three outcomes, but most outspoken for mortality. This is highlighted by the observation of the highest MOR as well as highest MOR increase over time for mortality. For the 2016-2018 period, the odds of a similar patient dying at a higher-risk hospital was more than 150% greater than for a lower-risk hospital, indicating tremendous room for improvement. This is further confirmed by the largest relative potential in avoided deaths (76.2%) when improving the bottom-performing hospitals. Worldwide, *hypertension* is seen as one of the largest contributors to death.[129] Our numbers suggest that targeting variation in *hypertension* care could bring about vital improvements. Third, *cardiac arrest* patients demonstrated the highest relative gain for readmissions, with nearly 39% of readmissions that could potentially be avoided in bottom-performing hospitals. Again, this variation increased over time. Finally, *angina pectoris* has reached statistical significance with a p-value below 0.001 across the three surveyed outcomes and showed the highest MOR for pLOS, which in addition has increased over time. It also showed the largest relative potential gain for pLOS with over 50% of long patient stays avoided when improving bottom-performing hospitals to the median.

Variation persists despite adjustments for patient and hospital factors

Our analyses discovered remarkable inter-hospital variation despite adjusting for patient case-mix. Even after additional adjustment for known hospital characteristics that might contribute to variation such as region[92,119], teaching status[96,121] and volume[130,131], variation still persisted. Additionally, MORs for APR-DRGs with significant between-hospital variation were often higher than odds ratios for hospital characteristics, indicating between-hospital variation exceeds variation explained by the included hospitals characteristics. This was also observed in previous research on hospital-wide and urological Belgian hospital care.[123,132] Further investigation is required on other hospital context factors that might be contributing to this variation, including leadership characteristics, quality education or quality culture.[76–78] They might help clarify the observed and previously reported regional differences in outcomes[123], wherein Flanders outperformed other regions for mortality and pLOS but demonstrated

worse readmission rates. Additionally, staffing levels of physicians and nurses might also play a part in outcome disparities.[93] Finally, differences in discharge policies and follow-up care could account for differences in readmissions and pLOS, further reinforcing the need for integrated care[114,128].

Towards reduction in inter-hospital variation

Previous research within our team on urological care discovered that medical diagnoses such as *urinary tract infections* are more prone to inter-hospital variation than surgical procedures.[132] Similarly, we found that four medical diagnoses (*heart failure, hypertension, cardiac arrest* and *angina pectoris)* are the largest drivers of inter-hospital variation in cardiovascular care. However, while we argued that urological medical diagnoses have not received the same attention in clinical guideline development and standardisation than surgical and oncological diagnoses, we feel this does not hold for cardiovascular care. The European Society of Cardiology has developed and disseminated strong evidence-based guidelines with clear indications for appropriate use for surgical procedures and medical diagnoses and established treatment strategies and integrated care pathways.[133] Cardiologists have reported high awareness of these guidelines, which are well accepted within the profession.[118,122] One aspect that all above-mentioned medical diagnoses have in common, though, is the fact that while physicians in charge of treatment are often cardiologists, internists and geriatricians also take part in their treatment, as well as primary care physicians.[134] It has been shown that implementation of guidelines differs between specialities.[134,135] As cardiovascular care is practiced within interdisciplinary teams and across both primary and secondary care, improving guideline implementation is a multi-faceted clinical issue,[136] that has demonstrated to influence patient outcomes.[117,118,137] Strategies such as hospital-wide care pathways[138], bundled payments initiatives[139] or collaborative and peer-reviewed learning could aid in this regard[72] and should be expanded from existing initiatives.[111] In the spirit of a Safety-II approach[140], the systematic collation and benchmarking of outcomes on a national level, such as we propose within this paper, could be the starting point towards their implementation.

Limitations

Several study limitations merit attention. First, readmission rates are likely underestimated because we were unable to include readmissions occurring in December and readmissions to other hospitals. Second, while we accounted for numerous patient-related factors associated with disease severity, the lack of hemodynamic parameters or information on inflammatory burden and kidney function[120] might help explain some of the observed variation in care. Additionally, other patient-related factors such as ethnicity or economic status were not accounted for.[141,142] Perhaps these additional factors could help explain the higher odds of mortality in academic hospitals for e.g. *major thoracic & abdominal procedures* patients, for which past studies have indicated better outcomes at major teaching and cardiac centres.[121,130] Third, we did not obtain results for some outcome-APR-DRG combinations because the random component was estimated to be zero, which could indicate low inter-hospital variation, but which also could result from a model misspecification, especially in case of low numbers. This could have contributed to a potential lack of power in some mortality and readmission models. Despite these limitations, our study comprised the majority of the Belgian cardiovascular population and was able to identify cardiovascular APR-DRGs with important variation for mortality, readmission and pLOS.

4.4.6 Conclusions

Cardiovascular care is characterised by notable inter-hospital variation in mortality, readmission and prolonged length of stay in Belgium. In particular, four medical diagnoses (*heart failure, hypertension, angina pectoris* and *cardiac arrest*) that are often treated in an interdisciplinary setting, demonstrated remarkable variation in outcomes which should be prioritised by policy makers and hospital managers. Reducing variation via targeted health care strategies such as improving guideline implementation across specialties has the potential of major mortality and morbidity benefits as well as substantial reductions in societal health care costs. The presented methods within this paper are easily transferrable to other disease groups besides cardiology, allowing priority setting across the healthcare spectrum.

4.5 Identifying High Impact Opportunity Hospitals for improving healthcare quality based on a national population analysis of inter-hospital variation in mortality, readmissions and prolonged length of stay

4.5.1 Abstract

Excessive between-hospital variation threatens hospital quality. Data on hospital-wide variation in mortality, readmissions and prolonged length-of-stay is lacking for Belgian hospitals. We aimed to study variation for 4,606,721 hospital stays in 99 (98%) Belgian acute-care hospitals between 2016 and 2018. Using generalised linear mixed models, we calculated hospital-specific and Major Diagnostic Category (MDC)-specific risk-adjusted in-hospital mortality, readmissions within 30 days and length-of-stay above the MDC-specific 90th percentile and assessed between-hospital variation through estimated variance components. There was strong evidence of between-hospital variation in mortality, readmissions and prolonged length-of-stay across the vast majority of patient service lines. Overall, should hospitals with upper-quartile risk-standardised rates succeed to improve to the median level, a yearly 4,086 hospital deaths, 3,684 readmissions and 16,009 long patient stays could potentially be avoided in those hospitals. Our analysis revealed a select set of 'high impact opportunity hospitals' characterised by poor performance across outcomes and across a large number of MDCs. Analysis of between-hospital variation highlights important differences in patient outcomes that are not explained by known patient or hospital characteristics. Identifying 'high impact opportunity hospitals' can help government inspection bodies and hospital managers to establish targeted audits and inspections to generate effective quality improvement initiatives.

Key words: Hospitals, Healthcare Quality, Variation, Mortality, Length of Stay, Readmission

4.5.2 Introduction

In early 2023, Bates and colleagues published their already seminal article demonstrating how patient harm remains an important concern in hospital care,[143] urging a reprioritisation of patient safety and healthcare quality.[144] The past twenty years have been characterised by indispensable quality developments,[34] which included implementation of accreditation bodies and public reporting to provide foundations for monitoring and promoting healthcare organisation performance, in particular concerning adherence to process measures.[145] Yet, it appears that quality progress made was not sustainable on the long term, as indicated by e.g. nosocomial infections rising in the aftermath of the covid-19 pandemic,[146,147] or mortality reductions being abolished weeks after accreditation survey visits.[148] A resilient safety culture with quality truly embedded into every day practice can only occur after increased awareness of hospital-wide safety risks.[34,149]

In Belgium, the setting of this study, there is a lack of systematic hospital-wide quality monitoring, despite indications of important differences in patient outcomes between hospitals that continue to persist over time.[123] It has been shown for specific patient groups, such as urology [132] or cardiology,[150] that outcomes such as mortality, readmissions and prolonged length-of-stay vary excessively between hospitals, largely impacting healthcare equity and patient safety.[113,114] No data are available on variation in patient outcomes across all patient service lines and across multiple patient outcomes. Nationwide monitoring and understanding of such overarching variability can provide critically important information and insights for policy makers, government inspection bodies, managers and healthcare professionals. By recognising which patient service lines are most prone to between-hospital variation and by identifying which hospitals have the highest potential for quality improvement, targeted quality improvement initiatives can be established. Such focused efforts are highly required in times of scarce financial and human resources and poor outcome prevalence.

The primary aim of this study was to examine inter-hospital variability in in-hospital mortality, unplanned 30-day readmissions and prolonged length of hospital stay (pLOS) across all Major Diagnostic Categories (MDCs) for all Belgian acute-care hospitals. Secondly, we aimed to estimate the number of outcomes potentially avoidable, if successful quality improvement policies could be established. Finally, we aimed to identify a set of high impact opportunity hospitals where policy makers can stimulate quality improvement initiatives set to improve patient outcomes.

4.5.3 Methods

Data source and study population

The Belgian Hospital Discharge Set is a large administrative database that is used for reimbursement purposes. Information regarding all inpatient hospitalisations from all 99 Belgian acute-care hospitals was retrieved from this database for the study years 2016-2018. Our study excluded psychiatric patient stays and one-day clinics as well as hospitals with exclusive specialist care that are dedicated to only one or a few related medical specialties. The following variables were obtained: patient demographics, hospital stay characteristics and clinical data. The latter information involved primary and secondary diagnosis and procedure codes classified according to International Classification of Diseases 10-Clinical Modification (ICD-10-CM).

The APR-DRG 31.0 (3M) grouping system was used to select 20 All Patient Defined-Major Diagnostic Categories (MDCs), encompassing the majority of hospitalised care in Belgium.[151] Five MDCs were

excluded because of their specialised patient population, i.e. MDC 14 *("Pregnancy, Childbirth and the Puerperium"*), 15 *("Newborns and Other Neonates with Conditions Originating in the Perinatal Period"),* 20 *("Alcohol/Drug Use and Alcohol/Drug Induced Organic Mental Disorders"),* 22 *("Burns")* and 24 *("Human Immunodeficiency Virus Infections").* An overview of the most frequent All Patient Refined Diagnosis Related Groups (APR-DRGs) per MDC is provided in Appendix A.3.15. The final study population consisted of 4,606,721 hospital stays.

Outcomes and patient and hospital characteristics

As in prior research within our research group,[123,132] we focused our investigations on three outcome measures: all-cause mortality during the hospital stay, readmissions to the same hospital within 30 days and length-of-stay (LOS) above the MDC-specific 90th percentile, hereafter referred to as prolonged LOS (pLOS). A readmission was defined as an "all-cause, nonelective admission to the same hospital within 30 days of discharge following the index admission." Because patient identifiable information is specific to each hospital, calculations of readmissions had to remain limited to those within-hospital. Additionally, anonymised patient identifiers are changed each calendar year. This led to the exclusion of all admissions occurring in December as index admissions, as readmissions to the next calendar year could not be identified.[123,132] The unit of analysis was the index admission, meaning each readmission is again considered to be an index admission for a subsequent readmission. We excluded transfers, discharges against medical advice and admissions resulting in a patient's death from being considered as index admissions.

The following patient demographics were included: sex, age, the number of comorbidities, place before admission ('home', 'other hospital or nursing home' or 'in transit or other'), and admission type ('elective' or 'emergency'). Age was categorised in 10-year age groups. In order to obtain the (unweighted) number of Elixhauser-comorbidities, which were categorised as either zero, one to four or five and more comorbidities, we made use of the R package "comorbidity".[57] Hospital characteristics included region (Flanders, Wallonia, Brussels), teaching status (academic or general) and admission volume. The latter was calculated by MDC for each hospital as the average annual number of admissions.

Statistical analyses

Using SAS software version 9.4, we fitted generalised linear mixed models with a binary response distribution and logit link function. All models included fixed effects for patient characteristics and a random intercept for hospital to account for hospital-level clustering. MDC-specific models were run for each of the three binary outcomes separately. Similar to prior research,[123,132] we calculated hospital-specific risk-standardised mortality rates as the ratio of predicted and expected deaths, which were estimated by the model including only patient characteristics. Subsequently, we multiplied this number by the overall crude mortality rate per MDC. The predicted number of deaths was calculated as the hospital-specific prediction from the model and included both the fixed effects and the hospital-specific random intercept, i.e. the best linear unbiased predictor. The expected number of deaths on the other hand is the prediction including only the fixed effects. We identified hospitals as having a significantly higher (or lower) than expected mortality rate, when their random intercept estimate was significantly higher (or lower) than zero. We assessed significance of the between-hospital variation in mortality risk by a Wald test for the random hospital effect and quantified variation by means of the median odds ratio (MOR).[102] The MOR describes the odds of patients with similar covariates having different outcomes

at randomly chosen hospitals by repeatedly sampling at random two subjects with the same fixed patient effects but from different hospitals. A MOR of 1 suggests that no statistically significant variation in mortality across hospitals can be observed, whereas e.g. a MOR of 1.5 suggests that the odds of a patient dying at that hospital are 1.5 times the odds of a similar patient dying at another randomly identified hospital. Between-hospital variation (significance and MOR) was reassessed after additional adjustment for hospital characteristics in the model, in order to evaluate whether between-hospital variation can be explained by those characteristics. The same methods were used for readmissions and pLOS. Finally, to identify hospitals with a high potential to improve quality of care, we visualised hospital-specific outcomes adjusted for patient characteristics in a heatmap, by categorising rates into quartiles, using the 25th, 50th and 75th percentiles calculated across the 2016-2018 study period. To increase comparability, the identification of high-improvement opportunity hospitals was subdivided by hospital size, with small hospitals defined as having 400 beds or less (n=44), middle-sized hospitals defined as having between 400 and 800 beds (n=37) and large hospitals defined as having more than 800 beds (n=18).

4.5.4 Results

Descriptives

Of the 99 included hospitals, 52 are located in Flanders, 36 in Wallonia, and 11 in Brussels. Seven hospitals are academic teaching hospitals. The majority of included MDCs occurred in all included hospitals (Table 4.11), except for *25-Multiple significant trauma,* which occurred in 98 hospitals. Admissions per MDC ranged from 8,914 for *25-Multiple significant trauma* to 783,865 for *8-Diseases & disorders of the musculoskeletal system & connective tissue.* Highest in-hospital mortality was observed in patients admitted for diseases and procedures within *25-Multiple significant trauma* (10.7%), while on average only 0.3% of patients admitted for *2-Diseases & disorders of the eye* died during their hospital stay. Readmission rates ranged from 1.7% (*2-Diseases & disorders of the eye)* to 10.0% (*17-Myeloproliferative diseases & disorders, poorly differentiated neoplasms)*, while the longest LOS was observed for *25-Multiple significant trauma,* with 10% of patients staying 55 days or longer. The latter was also cause of the highest percentage of emergency admissions (95.6%).

Between-hospital variation in patient outcomes

Adjusting for patient characteristics, statistically significant between-hospital variation in risk for all three outcomes was observed across 17 out of 20 included Major Diagnostic Categories (MDCs) at the highest surveyed level of significance ($p<0.001$) (Figure 4.15). For both mortality and readmissions, inter-hospital variation for *19-Mental diseases & disorders* was found to be statistically insignificant at an alpha-value of 0.05 ($p<0.05$), while *2-Diseases & disorders of the eye* was found to be significant only when considering an alpha-value of 0.01 ($p<0.01$). Additionally, variation for *25-Multiple significant trauma* was found to be not statistically significant for readmissions at $p<0.05$. For pLOS, all included MDCs were found to be statistically significant at $p<0.001$.

Further adjusting for hospital factors only minimally helped explain the observed inter-hospital variation. For mortality, *21-Injuries, poisoning & toxic effect of drugs* was significant at $p<0.05$, while *2-Diseases & disorders of the eye, 16-Diseases & disorders of blood, blood forming organs, immunological disorders* and *25-Multiple significant trauma* were significant at $p<0.01$. For readmissions, *16-Diseases & disorders of blood, blood forming organs, immunological disorders* and

18-Infectious & parasitic diseases, systemic or unspecified sites were significant at p<0.01, while *21-Injuries, poisoning & toxic effect of drugs* was at p<0.05.

Quantifying inter-hospital variation resulted in 19, 18 and 20 statistically significant MORs for mortality, readmissions and pLOS, respectively, when accounting for patient characteristics (Figure 4.15, numerical MOR values supplied in Appendix A.3.16). The MOR of dying at a randomly identified hospital compared with a similar patient exceeded 2 in *2-Diseases & disorders of the eye* (2.11). For readmissions, the highest MORs could be observed for by *2-Diseases & disorders of the eye* (1.40), *3-Diseases & disorders of the ear, nose, mouth & throat* (1.40) and *23-Factors influencing health status & other contacts with health services* (1.40). Finally, the highest MOR for pLOS was seen in *19-mental diseases & disorders* (1.98). Overall, additional adjustments for hospital characteristics only marginally reduced MORs, which continued to be statistically significant across all three outcomes, except for mortality for *19-Mental diseases & disorders* and for readmissions in *25-Multiple significant trauma.* This further indicates that the observed between-hospital variation cannot be explained by the surveyed hospital characteristics.

Potential deaths, readmissions and long patient stays avoided

A total of 4,086 hospital deaths per year, or 25.2% of observed mortality in those hospitals could potentially be avoided if MDC-specific risk-standardised mortality, readmission and pLOS rates in upper-quartile (i.e. poorest performing) hospitals would be reduced to the median values (Figure 4.16). Furthermore, 3,684 readmissions (16.4%) and 16,010 (33.4%) prolonged patient stays could potentially be avoided in those upper-quartile hospitals. The highest absolute potential gain for mortality could be seen for *5-Diseases & disorders of the circulatory system*, with 701 deaths potentially avoided annually, followed by *1-Diseases & disorders of the nervous system,* with an overall potential of saving 641 lives should upper-quartile performing hospitals improve to the median level of care. For readmissions, the highest absolute potential could be seen for *6-Diseases & disorders of the digestive system*, with a potential of 677 readmissions within 30 days being avoided. For pLOS, 2,456 long patient stays could potentially be avoided for *3-Diseases & disorders of the ear, nose, mouth & throat.* Finally, the highest relative potential could be observed for *2-Diseases & disorders of the eye* (49.9%), *3-Diseases & disorders of the ear, nose, mouth & throat* (31.3%) and *19-Mental diseases & disorders* (54.3%) for mortality, readmissions and pLOS respectively.

Identification of high impact opportunity hospitals

The heatmaps displayed in Supplementary Appendices A.3.17, A.3.18 and A.3.19 show the standardised rates per MDC for each included hospital for mortality, readmissions and pLOS respectively. Hospitals are sorted according to the number of MDCs categorised within the upper-quartile (indicated in red). The heatmaps demonstrate how a large number of hospitals display patient outcome rates categorised within the upper-quartile for the majority of surveyed MDCs, i.e. 10 MDCs indicated in red or more. For mortality, this amounts to 19 hospitals with over 10 upper-quartile MDCs. Two of these (i.e. hospitals 45 and 82) continue to have 10 or more red MDCs when only taking the MDCs in the upper-quartile into account that deviate significantly from the benchmark, as indicated by an asterisk. Similarly, 19 hospitals could be identified as having 10 or more upper-quartile performing MDCs for readmissions. When only considering the statistically significant MDCs, only hospitals 1, 82 and 87 continued to have over 10 upper-quartile performing MDCs. For pLOS, 15 hospitals had 10 or more upper-quartile MDCs, of which 11 hospitals (hospitals 1, 2, 45, 46, 47, 48, 49, 50, 82, 83 and 85)

remained when considering statistically significant MDCs. Conversely, 15, 14 and 15 hospitals could be identified with 10 or more lower-quartile MDCs (indicated in green) for mortality, readmissions and pLOS respectively. Of these, three (hospitals 22, 42 and 93), zero and nine (hospitals 22, 28, 37, 42, 65, 79, 80, 81 and 88) for mortality, readmissions and pLOS respectively, continued to have the majority of their MDCs categorised within the lower-quartile when only considering MDCs that are statistically significant. For each patient outcome, a middle section could be identified within the heatmaps of hospitals that demonstrate MDCs with exceptional performance on both ends of the spectrum.

Ranking hospitals according to the combined number of statistically significant MDCs categorised within the upper-quartile across all three patient outcomes and according to hospital size (Figure 4.17), provides an overview of the hospitals that potentially could have a large impact on quality of care improvement, should they be targeted by policy makers and hospital leaders. Overall, hospitals 45 and 82 had more than 30 (32 and 37, respectively) MDCs out of 60 possible MDCs that were categorised within the upper-quartile. Hospital 82 even had more than 10 MDCs classified within the upper-quartile for each patient outcome. In contrast, Supplemental Figure S4 ranks hospitals within their hospital size according to the combined number of statistically significant MDCs categorised within the lower-quartile for the three patient outcomes. Combined numbers were generally lower for lower-quartile categories than for upper-quartile classification, indicating fewer hospitals exist that outperform others compared with hospitals that fall behind on other hospitals. Hospital 42 managed to achieve an overall count of 35 statistically significant MDCs that were categorised within the lower-quartile. Upper-quartile and lower-quartile rankings correlated with each other. For each hospital size, the top-10 ranked hospitals for the lower-quartile rankings contained the bottom-3 ranked hospitals for the upper-quartile rankings.

Table 4.11. Characteristics of hospital admissions in Belgium, 2016-2018

MDC	N Hospitals	Admissions		Mortality, (%)	Readmissions (%)	LOS P90 (days)	Age, mean ± SD	Sex	Number of comorbidities		Place before admission		Type of admission
		N Admissions	Yearly admissions per hospital, median (IQR)					Male (%)	1-4 (%)	≥5 (%)	home (%)	Other hospital or nursing home (%)	Emergency (%)
Total	99	4,604,721	18,027 (12,384-29,274)	3.1	5.3	15	59±23	49.6	44.5	8.4	90.3	5.9	48.1
1-Diseases & disorders of the nervous system	99	385,190	1,005 (658-1,703)	4.8	4.9	22	58±25	49.3	45.7	8.8	83.3	9.0	65.2
2-Diseases & disorders of the eye	99	43,728	48 (25-111)	0.3	1.7	5	64±20	47.9	28.0	2.4	94.0	2.7	25.7
3-Diseases & disorders of the ear, nose, mouth & throat	99	359,125	914 (510-1,756)	0.4	2.0	4	46±22	58.3	38.2	1.8	97.1	1.2	23.0
4-Diseases & disorders of the respiratory system	99	402,222	1,138 (862-1,705)	8.1	9.3	20	62±26	54.4	56.8	15.4	85.4	11.0	78.6
5-Diseases & disorders of the circulatory system	99	619,285	1,433 (940-2,817)	3.9	6.0	14	69±16	59.0	53.9	15.8	89.3	7.2	49.8
6-Diseases & disorders of the digestive system	99	544,569	1,553 (1,136-2,343)	2.5	5.9	12	54±26	49.9	43.1	6.2	93.8	4.0	59.2
7-Diseases & disorders of the hepatobiliary system & pancreas	99	172,261	491 (325-736)	4.8	7.5	15	59±18	47.8	47.0	10.1	93.9	4.2	52.0
8-Diseases & disorders of the musculoskeletal system & connective tissue	99	783,865	2,207 (1,486-3,402)	1.1	3.2	19	60±20	42.4	33.6	4.2	89.4	4.3	35.8
9-Diseases & disorders of the skin, subcutaneous tissue & breast	99	185,805	537 (323-805)	1.8	3.6	13	56±22	29.3	37.8	6.3	92.0	3.9	40.5
10-Endocrine, nutritional & metabolic diseases & disorders	99	156,420	436 (284-652)	2.0	4.8	12	52±22	36.1	42.3	8.7	93.7	4.6	34.4
11-Diseases & disorders of the kidney & urinary tract	99	249,531	709 (491-1,076)	2.4	8.2	14	62±22	57.3	42.5	9.4	91.6	6.5	58.2
12-Diseases & disorders of the male reproductive system	99	71,259	188 (125-284)	1.5	6.4	8	65±18	100.0	37.8	3.5	97.2	1.8	24.4
13-Diseases & disorders of the female reproductive system	99	97,522	262 (152-444)	1.0	2.8	6	52±17	0.0	27.4	1.3	98.5	0.9	12.5

16-Diseases & disorders of blood, blood forming organs, immunological disorders	99	49,272	133 (87-205)	3.2	9.4	15	61±26	46.3	53.6	15.5	89.6	7.7	67.5
17-Myeloproliferative diseases & disorders, poorly differentiated neoplasm	99	107,205	177 (66-401)	4.2	10.0	17	62±18	56.7	78.1	7.1	96.9	2.4	12.7
18-Infectious & parasitic diseases, systemic or unspecified sites	99	100,787	268 (185-448)	10.0	7.8	23	55±29	53.2	49.8	16.3	86.2	10.9	85.2
19-Mental diseases & disorders	99	10,897	22 (10-53)	2.0	3.5	16	53±25	41.9	41.0	6.9	92.0	4.9	41.0
21-Injuries, poisonings & toxic effects of drugs	99	72,106	207 (137-295)	1.7	4.9	11	47±24	44.5	41.2	5.0	86.8	5.5	82.3
23-Factors influencing health status & other contacts with health services	99	184,754	474 (287-851)	2.0	3.3	23	58±22	48.9	46.8	6.6	83.8	14.0	23.2
25-Multiple significant trauma	98	8,914	22 (14-41)	10.7	4.5	55	59±24	60.1	45.0	8.5	44,4	13.4	95.6

Abbreviations: MDC, Major Diagnostic Category; hosp., hospitals; Mort., mortality; Readm., readmission; LOS, length-of-stay; P90, 90th percentile; SD, standard deviation;

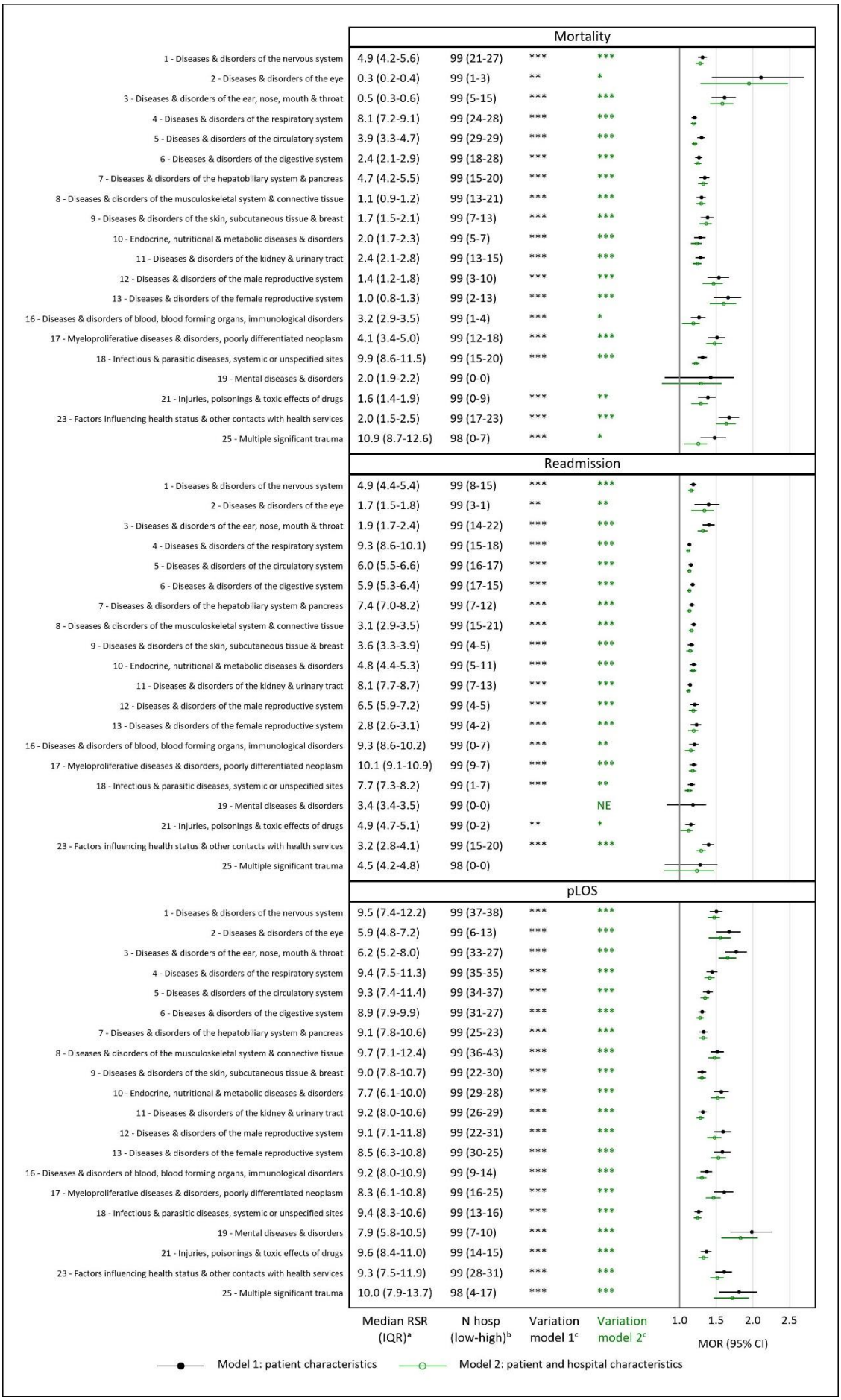

Mortality
1 - Diseases & disorders of the nervous system 4.9 (4.2-5.6) 99 (21-27) *** ***
2 - Diseases & disorders of the eye 0.3 (0.2-0.4) 99 (1-3) ** *
3 - Diseases & disorders of the ear, nose, mouth & throat 0.5 (0.3-0.6) 99 (5-15) *** ***
4 - Diseases & disorders of the respiratory system 8.1 (7.2-9.1) 99 (24-28) *** ***
5 - Diseases & disorders of the circulatory system 3.9 (3.3-4.7) 99 (29-29) *** ***
6 - Diseases & disorders of the digestive system 2.4 (2.1-2.9) 99 (18-28) *** ***
7 - Diseases & disorders of the hepatobiliary system & pancreas 4.7 (4.2-5.5) 99 (15-20) *** ***
8 - Diseases & disorders of the musculoskeletal system & connective tissue 1.1 (0.9-1.2) 99 (13-21) *** ***
9 - Diseases & disorders of the skin, subcutaneous tissue & breast 1.7 (1.5-2.1) 99 (7-13) *** ***
10 - Endocrine, nutritional & metabolic diseases & disorders 2.0 (1.7-2.3) 99 (5-7) *** ***
11 - Diseases & disorders of the kidney & urinary tract 2.4 (2.1-2.8) 99 (13-15) *** ***
12 - Diseases & disorders of the male reproductive system 1.4 (1.2-1.8) 99 (3-10) *** ***
13 - Diseases & disorders of the female reproductive system 1.0 (0.8-1.3) 99 (2-13) *** ***
16 - Diseases & disorders of blood, blood forming organs, immunological disorders 3.2 (2.9-3.5) 99 (1-4) *** *
17 - Myeloproliferative diseases & disorders, poorly differentiated neoplasm 4.1 (3.4-5.0) 99 (12-18) *** ***
18 - Infectious & parasitic diseases, systemic or unspecified sites 9.9 (8.6-11.5) 99 (15-20) *** ***
19 - Mental diseases & disorders 2.0 (1.9-2.2) 99 (0-0)
21 - Injuries, poisonings & toxic effects of drugs 1.6 (1.4-1.9) 99 (0-9) *** **
23 - Factors influencing health status & other contacts with health services 2.0 (1.5-2.5) 99 (17-23) *** ***
25 - Multiple significant trauma 10.9 (8.7-12.6) 98 (0-7) *** *
Readmission
1 - Diseases & disorders of the nervous system 4.9 (4.4-5.4) 99 (8-15) *** ***
2 - Diseases & disorders of the eye 1.7 (1.5-1.8) 99 (3-1) ** **
3 - Diseases & disorders of the ear, nose, mouth & throat 1.9 (1.7-2.4) 99 (14-22) *** ***
4 - Diseases & disorders of the respiratory system 9.3 (8.6-10.1) 99 (15-18) *** ***
5 - Diseases & disorders of the circulatory system 6.0 (5.5-6.6) 99 (16-17) *** ***
6 - Diseases & disorders of the digestive system 5.9 (5.3-6.4) 99 (17-15) *** ***
7 - Diseases & disorders of the hepatobiliary system & pancreas 7.4 (7.0-8.2) 99 (7-12) *** ***
8 - Diseases & disorders of the musculoskeletal system & connective tissue 3.1 (2.9-3.5) 99 (15-21) *** ***
9 - Diseases & disorders of the skin, subcutaneous tissue & breast 3.6 (3.3-3.9) 99 (4-5) *** ***
10 - Endocrine, nutritional & metabolic diseases & disorders 4.8 (4.4-5.3) 99 (5-11) *** ***
11 - Diseases & disorders of the kidney & urinary tract 8.1 (7.7-8.7) 99 (7-13) *** ***
12 - Diseases & disorders of the male reproductive system 6.5 (5.9-7.2) 99 (4-5) *** ***
13 - Diseases & disorders of the female reproductive system 2.8 (2.6-3.1) 99 (4-2) *** ***
16 - Diseases & disorders of blood, blood forming organs, immunological disorders 9.3 (8.6-10.2) 99 (0-7) *** **
17 - Myeloproliferative diseases & disorders, poorly differentiated neoplasm 10.1 (9.1-10.9) 99 (9-7) *** ***
18 - Infectious & parasitic diseases, systemic or unspecified sites 7.7 (7.3-8.2) 99 (1-7) *** **
19 - Mental diseases & disorders 3.4 (3.4-3.5) 99 (0-0) NE
21 - Injuries, poisonings & toxic effects of drugs 4.9 (4.7-5.1) 99 (0-2) ** *
23 - Factors influencing health status & other contacts with health services 3.2 (2.8-4.1) 99 (15-20) *** ***
25 - Multiple significant trauma 4.5 (4.2-4.8) 98 (0-0)
pLOS
1 - Diseases & disorders of the nervous system 9.5 (7.4-12.2) 99 (37-38) *** ***
2 - Diseases & disorders of the eye 5.9 (4.8-7.2) 99 (6-13) *** ***
3 - Diseases & disorders of the ear, nose, mouth & throat 6.2 (5.2-8.0) 99 (33-27) *** ***
4 - Diseases & disorders of the respiratory system 9.4 (7.5-11.3) 99 (35-35) *** ***
5 - Diseases & disorders of the circulatory system 9.3 (7.4-11.4) 99 (34-37) *** ***
6 - Diseases & disorders of the digestive system 8.9 (7.9-9.9) 99 (31-27) *** ***
7 - Diseases & disorders of the hepatobiliary system & pancreas 9.1 (7.8-10.6) 99 (25-23) *** ***
8 - Diseases & disorders of the musculoskeletal system & connective tissue 9.7 (7.1-12.4) 99 (36-43) *** ***
9 - Diseases & disorders of the skin, subcutaneous tissue & breast 9.0 (7.8-10.7) 99 (22-30) *** ***
10 - Endocrine, nutritional & metabolic diseases & disorders 7.7 (6.1-10.0) 99 (29-28) *** ***
11 - Diseases & disorders of the kidney & urinary tract 9.2 (8.0-10.6) 99 (26-29) *** ***
12 - Diseases & disorders of the male reproductive system 9.1 (7.1-11.8) 99 (22-31) *** ***
13 - Diseases & disorders of the female reproductive system 8.5 (6.3-10.8) 99 (30-25) *** ***
16 - Diseases & disorders of blood, blood forming organs, immunological disorders 9.2 (8.0-10.9) 99 (9-14) *** ***
17 - Myeloproliferative diseases & disorders, poorly differentiated neoplasm 8.3 (6.1-10.8) 99 (16-25) *** ***
18 - Infectious & parasitic diseases, systemic or unspecified sites 9.4 (8.3-10.6) 99 (13-16) *** ***
19 - Mental diseases & disorders 7.9 (5.8-10.5) 99 (7-10) *** ***
21 - Injuries, poisonings & toxic effects of drugs 9.6 (8.4-11.0) 99 (14-15) *** ***
23 - Factors influencing health status & other contacts with health services 9.3 (7.5-11.9) 99 (28-31) *** ***
25 - Multiple significant trauma 10.0 (7.9-13.7) 98 (4-17) *** ***
Median RSR (IQR)a
N hosp (low-high)b
Variation model 1c
Variation model 2c
1.0 1.5 2.0 2.5
MOR (95% CI)
Model 1: patient characteristics
Model 2: patient and hospital characteristics

Figure 4.15. Hospital variation in in-hospital mortality, 30-day readmissions, and prolonged length-of-stay across 20 Major Diagnostic Categories (MDCs).

The median odds ratio represents the odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital. MDCs are ordered by MDC number.

Abbreviations: pLOS, prolonged length-of-stay; RSR, risk-standardised rate; IQR, interquartile range; NE, not estimable; MOR, median odds ratio; CI, confidence interval

[a]Based on the model including only patient characteristics (model 1)

[b]Total number of hospitals (number with RSR significantly lower than expected - number with RSR significantly higher than expected), based on model 1.

[c]Significance of the variation in risk across hospitals (testing whether the random hospital effect differs from zero): * P<0.05, ** P<0.01, *** P<0.001

Note: Results are not presented for models in which the random hospital effect was estimated to be zero (indicated as NE).

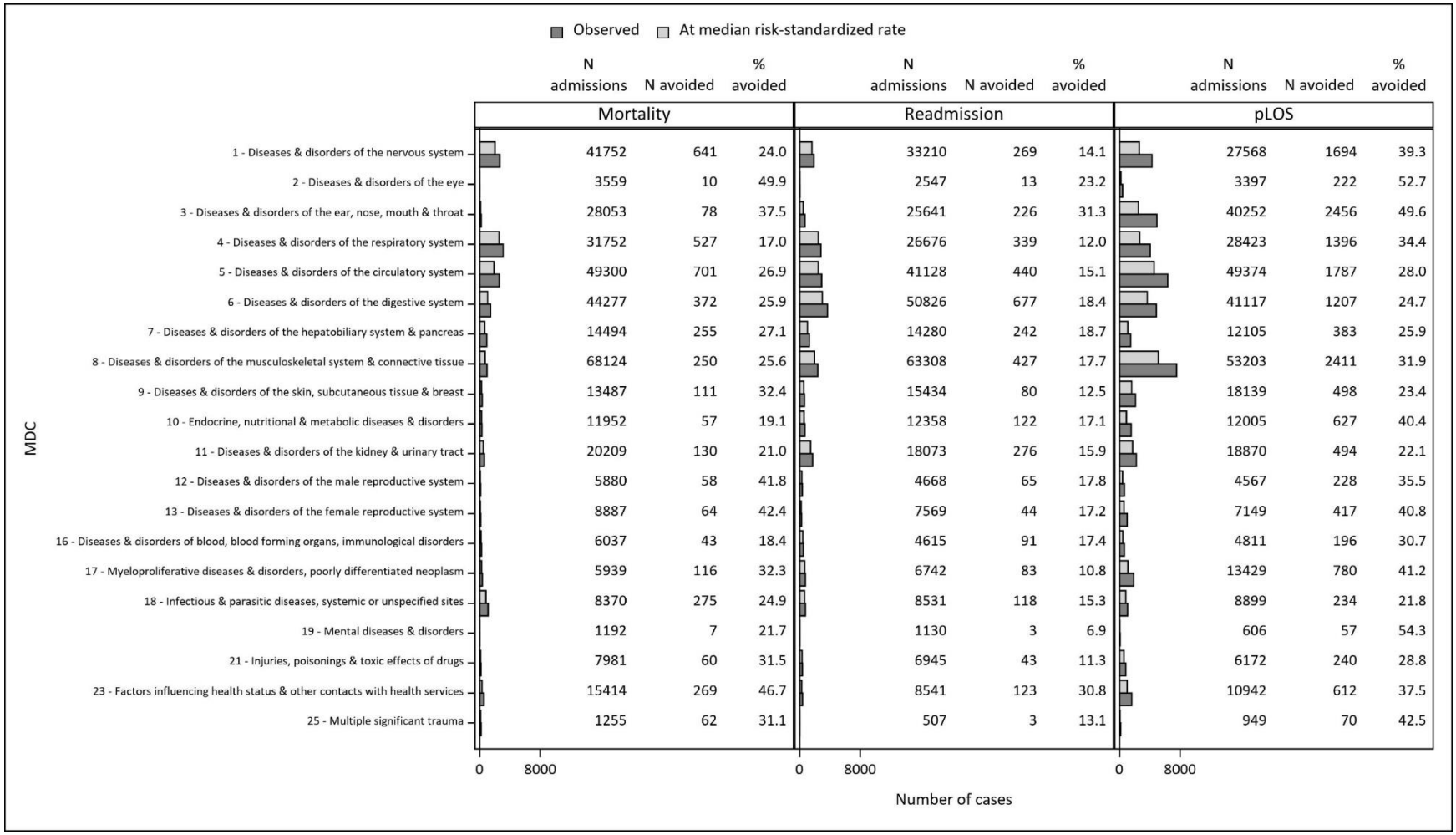


Figure 4.16. Annual number of observed deaths, readmissions and prolonged length-of-stay and estimated deaths, readmissions and prolonged length of stay (pLOS) among Major Diagnostic Categories (MDCs) if outcomes in hospitals with risk-standardised outcome rates in the upper quartile would be reduced to the median value.

Results are based on the risk-standardised mortality, readmissions and pLOS distribution estimated by the model including only patient characteristics. Numbers at the bottom of the figure represent the annual MDC-specific number of admissions and cases saved in hospitals with risk-adjusted mortality, readmission and pLOS, respectively in the upper quartile. The percentage of cases saved is calculated relative to the number of risk-adjusted observed deaths, readmissions and pLOS in those hospitals.

<400 beds	Mortality	Readm.	pLOS	TOTAL	400-800 beds	Mortality	Readm.	pLOS	TOTAL	>800 beds	Mortality	Readm.	pLOS	TOTAL
1	9	10	10	29	45	10	4	18	32	82	14	11	12	37
2	7	0	15	22	46	0	4	16	20	83	9	5	15	29
3	4	2	9	15	47	5	0	15	20	84	13	3	9	25
4	3	0	9	12	48	5	5	10	20	85	9	4	12	25
5	2	0	9	11	49	7	0	12	19	86	10	8	5	23
6	7	0	3	10	50	7	0	12	19	87	0	14	7	21
7	8	0	2	10	51	7	2	6	15	88	6	8	2	16
8	0	5	5	10	52	8	0	7	15	89	7	2	7	16
9	1	1	6	8	53	5	3	5	13	90	8	1	6	15
10	0	5	2	7	54	9	0	4	13	91	7	6	2	15
11	4	2	1	7	55	3	0	9	12	92	4	3	7	14
12	0	1	6	7	56	0	7	5	12	93	0	9	5	14
13	2	1	3	6	57	10	0	2	12	94	0	8	1	9
14	3	0	3	6	58	7	2	2	11	95	1	3	4	8
15	1	0	5	6	59	3	0	8	11	96	3	1	4	8
16	2	1	3	6	60	5	4	1	10	97	3	0	5	8
17	0	0	6	6	61	6	0	3	9	98	1	2	4	7
18	1	1	3	5	62	2	1	6	9	99	1	0	3	4
19	1	0	4	5	63	4	0	5	9					
20	0	5	0	5	64	6	1	2	9					
21	3	0	2	5	65	0	7	1	8					
22	0	4	1	5	66	5	2	1	8					
23	1	0	4	5	67	0	1	6	7					
24	0	1	3	4	68	1	0	6	7					
25	2	0	2	4	69	0	3	4	7					
26	0	3	1	4	70	1	0	5	6					
27	0	4	0	4	71	4	0	2	6					
28	1	2	1	4	72	1	0	3	4					
29	1	1	1	3	73	0	1	3	4					
30	1	0	2	3	74	3	0	0	3					
31	0	3	0	3	75	0	0	3	3					
32	0	3	0	3	76	0	0	2	2					
33	0	0	3	3	77	2	0	0	2					
34	0	2	0	2	78	0	1	1	2					
35	1	0	1	2	79	0	1	0	1					
36	0	1	1	2	80	1	0	0	1					
37	0	0	2	2	81	0	0	0	0					
38	1	0	1	2										
39	0	0	1	1										
40	0	0	1	1										
41	1	0	0	1										
42	0	0	0	0										
43	0	0	0	0										
44	0	0	0	0										

Figure 4.17. Combined number of MDCs categorised within the upper quartile category for standardised mortality, readmissions and prolonged length-of-stay between 2016-2018 for individual hospitals in Belgium, in descending order

4.5.5 Discussion

Excessive variation exists in patient outcomes between Belgian hospitals

Between-hospital variation is highly prevalent in Belgium. This holds true for the overwhelming majority of hospital care service lines, categorised according to Major Diagnostic Categories. The presence of this variation has grievous consequences for patient care, as demonstrated by the high and statistically significant median odds ratios for mortality, readmissions and pLOS. Furthermore, the large potential mortality, morbidity and societal benefits of reducing this variation is abundantly clear from our analyses that hypothesised the potential outcome gains when improving upper-quartile hospitals to the median level of care. A yearly total of 4,086 hospital deaths, 3,684 readmissions and 16,009 long patient stays could potentially be avoided in those hospitals, should quality improvements targeting these patient outcomes succeed.

While significant between-hospital variation was observed across all MDCs, several MDCs in particular are deserving of prioritised attention for future quality improvement initiatives. Both *2-Diseases & disorders of the eye* and *19-Mental diseases & disorders* are among the least occurring MDCs. Yet, they are responsible for the highest MORs for mortality and pLOS, respectively (2.11 and 1.98). This indicates how the odds of a similar patient dying or being readmitted at a hospital with higher risk for mortality and readmissions was close to two times as high when compared to a hospital with lower risk. Additionally, they also demonstrated the highest relative potential gain when improving the upper-quartile performing hospitals to the median level of care for mortality (49.9%) and pLOS (54.3%), respectively. MDC *3-Diseases & disorders of the ear, nose, mouth & throat* on the other hand was seen to have the largest MOR (1.4) and highest relative potential gain when improving the upper-quartile performing hospitals to the median level (31.3%) for readmissions as well as the highest absolute potential for pLOS, with 2,456 long patient stays potentially avoided. Finally, the highest absolute number of lives (n=701) saved and readmissions (n=677) avoided was seen in MDCs *5-Diseases & disorders of the circulatory system* and *6-Diseases & disorders of the digestive system*, respectively.

Systemic hospital factors are apparent drivers of variation

Between-hospital variation persisted despite having adjusting for patient case-mix and despite additional adjustments for known hospital characteristics that might be driving variation (i.e. teaching status [96,121], volume [130,131] and region [92,119]). There appear to be other systemic factors at play that drive the occurrence of inferior patient outcomes, which are not linked to a limited set of specific patient service lines, but instead occur overall. As was revealed from individual hospital-level analyses, there seems to be a differentiation into three groups, i.e. those hospitals that outperform other hospitals across the majority of MDCs, those that are among the bottom performers for the majority of MDCs and finally a middle group with both good and poor-performing MDCs. All three groups represent a diverse set of smaller and larger, general and university hospitals located in different regions, confirming the lack of influence the currently surveyed hospital factors have.

As hypothesised in previous research [123,132], this urges further investigation of other hospital context factors that might be contributing to this variation, including leadership characteristics, quality education, quality culture or guideline implementation.[76–78,137] Differences in hospital boards, management practices and front-line management across medical wards have been shown to be strongly related to clinical patient outcomes.[152] Additionally, staffing levels of physicians and nurses might also play a part in outcome disparities,[93] as well as differences in discharge policies and aftercare.[114]

High impact opportunity hospitals

Our analyses on individual hospital-level have revealed how a number of hospitals are performing poorly for mortality, readmissions and pLOS when compared to other hospitals in Belgium. The identification of these so-called 'high impact improvement opportunity hospitals', such as e.g. hospital 45 or 82, provides potential for governmental inspection bodies to set up targeted audits and inspections. Moreover, governments can choose to prioritise certain patient outcomes, patient service lines or hospital groups depending on strategic planning, available time, personnel and financial means. To date, despite a scarcity on the evidence-base of inspections on patient outcomes,[145] past literature has indicated a lack of effects of inspections on clinical outcomes.[153–155] Perhaps a more directed selection of hospitals to be inspected can aid in generating a stronger influence of inspections on patient outcomes.

Next to governmental inspection bodies, making the 'high impact opportunity hospital'-rankings available via personalised benchmark reports can also provide opportunities for hospital managers to improve patient outcomes internally within their own hospitals and hospital networks. The identification of champion patient service lines (MDCs) as well as MDCs with poorer performance can help set up targeted quality improvement initiatives by identifying barriers and facilitators for achieving quality hospital care. Strategies such as care pathways,[138] guideline implementation[156] or collaborative and peer-reviewed learning could aid in this regard.[72] Hospitals can learn from the selected 'high impact learning opportunity hospitals', i.e. those that are seen to outperform other hospitals in terms of mortality, readmissions and pLOS, for differences in any of the aforementioned hospital context factors. Regional initiatives such as the Flemish Hospital Network[111] and collaborative and peer-reviewed learning within the Flanders Quality Model (FlaQuM) Consortium[78] can be expanded on with the analyses proposed in this paper, helping to generate targeted learning and speed up quality improvement.

Future perspectives

Continued and systematic monitoring of the nationwide patient outcome rates by MDC and by hospital perfectly fits within the scope of a Safety-II approach.[140] As the utilised administrative data can be applied without putting additional strain on healthcare frontline workers, the surveyed patient outcomes can be used as quality indicators in a sustainable manner. While indicators derived from administrative data have their disadvantages, such as a lack of additional prognostic clinical data and concerns around accuracy of coding and completeness of the data, they have large potential for continued follow-up as they are inexpensive, readily available, computer readable and encompass large and comparable populations.[83] Moreover, there is large transferability and comparability across countries due to the shared coding langue, offering potential for future international research.

Limitations

Several study limitations merit attention. First, readmission rates are likely underestimated because we were unable to include readmissions occurring in December and readmissions to other hospitals. Second, while we accounted for numerous patient-related factors associated with disease severity, the lack of hemodynamic and laboratory parameters or information on inflammatory burden and kidney function [120] might help explain some of the observed variation in care. Additionally, other patient-related factors such as ethnicity or economic status were not yet accounted for.[141,142] Third, we potentially lacked granularity by combining the analyses on an MDC rather than on a APR-DRG-level, as highlighted by the differences in results of the cases avoided when looking at previous research.[132,150] This is in part

also explicable as past papers have selected additional APR-DRGs outside of the MDC *11-Diseases & disorders of the kidney & urinary tract* and excluded some APR-DRGs within the MDC *5-Diseases & disorders of the circulatory system.* Finally, we potentially lacked statistical power in some mortality and readmission models due to lower case numbers for specific MDCs (e.g. *2-Diseases & disorders of the eye*). Despite these limitations, our study comprised the majority of the Belgian hospital population and was able to identify hospitals with poor performance for mortality, readmission and pLOS that have a high opportunity for improving quality of care when targeted in future initiatives.

4.5.6 Conclusions

Belgian hospital care is characterised by extensive between-hospital variation in mortality, readmission and prolonged length of stay across the vast majority of patient service lines. Reducing this variation has tremendous societal consequences. Should quality improvement initiatives manage reductions in patient outcomes in hospitals currently categorised within the upper-quartile to the median, a yearly total of 4,086 hospital deaths, 3,684 readmissions and 16,009 long patient stays could potentially be avoided in those hospitals. Identifying these 'high impact opportunity' hospitals characterised by poor performance for mortality, readmission and prolonged length-of-stay across a large number of patient service lines can help government inspection bodies and hospital managers to establish targeted inspections and clinical audits. These in turn can help to generate quality improvement initiatives with the highest potential to improve nationwide hospital care.

4.6 Convergent validity of two widely used methodologies for calculating the hospital standardised mortality ratio in Flanders, Belgium

4.6.1 Abstract

Objectives: To assess their construct validity, we compared results from two models used for estimating hospital standardised mortality ratios (HSMRs) in Belgium. The method of the Flemish Hospital Network (FHN) is based on a logistic regression for each of the 64 All Patient Refined Diagnosis-Related Groups (APR-DRG) that explain 80% of mortality and uses the Elixhauser-score to correct for comorbidities. (H)SMRs published on the 3M-Benchmark-Portal are calculated by a simpler indirect standardisation for APR-DRG and risk of mortality (ROM) at discharge.

Methods: We used administrative data from all eligible hospital admissions in 22 Flemish hospitals between 2016 and 2019 (FHN: n=682,935; 3M: n=2,122,305). We evaluated model discrimination and accuracy and assessed agreement in estimated HSMRs between methods.

Results: The Spearman-correlation between HSMRs generated by the FHN-model and the standard 3M-model was 0.79. Although 2 out of 22 hospitals showed opposite classification results, i.e. a HSMR significantly <1 according to the FHN-method but significantly >1 according to the 3M-model, classification agreement between methods was significant (agreement for 59.1% of hospitals, kappa=0.45). The 3M-model (C-statistic=0.96, adjusted Brier-score=26%) outperformed the FHN-model (0.87, 17%). However, using ROM at admission instead of at discharge in the 3M-model significantly reduced model performance (C-statistic=0.94, adjusted Brier-score=21%), but yielded similar HSMR-estimates and eliminated part of the discrepancy with FHN-results.

Conclusions: Results of both models agreed relatively well, supporting convergent validity. Whereas the FHN-method only adjusts for disease severity at admission, the ROM-indicator of the 3M-model includes diagnoses not present on admission. Although diagnosis codes generated by complications during hospitalisation have the tendency to increase the predictive performance of a model, these should not be included in risk-adjustment procedures.

Key words: In-hospital mortality, standardised mortality ratio, hospital performance

4.6.2 Introduction

Measuring the quality of healthcare is a key component in improving care, and various performance indicators have been developed for this purpose.[157,158] In-hospital mortality is one of the most appealing and commonly used indicators because of its clinical relevance and straightforward registration. Different approaches have been developed to obtain standardised measures which adjust for differences in case-mix between hospitals. In direct standardisation, the case-mix of a hospital is standardised to a reference case-mix, whereas indirect standardisation standardises the mortality rate of the case-mix to a reference (expected) mortality rate. The advantage of directly standardised mortality rates is that these rates are comparable with each other, which is not always the case for rates adjusted via the indirect standardisation method.[159] In case of multiple predictors, however, the direct method often results in unreliable mortality rates because of low numbers of patients in the various subcategories, leaving the indirect method as the only option for standardisation.[159]

The hospital-standardised mortality ratio (HSMR) is an indirect standardisation method developed in 1999.[160] It has become a key quality indicator in health systems across the world.[161–164] The HSMR compares the actual numbers of deaths to the number of deaths expected given the case-mix of the hospital. The expected number of deaths is derived by estimating mortality rates in predefined strata of patients with similar risk, often using regression modelling, and then aggregating these stratum-specific estimates according to the hospital's case mix. The HSMR is a measure for hospital-wide overall mortality, but using the same methodology, disease-specific standardised mortality rates (SMR) can be obtained.

In Flanders, Belgium, hospitals have two main models at their disposal to benchmark their HSMR and disease-specific SMRs. One model has been built by 3M™, which presents (H)SMR results for 83 (out of the 103 acute-care Belgian hospitals) at their secured 3M-Benchmark-Portal.[165] A second model was conceived within the Flemish Hospital Network KU Leuven, further referred to as FHN, a not-for-profit association of 31 hospitals that aims to optimize quality and efficiency of patient care. FHN-members can consult the (H)SMR results using a secured web tool. Both models use the same hospital discharge datasets, collected for the purpose of hospital financing, and both use the All Patient Refined Diagnoses-Related Group (APR-DRG) Classification System, but there are some differences in case-mix adjustment.

The FHN-model[164] makes use of the Elixhauser-comorbidity-index,[166] which is, together with the Charlson-index, the most widely used approach for risk-adjustment and mortality prediction based on comorbidities. More specifically, the FHN-model relies on the composite Elixhauser-score, which has been found to have similar discriminating ability in predicting in-hospital mortality as using the 30 individual comorbidities.[127] The Elixhauser-score and other patient-level variables are entered in APR-DRG-specific logistic regression models for those APR-DRGs that account for 80% of all in-hospital mortality. The 3M-model, however, includes nearly all APR-DRGs for HSMR-estimation, but excludes patients transferred to or from another hospital. The 3M-HSMR is estimated through indirect standardisation by APR-DRG and risk of mortality (ROM). The ROM-indicator has been developed for risk-stratification within each APR-DRG and classifies the risk of death as minor, moderate, major, or extreme. The ROM-classification is based on interactions of age, type of surgical procedure, co-morbidity, and the principal diagnosis, and has been validated previously.[167–169] Whereas the 3M™-Core Grouping Software generates separate indicators for ROM at admission and ROM at discharge, the 3M-model uses the latter for risk-adjustment, thereby not only taking into account comorbidities present on

admission (POA), but also those due to complications generated during the hospital stay. The Elixhauser-comorbidity score on the other hand, is typically restricted to POA-diagnoses.

If the process of benchmarking in-hospital mortality has construct validity, one would expect different (reliable) scoring systems to agree substantially on which hospitals are identified as quality outliers. There are however, a number of potential sources of discrepancies: observed differences in HSMRs estimated by the FHN- and 3M-models can be the result of the different sets of hospitals serving as the benchmark, the different exclusion criteria used by both methods, or the different statistical methods and variables used for risk-adjustment. The aim of this study was to compare results of both risk-adjustment methods applied to the same set of hospitals. We evaluated the performance of both models with respect to patient-level predictions as well as the agreement in obtained HSMRs. To assess the influence of differences in exclusion criteria of both methods, the 3M-method was applied to the FHN as well as the 3M-sample. In addition, we examined the effect of the exclusion of non-POA diagnoses by using ROM at admission instead of ROM at discharge in the 3M-model.

4.6.3 Methods

Data

In Belgium, hospital discharge data are delivered to the federal health authorities every semester for financing purposes. Involved hospitals also send these data to the FHN and to 3M, who use them for hospital performance benchmarking. The hospital discharge dataset contains patient demographics, hospital stay characteristics, as well as primary and secondary diagnoses and diagnostic and therapeutic procedures. From 2016 onwards, diagnoses and procedures are coded according to the International Classification of Diseases ICD-10th Revision-Clinical Modification (ICD-10-CM), with mandatory registration of the POA-indicator, which distinguishes POA-comorbidities from complications that occurred during the admission.

Twenty-two out of 30 members from the FHN provided written consent to participate in this study. We assessed all inpatient hospitalisations between 2016 and 2019, excluding psychiatric stays and one-day clinics. APR-DRG and ROM-classifications were obtained by the 3M™-Core Grouping Software, using grouping system 38.0.

Common and model-specific exclusions

APR-Major Diagnostic Categories (MDCs) SS (special APR-DRGs) and APR-DRGs 955 and 956 were excluded in both the FHN and 3M-model. The FHN-model additionally excluded pathologies irrelevant to hospital mortality, APR-DRGs with vague descriptions, and APR-DRGs with ungroupable hospital stays (as identified by an expert panel of CMOs of the FHN): APR-DRGs 950-952, MDC 14 (*Pregnancy, childbirth and the puerperium*), MDC 15 (*Newborns and other neonates*), MDC 22 (*Burns*), and MDC 24 (*HIV infections*). Of a total of 282 remaining APR-DRGs, 64 accounted for 80% of the in-hospital mortality in the FHN and were retained for (H)SMR analysis (Appendix A.3.21). Instead, patients transferred from another hospital and transfers to another hospital were excluded from predictions by the 3M-model. FHN and 3M (H)SMR calculations were done using their respective samples, but to be able to disentangle the effect of differences in risk-adjustment from that of differences in exclusion criteria, the HSMR-calculation by the 3M-model was repeated on the FHN-sample.

Statistical analyses

Expected mortality by the FHN-method was calculated using a logistic regression model with automated backward variable selection for each of the 64 APR-DRGs, starting with the following variables: gender, age, the Elixhauser-comorbidity score, admission source, admission type and discharge year. The deletion-criterion was set at α=0.10 to prevent the unwanted deletion of relevant variables. Age was categorised into 10-year age groups, which were, when necessary, combined in order to contain at least 10 deaths in each APR-DRG by age-group combination. The Elixhauser-comorbidity score is a weighted composite score of 30 individual comorbidities based on the association between each comorbidity and in-hospital mortality.[127] The delineation of each of the 30 comorbidities was accomplished using the ICD-10-CM mappings of the AHRQ.[58] The weights were obtained from a separate logistic regression model on mortality including the 30 binary comorbidities, using data from the complete set of hospitals (n=31) of the FHN. Only comorbidities POA were included in the calculation of the Elixhauser-score. Admission source was categorized as follows: "Home", "Other hospital", "Nursing home", "Public space", or "Other". Admission type was classified as "Emergency" or "Elective". Discharge year was modelled as a categorical variable. 95% confidence intervals (CIs) of the HSMRs were calculated using Byar's approximation[170] and were used to classify hospitals into one of three groups: mortality lower than expected, as expected, and higher than expected.

Expected mortality of the 3M-model was obtained by calculating the rate of mortality over all participating hospitals per APR-DRG*ROM*year. The 3M-model typically uses the ROM-indicator at discharge, which is based on all diagnoses registered upon completion of the hospitalisation, thereby including both POA comorbidities as well as in-hospital complications. Because the FHN-model does not use non-POA diagnoses for risk-adjustment, we reran the 3M-model by using ROM at admission instead at discharge. Significance of the HSMRs estimated by 3M is normally determined by the Cochran-Mantel-Haenszel test. To allow for a comparison of risk-adjustment models irrespective of the type of significance test, we also applied Byar's approximation to the HSMRs calculated by the 3M-model.

Models were internally validated using 100 bootstrap samples. Model discrimination was assessed by the C-statistic (which is equal to the Area Under the Receiver Operating-Characteristic Curve), whereas the balance between sensitivity (recall) and the positive predictive value (precision) was measured by the Area Under the Precision-Recall Curve (AUC-PR). Because the Brier-score is affected by the incidence of mortality, accuracy was determined by the adjusted Brier-score.[171] The adjusted Brier-score represents the percent reduction in deviation when using a specific predictive model as opposed to assigning everyone a probability equal to the incidence rate, so a higher score indicates better model accuracy. In addition to overall model performance, performance within each of the 64 APR-DRG groups was assessed.

To compare hospital-level model performance, we calculated Spearman-correlations between HSMRs obtained from the different models. Agreement of hospital classification (mortality lower than expected, as expected, or higher than expected) between methods was assessed using exact tests for the Kappa-statistic and the Bowker-test of symmetry. All analyses were performed with SAS V.9.4 for Windows.

4.6.4 Results

Twenty-one regional and one academic hospital were included in this study, with a median (IQR) number of beds of 536 (310-844). There were 2,264,761 hospitalisations during the study period, including 56,331 deaths (Table 4.12). A total of 72,447 (3.2%) stays, including 165 deaths (0.3%), were excluded by exclusion criteria common to both models. Model-specific exclusion criteria resulted in the additional exclusion of 1,509,379 (66.6%) stays or 12,794 (22.7%) deaths from the FHN-model, and 70,009 (3.1%) stays or 3,316 (5.9%) deaths from the 3M-model, resulting in a final FHN-sample of 682,935 (30.2%) stays and 43,372 (77.0%) deaths and a final 3M-sample of 2,122,305 (93.7%) stays and 52,850 (93.8%) deaths. The large reduction in the size of the FHN-sample was mainly due to the selection of the 64 APR-DRGs responsible for 80% of mortality, resulting in the exclusion of 1,236,641 (54.6%) stays. Only 11,086 (0.9%) of these, however, were in-hospital deaths. Because of this, the final mortality rate in the FHN-sample (6.4%) was much higher than the 3M-sample (2.5%) and some differences in the distribution of patient characteristics were observed (Table 4.13). For instance, the FHN-sample contained a smaller proportion of elective admissions (29.0% versus 54.9%), a smaller proportion of admissions with a surgical primary diagnosis (9.7% versus 34.3%), and a smaller proportion of admissions with a minor ROM at discharge (51.1% versus 72.8%). Distributions of characteristics among deaths, however, were more similar between the two samples. The median (IQR) number of admissions per hospital (across the 4-year period) was 27,055 (16,007-43,924) in the FHN-sample and 86,241 (48,016-140,737) in the 3M-sample, whereas the median (IQR) number of deaths per hospital was 1,771 (1,008-2,843) and 2,163 (1,204-3,482), respectively.

The mean C-statistic of the 100 bootstrap samples was 0.87 for the FHN-model, 0.96 for the standard 3M-model, and 0.94 for the 3M-model using ROM at admission instead of ROM at discharge ($p<0.05$ for each of the three model comparisons) (Appendix A.3.22). Corresponding AUC-PR values were 0.34, 0.42, and 0.36, and estimated reductions in variability from random prediction (adjusted Brier-score) were 17%, 26%, and 21%, respectively. At an alpha-level of 0.05, differences in AUC-PR and adjusted Brier-score between the three models were significant, except for the difference in AUC-PR between the FHN-model and the 3M-model using ROM at admission. Running the 3M-model on the FHN-sample instead of the 3M-sample reduced the C-statistic (0.90, $p=0.008$), but not the AUC-PR and adjusted Brier-score (0.42 and 23% respectively, $p>0.05$) (results not shown).

Consistent with overall results, APR-DRG-specific performance measures were mostly highest for the standard 3M-model (for 53, 57, and 55 out of the 64 APR-DRGs according to the C-statistic, AUC-PR and adjusted Brier-score, respectively) (Appendix A.3.22). The FHN-model showed the highest performance for about 10 APR-DRGs (11, 13 and 7 APR-DRGs according to the C-statistic, AUC-PR, and adjusted Brier-score, respectively). At an alpha-level of 0.05, however, significant differences in measures between models were observed for only two APR-DRGs (194–*Heart failure* and 720–*Septicemia & disseminated infections*), with the standard 3M-model outperforming the FHN-model.

The distribution of HSMRs obtained by the FHN-model was more symmetric around 1 than the distributions obtained for the two samples by the 3M-model (Figure 4.18). The median (IQR) HSMR was 1.01 (0.93-1.12) for the FHN-model, 1.08 (0.97-1.15) for the standard 3M-model, and 1.05 (0.99-1.13) for the 3M-model using ROM at admission. Appendix A.3.23 also shows the systematic deviation from the 45-degree line when comparing the FHN with the 3M-models, with the majority of hospitals having higher HSMRs estimated by the 3M-models. Spearman-correlations between HSMRs from the FHN-model and the 3M-models were 0.79 when using the ROM at discharge and 0.81 when using ROM at admission in the 3M-model. The correlation between HSMRs of the two 3M-models with different

ROM indicators was 0.97, whereas the correlation between HSMRs of the standard 3M-model estimated on the different samples was 0.95.

HSMRs with 95% CIs obtained by the different models are presented in Figure 4.19. HSMRs estimated by the 3M-models using different ROM indicators were similar with CIs always overlapping. CIs of HSMRs of the standard 3M-model run on the different samples were also always overlapping (results not shown). Comparing the FHN-model with the 3M-models, CIs of HSMRs were non-overlapping for eight hospitals (regardless of ROM-indicator used). For 2 out of the 8, a HSMR significantly lower than expected was obtained by the FHN-method, whereas corresponding HSMRs of the standard 3M-model were significantly higher than expected. For the 3M-model using ROM at admission, however, HSMRs of these two hospitals were not significantly higher than expected (CIs including 1.00). The HSMR was significantly less than 1.00 for 6 hospitals using the FHN-model, for 5 hospitals using the standard 3M-model, and for 4 hospitals using the 3M-model with ROM at admission (Table 4.14). The HSMR was significantly higher than 1.00 for 8, 14, and 10 hospitals using the FHN-model, the standard 3M-model, and the 3M-model using ROM at admission, respectively. The same hospitals were identified as significantly deviating from expected when using the Cochran-Mantel-Haenszel test instead of Byar approximation (as done in the actual 3M-model).

HSMRs generated by the FHN-model and the standard 3M-model agreed on significance and direction 13 times (59.1%), which was significantly higher than expected by chance (κ=0.45, p=0.006) (Table 4.15). Similar results were observed when comparing the FHN-model with the 3M-model using ROM at admission, with 12 hospitals (54.5%) showing classification agreement (κ=0.46, p=0.008). HSMR classification by the two 3M-models using different ROM indicators agreed 17 times (77.3%, κ=0.73, p<0.001), and classification by the standard 3M-model ran on the two different samples agreed 18 times (81.8%, κ=0.78, p<0.001). Across the three surveyed methods, agreement of direction occurred 11 times (50.0%). Out of these 11 hospitals that saw their status change by applying a different method, 9 were classified within two and 2 hospitals were classified in three separate categories.

The differences in HSMRs between models appeared to be correlated with ROM-distribution, with hospitals with low ROM-levels having higher HSMRs estimated by the 3M-model than by the FHN-model, and the other way around for hospitals with high ROM-levels. The Spearman-correlation between the difference in HSMR (3M-model minus FHN-model) and the percentage of patients with extreme ROM at discharge for instance was -0.59 (Appendix A.3.24). The two hospitals with opposite significance classification by both models were among the three hospitals with the lowest mean ROM. The mean ROM of a hospital correlated relatively well with the mean Elixhauser-score (Spearman-correlation=0.75) (Appendix A.3.25), except for some outlying hospitals (e.g. the hospital with the lowest mean Elixhauser-score had a relatively high mean ROM, whereas one of the two hospitals with opposite significance classification had a low mean ROM but an intermediate Elixhauser-value).

Table 4.12. Common and model-specific patient exclusions, n = 22 hospitals.

	Number (%)			
	FHN		3M	
	Admissions	**Deaths**	**Admissions**	**Deaths**
Total eligible admissions	2,264,761 (100)	56,331 (100)	2,264,761 (100)	56,331 (100)
Exclusions applicable to both models				
MDC SS (Special APR-DRGs)	70,821 (3.1)	20 (0.0)	70,821 (3.1)	20 (0.0)
DRG 955-956 (Rest APR-DRGs)	1,626 (0.1)	145 (0.3)	1,626 (0.1)	145 (0.3)
Exclusions applicable to one model				
DRG 950-952 (Rest APR-DRGs)	15,294 (0.7)	989 (1.8)	/	/
MDC 14 (Pregnancy, childbirth and the puerperium)	137,088 (6.1)	3 (0.0)	/	/
MDC 15 (Newborns and other neonates)	118,832 (5.2)	686 (1.2)	/	/
MDC 22 (Burns)	1,178 (0.1)	15 (0.0)	/	/
MDC 24 (HIV infections)	346 (0.0)	15 (0.0)	/	/
DRGs not explaining 80% of mortality (n = 64)	1,236,641 (54.6)	11,086 (19.7)	/	/
Transfers from other hospitals	/	/	43,401 (1.9)	3,316 (5.9)
Transfers to other hospitals	/	/	26,608 (1.2)	0 (0.0)
Total excluded	1,581,826 (69.8)	12,959 (23.0)	142,456 (6.3)	3,481 (6.2)
Total included	682,935 (30.2)	43,372 (77.0)	2,122,305 (93.7)	52,850 (93.8)

Table 4.13. Patient characteristics.

Characteristic	Number (%) or median (IQR)			
	FHN		3M	
	Admissions	Deaths	Admissions	Deaths
Gender				
Male	341,203 (50.0)	23,372 (53.9)	999,736 (47.1)	28,533 (54.0)
Female	341,732 (50.0)	20,000 (46.1)	1,122,569 (52.9)	24,317 (46.0)
Admission source				
Home	592,041 (86.7)	32,705 (75.4)	1,870,435 (88.1)	41,949 (79.4)
Other hospital	18,787 (2.8)	2,459 (5.7)	0 (0.0)	0 (0.0)
Nursing home	39,651 (5.8)	6,393 (14.7)	55,166 (2.6)	7,780 (14.7)
Public space	15,958 (2.3)	642 (1.5)	48,312 (2.3)	969 (1.8)
Other	16,498 (2.4)	1,173 (2.7)	148392 (7.0)	2,152 (4.1)
Admission type				
Emergency	485,119 (71.0)	35,781 (82.5)	957,944 (45.1)	43,248 (81.8)
Elective	197,816 (29.0)	7,591 (17.5)	1,164,361 (54.9)	9,602 (18.2)
APR-DRG type				
Medical	616,555 (90.3)	39,322 (90.7)	1,394,676 (65.7)	44,439 (84.1)
Surgical	66,380 (9.7)	4,050 (9.3)	727,629 (34.3)	8,411 (15.9)
ROM at discharge				
Minor	348,784 (51.1)	1,945 (4.5)	1,545,544 (72.8)	2,802 (5.3)
Moderate	211,377 (31.0)	11,487 (26.5)	394,561 (18.6)	13,090 (24.8)
Major	94,624 (13.9)	17,109 (39.4)	144,223 (6.8)	20,716 (39.2)
Extreme	28,150 (4.1)	12,831 (29.6)	37,977 (1.8)	16,242 (30.7)
ROM at admission				
Minor	356,092 (52.1)	3,068 (7.1)	1,565,101 (73.7)	4,579 (8.7)
Moderate	218,118 (31.9)	15,088 (34.8)	402,631 (19.0)	18,123 (34.3)
Major	88,971 (13.0)	16,914 (39.0)	130,155 (6.1)	20,421 (38.6)
Extreme	19,754 (2.9)	8,302 (19.1)	24,393 (1.1)	9,727 (18.4)
Age (Years)	63 (52-82)	78 (71-87)	53 (34-75)	77 (71-87)
Length of stay (days)	9 (2-10)	15 (3-19)	6 (1-6)	16 (3-20)
Comorbidity Score	0.52 (0.00-0.87)	1.08 (0.60-1.54)	/	/
Total	682,935 (100.0)	43,372 (100.0)	2,122,305 (100.0)	52,850 (100.0)

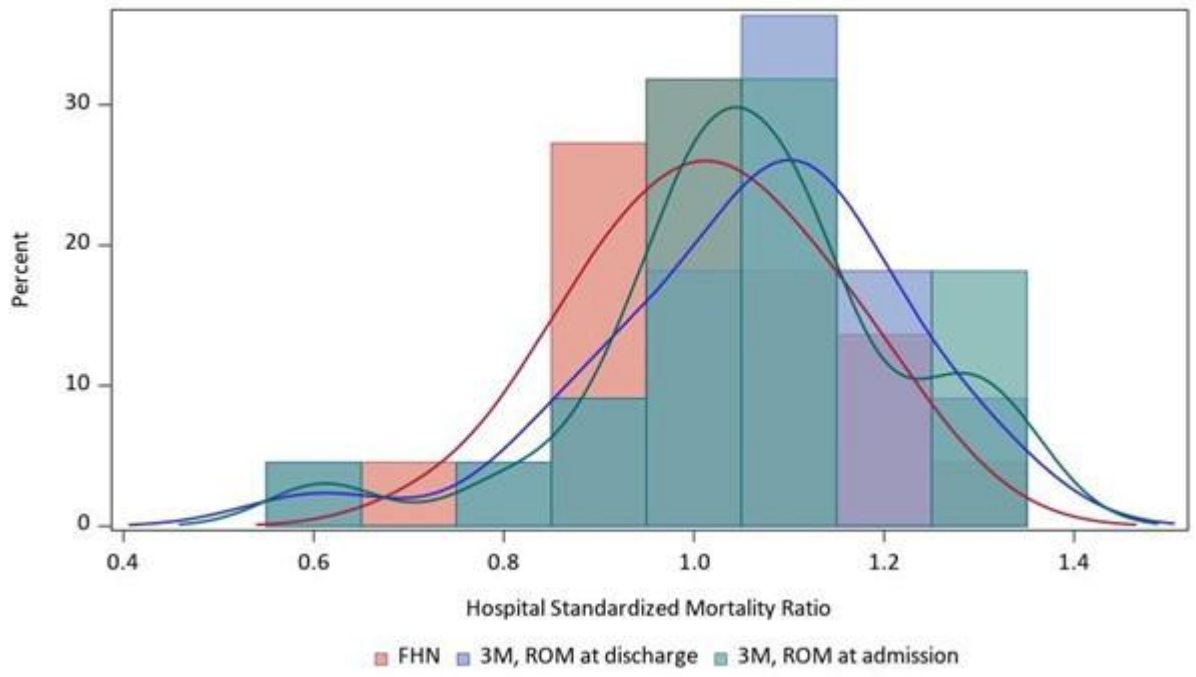


Figure 4.18 Distribution of the Hospital Standardised Mortality Ratios of the 22 hospitals, as calculated by the FHN-model (red), by the 3M-model using ROM at discharge (blue), and by the 3M-model using ROM at admission (green).

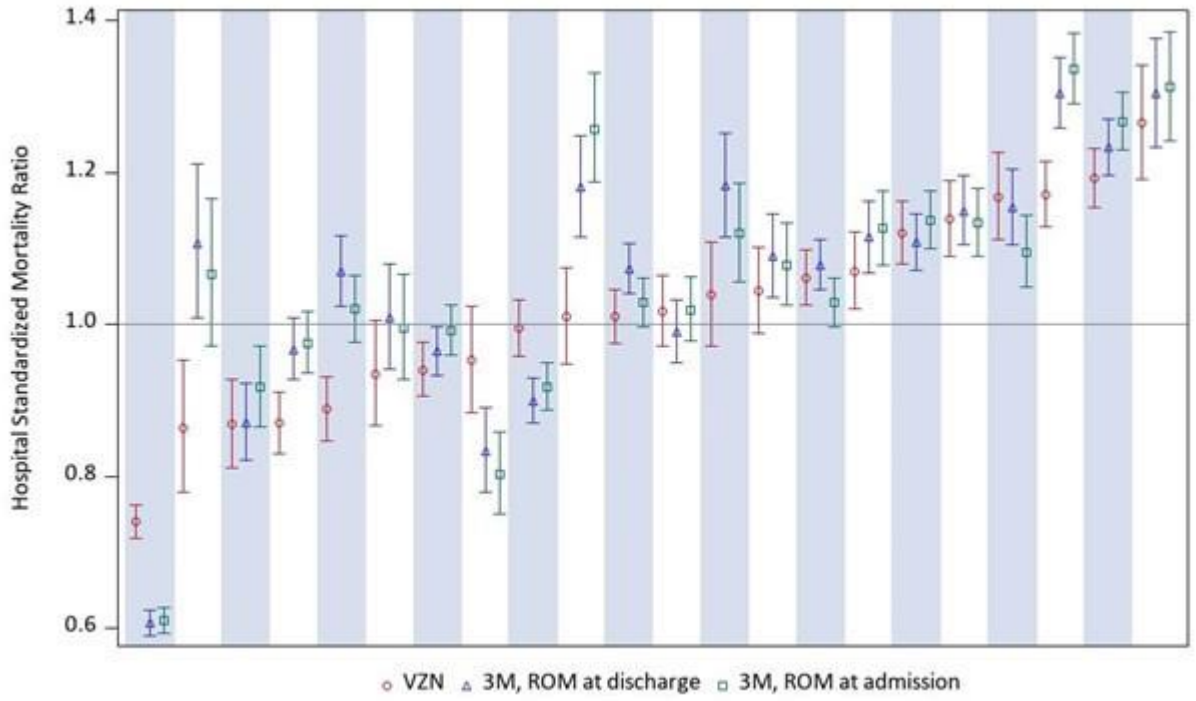


Figure 4.19 Hospital Standardised Mortality Ratios with 95% confidence intervals for the 22 hospitals, as calculated by the FHN-model (red), by the 3M-model using ROM at discharge (blue), and by the 3M-model using ROM at admission (green), with hospitals ordered according to the FHN results.

Table 4.14. Overview of number of hospitals classified into Hospital Standardised Mortality Ratios (HSMR) categories for included hospitals (n=22) according to estimations by the FHN-model, the standard 3M-model (using ROM at discharge) and the 3M-model using ROM at admission.

	FHN	3M, ROM at discharge	3M, ROM at admission
HSMR <1	6	5	4
HSMR =1	8	3	8
HSMR >1	8	14	10

Table 4.15. Direction and significance of Hospital Standardised Mortality Ratios (HSMR) for the 22 hospitals, obtained from the different models/samples, with numbers in bold indicating agreement.

	HSMR < 1.00	**HSMR = 1.00**	**HSMR > 1.00**	**Kappa**	***p-value***	
FHN		**3M, ROM at discharge**			**Kappa[b]**	**Bowker[a]**
HSMR < 1.00	**3**	1	2	0.45	0.006	0.078
HSMR = 1.00	2	**2**	4			
HSMR > 1.00	0	0	**8**			
FHN		**3M, ROM at admission**				
HSMR < 1.00	**2**	4	0	0.46	0.008	0.551
HSMR = 1.00	2	**3**	3			
HSMR > 1.00	0	1	**7**			
3M, ROM at discharge		**3M, ROM at admission**				
HSMR < 1.00	**4**	1	0	0.73	<0.001	0.125
HSMR = 1.00	0	**3**	0			
HSMR > 1.00	0	4	**10**			

[a] Exact Bowker test of symmetry

[b] Exact test of kappa equal to zero

4.6.5 Discussion

Based on data from eligible admissions in 22 Flemish hospitals between 2016 and 2019, HSMRs obtained by the FHN and 3M-models correlated relatively well (Spearman-correlations > 0.79) and there was significant agreement in hospitals identified as performing significantly better or worse than expected. Nevertheless, CIs of HSMRs were not overlapping for 8 hospitals and two of these even showed opposite classification results, i.e. a HSMR significantly <1 according to the FHN-method but significantly >1 according to the 3M-model. Although HSMRs from the 3M-models with different ROM-indicators were similar (correlation=0.97), these two hospitals were no longer classified as performing worse than expected when ROM at admission instead of ROM at discharge was used. Differences in results between the FHN and 3M-model appeared to be due to the risk-adjustment procedures rather than the method-specific patient exclusions, as indicated by the high correlation (0.95) and classification agreement (81.8%) of HSMRs obtained by the 3M-model ran on the different samples.

Measures of model performance indicated superiority of the 3M-model, suggesting that the APR-DRG ROM-subclasses are better predictors of in-hospital mortality than the set of variables used in the FHN-model. This was confirmed by including the ROM-indicator (at discharge) in the FHN-model (as an exploratory analysis, results not shown), which resulted in increased performance (C-statistic=0.92, AUC-PR=0.46, adjusted Brier-score=27%), similar to that of the 3M-model (C-statistic=0.96, AUC-PR=0.42, adjusted Brier-score=26%). APR-DRGs' ROM (at discharge) has been shown to be a good predictor of in-hospital mortality in different settings and disease groups.[167–169,172,173] Consistent with our findings for the Elixhauser-score, these studies reported superior discrimination by ROM compared to (different variants of) the Charlson- and Elixhauser-indices.[167,169,172,173] This is not surprising given that ROM is specifically designed to estimate the likelihood of death within APR-DRG groups, whereas the Charlson-and Elixhauser-indices were solely developed for the quantification of comorbidities. Also the APR-DRG Severity of Illness (SOI) indicator has been found to be a better predictor of in-hospital mortality than the comorbidity indices.[167,169,172] SOI is defined as the extent of organ system loss of function or physiologic decompensation and is designed to predict increased resource use due to comorbidities and acute illness.[174] The higher predictive performance of ROM and SOI is likely due to the inclusion of both POA and non-POA diagnoses, whereas the comorbidity indices typically only incorporate POA codes. Consistent with our results, a study on acute myocardial infarction mortality found that the predictive power of ROM and SOI dropped significantly when only POA diagnoses were included.[168] To compare hospital performance, however, risk-adjustment procedures must be limited to disease severity at admission, as it are exactly the in-hospital complications that might reflect a hospital's quality of care. Therefore, comorbidity indices or ROM/SOI indicators including only diagnoses POA at admission are likely to be more suitable for benchmarking purposes, even if the exclusion of complications developed after hospital admission is at the expense of model performance. Including ROM at admission instead of discharge still outperformed the FHN-method, so the alteration of the 3M-model seems like a feasible feat.

The 3M-method has the advantage of being easier to implement than logistic regression-based modelling approaches, at least once the APR-DRG and ROM variables are available. The ROM-indicator, however, relies on a highly sophisticated patient classification algorithm, which is not straightforward. Moreover, ROM is DRG-specific, so patients from different DRGs cannot be compared using ROM, but might be compared using the Elixhauser-score. A logistic regression approach has the advantage that additional variables can easily be incorporated, although at the expense of computation time in case of a high number of parameters. Although outside the scope of this study, the inclusion of more detailed administrative or laboratory data in combination with artificial intelligence techniques may further

improve the predictive performance of the risk-adjustment models.[175–177] A study aiming at the early prediction of mortality in a Belgian setting showed that a predictive model containing individual ICD-10-CM codes outperformed the conventional compose scores such as ROM and the Charlson-comorbidity index.[175]

Although we used a large multi-centre dataset of over 2,000,000 hospital admissions, only FHN-members were included, which may not be representative for hospitals outside Belgium or Flanders, as differences in patient characteristics, coding habits, and clinical practices between countries or regions may affect results from risk-adjustment procedures. As for most benchmarking systems for in-hospital mortality, results are based on administrative data, so comorbidity estimates may reflect the quality of clinical documentation. Also, although we believe that procedures to account for hospital case-mix should only consider the patient's disease status at admission, POA indicators may introduce bias in case of differences in coding practices between hospitals. The incorporation of POA information in pay-for-performance measures for instance may lead to overreporting of POA, which will mistakenly lower a hospital's risk-adjusted mortality rate. Previous research, however, supports the value of POA to increase the validity of hospital benchmarking.[178–180] While including POA indicators has substantial impact on hospital quality rankings, the impact of inaccuracies in POA reporting has been found to be small.[180] Results were aggregated over the study period of four years, in order to have more stable HSMR estimates which are less subject to random variations. This might, however, have masked changing hospital ranking over time. However, overall yearly fluctuations in mortality were accounted for in both methods, and previous research indicated that in general, good-performing hospitals continue to outperform other hospitals in Belgium.[123]

4.6.6 Conclusions

This study assessed the convergent validity of two common models used to estimate HSMR for 22 hospitals in Belgium. Hospital performance as measured by the 3M- and the FHN-method was found to be similar, except for the opposite classification results obtained for two hospitals. The Spearman-correlations between HSMRs calculated by both methods was equal to 0.79 and classification agreement (observed for 59.1% of hospitals) was significant (kappa=0.45). Differences identified between the two methods appeared to be due to differences in risk-adjustments rather than the method-specific patient exclusions. With the risk of reducing predictive performance, we recommend the exclusion of complications developed during hospitalisation in the risk-adjustment of the 3M-method, as this better fits the purpose of benchmarking a hospital's quality of care.

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Chapter 5

ASSESSMENT OF TRENDS AND VARIATION IN ADVERSE EVENTS

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Summary

This chapter focuses on how adverse events have evolved over time and how they vary between Belgian hospitals. The first section summarises the Belgian prevalence and variability of a selection of *Patient Safety Indicators*, as developed by the Agency for Healthcare Research and Quality. The second section provides a commentary on recent patient safety numbers presented by research under the lead of Dr. David W. Bates. The commentary included reflections of several healthcare frontrunners. However, for the purpose of this PhD dissertation, only the part written by Kris Vanhaecht and PhD candidate Astrid Van Wilder is presented within this chapter.

5.1 Actionability of Patient Safety Indicators for hospital quality and policy: prevalence and variability in Belgium

5.1.1 Abstract

Over two decades ago, the US Agency for Healthcare Research and Quality (AHRQ) developed their Patient Safety Indicators (PSIs) to monitor potentially preventable and severe adverse events within hospitals. Application of PSIs outside the US has thus far been neglected. It is uncertain if PSIs are relevant within Europe, as no up to date assessments of overall PSI rates or inter-hospital variability can be found within the literature. This paper assessed the nationwide occurrence and variability of 13 PSIs for the case study of Belgium. We studied 4,765,850 patient stays across all 101 hospitals for 2016-2018. We established that while PSI rates are generally low, with a PSI observed in 0.1% (n=3,082) of medical and in 1.2% (n=23,993) of surgical hospital stays, they are higher than equivalent US rates and are prone to considerable between-hospital variability. Failure-to-rescue rates e.g. equaled 23%, while some hospitals exceeded nationwide central-line bloodstream infections by a factor of 8. Our results highlight the improvement potential of PSIs and their importance for continued patient safety monitoring.

Key words: Hospitals, Healthcare Quality, Patient Safety, Quality Monitoring

5.1.2 Introduction

The established cornerstone of medicine 'first, do no harm' is pledged because of the fragility of life and health during medical encounters and represents the medical profession's understanding that patient safety is an important part of quality healthcare. However, concerns persist about the complexities of the healthcare system potentially causing patient harm and unintended adverse events.[1,2] Over two decades ago, the US Agency for Healthcare Research and Quality (AHRQ) developed their Patient Safety Indicators (PSIs)[3] to monitor potentially preventable and severe or sentinel adverse events based on routinely collected administrative data. These are low-cost screening tools for identifying potential patient safety problems with minimal registration burden on frontline staff. The present set of PSIs has been technically finetuned and clinically validated by applying strict inclusion and exclusion criteria to ensure specificity.[3–5] The PSIs allow comparison across hospitals due to their shared coding language[6] and measure systematic differences between hospitals with enough precision to detect hospitals with rates above the expected.[7] What's more, they are highly clinically relevant. PSI rates have been associated with higher mortality, length of stay and readmission rates as well as with a decrease in quality of life and healthy life years.[8–10] Furthermore, they lead to excess expenditures both within and outside of hospital care,[11,12] which is detrimental in times of scarcity in healthcare funding.

Yet, despite the widespread application of PSIs within US hospitals and demonstrated applicability of PSIs within different settings,[6,7,10,11] interest in their implementation outside of the US appears to have stagnated within clinical practice and hospital management. The only evidence for PSI utilisation in e.g. Belgium stems from research on data from the year 2000, investigating a different selection of indicators with incompatible definitions and outdated administrative coding.[13] It is uncertain if PSIs are relevant quality indicators to examine within the European continent. Relevance could be demonstrated if PSIs occur frequently and if they vary substantially among hospitals, which could indicate improvement potential. However, no up to date assessments of overall PSI rates or nationwide inter-hospital variability can be observed for any European country within the literature. As a reprioritisation of patient safety is in order, increased awareness of hospital-wide safety risks is in due course.[14] As a primary objective, we aimed to provide an overview of the nationwide occurrence of PSIs for the case study of Belgium. As a secondary objective, we determined PSI variability between acute-care hospitals in Belgium.

5.1.3 Methods

Data source

We conducted a retrospective observational study on the Belgian Hospital Discharge Dataset, a compulsory collection of hospital administrative discharge data in acute-care hospitals, which is primarily used for reimbursement purposes. The dataset contains patient demographics, hospital characteristics and clinical data, i.e. primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 10-Clinical Modification (ICD-10-CM).

Measurement of PSIs

We adopted the definition of an adverse event as described by the Institute of Medicine: 'Injuries caused by medical management rather than by underlying disease or condition of the patient'.[13] We selected 13 adverse events that can be coded on the basis of the Belgian Hospital Discharge Dataset, derived from standardised AHRQ PSI algorithms.[3] PSIs flag patient stays with potentially preventable adverse events attributable to hospital care. The numerator selects pre-defined ICD-10-codes representing secondary diagnoses which were not present on admission (POA) and which point towards the adverse event. Adding information on POA-status has been shown to improve PSI sensitivity and specificity,[15,16] including in PSI calculations on the Belgian Hospital Discharge Dataset.[13,17] The denominator of a PSI depicts the population at risk. PSIs have well-defined inclusion and exclusion criteria, which helps to increase homogeneity and comparability of the groups analysed. AHRQ has selected patient groups to be excluded from PSI analyses for whom a given diagnosis is, with great probability, not the expression of an adverse event, but part of the patient's underlying condition.

We identified eight PSIs that can be applied to both medical and surgical discharges *(02–Death rate in low-mortality DRGs [low-mortality DRGs], 03–Pressure ulcer rate [PU], 05–Retained surgical item or unretrieved device fragment count [retained item], 06–Iatrogenic pneumothorax rate [pneumothorax], 07–Central venous catheter-related blood stream infection rate [CLABSI], 08–In hospital fall with hip fracture rate [in-hospital fall], 14–Postoperative Wound Dehiscence Rate [wound dehiscence] and 15–Abdominopelvic accidental puncture or laceration rate [puncture]).* An additional five PSIs apply only to surgical discharges *(09–Perioperative hemorrhage or hematoma rate [hemorrhage], 10–Postoperative acute kidney injury requiring dialysis rate [kidney injury], 11–Postoperative Respiratory failure rate [respiratory failure], 12–Perioperative pulmonary embolism or deep vein thrombosis rate [PE/DVT], 13–Postoperative sepsis rate [sepsis]).* Finally, we examined *04–Death rate among surgical inpatients with serious treatable complications* in surgical discharges, hereafter referred to as failure-to-rescue. Failure-to-rescue is defined as a patient death that resulted from a hospital-acquired complication. Within failure-to-rescue, the following hospital-acquired complications were withheld: pulmonary emboly, pneumonia, sepsis, shock or cardiac arrest, gastro-intestinal bleeding, or acute ulcers. An overview of PSI definitions and in- and exclusion criteria is provided in Appendix A.4.1.

Study population

We obtained data on all inpatient hospitalisations from all 101 Belgian acute-care hospitals for the years 2016 to 2018. Patients admitted to one-day clinics and psychiatric stays were excluded as well as hospitals with exclusive specialist care that are dedicated to only one or a few related medical specialties. All patients categorized within Major Diagnostic Category (MDC) 15 (*Newborns and other neonates with conditions originating in perinatal period*) were excluded as well as those admitted within the ungroupable All Patient Refined-Diagnosis Related Groups (APR-DRGs) 955 and 956. Additionally, most PSIs excluded all patients below 18 years of age, except for *PSIs 05-retained item* and *07-CLABSI* as well as failure-to-rescue, which included patients younger than 18 if they were categorized into MDC 14 (*Pregnancy, childbirth, and puerperium*). Further PSI-specific exclusions are elucidated in Appendix A.4.1. The final sample included 4,765,850 patient stays, of which 2,781,192 were medical and 1,984,658 surgical inpatient stays.

Risk adjustment

AHRQ has provided specific risk adjustment software for each PSI.[3] However, this risk adjustment is inappropriate for use on the Belgian Hospital Discharge Dataset. We adapted a risk adjustment applied in previous research on mortality, readmission and length-of-stay.[18] This method adjusts for patient demographics including sex, age, Elixhauser-comorbidities, place before admission ('home', 'other hospital or nursing home' or 'in transit or other') and admission type ('elective' or 'emergency'). Age was categorized in 10-year age groups. We used the R package "comorbidity"[19] to obtain the (unweighted) number of Elixhauser-comorbidities, which were included as separate binary covariates. In addition, APR-DRG and discharge year were included as covariates.

Coding practice variability has been identified as one of the strongest correlates of PSI rates.[6,20] In order to increase comparability of PSI rates between hospitals, we added two proxy variables to adjust for coding practices, i.e. the mean number of secondary diagnoses registered and the percentage of secondary diagnoses registered as not POA. This interim approach to provide comparable information on hospital quality has been suggested to improve international consistency among 15 OECD countries.[6]

Statistical analysis

Using SAS software version 9.4 and the SAS programs developed by AHRQ Version 2020, we fitted generalised linear mixed models with a binary response distribution and logit link function with automated backward variable selection for each PSI. Adaptations to the SAS programs developed by AHRQ were made by replacing information on race and payer, as this was unavailable within the Belgian Hospital Discharge, with year of discharge and DRG-type (medical versus surgical), respectively. All PSI-specific models included fixed effects for patient characteristics and coding practice and a random intercept for hospital to account for hospital-level clustering. Hospital-specific risk-standardized PSI rates were calculated as the ratio of observed and expected PSIs multiplied by the overall crude PSI rate. The predicted number of PSIs was obtained as the hospital-specific prediction from the model including both the fixed effects and the hospital-specific random intercept (i.e. the best linear unbiased predictor), whereas the expected number of PSIs is the prediction including only the fixed effects. PSI rates are reported as the number of adverse events per 1000 discharges. Hospitals for which the random intercept estimate was significantly higher (or lower) than zero were identified as hospitals with significantly higher (or lower) than expected PSIs. Ninety five percent confidence intervals were calculated using Byar's approximation and were used to identify hospitals with PSI rates significantly higher (or lower) than expected. Dot plots and line charts were used to illustrate the variability of risk-adjusted PSI rates among Belgian hospitals in a graphical way. In order to avoid showing extreme rates due to low case numbers, hospitals were only graphically displayed if they had more than 30 patients at risk for a PSI.[3] In addition, between-hospital variability was assessed by calculating inter quartile ranges (IQRs) and coefficients of variation (CV), i.e. the ratio of the standard deviation to the mean, of risk-adjusted PSI rates.

5.1.4 Results

Descriptives

Of the 101 included hospitals, seven are academic hospitals. A median overall admission volume of 8,339 patients per year (IQR 5,035-15,478) could be observed (Table 5.1). The mean age of patients was 59.9 years with 45.1% of the population male. Almost half (46.9%) of patients were admitted via the emergency ward and the majority of patients (54.7%) had between 1 and 4 Elixhauser comorbidities. Compared to surgical patients, medical patients had a higher number of comorbidities (31.1% versus 44.7%) and were more often admitted via the emergency ward (23.1% versus 63.9%). Most patients were at home before their admission (95.5%). The average length of stay was 6.8 days for the medical and 6.6 days for the surgical population. The crude in-hospital mortality rate for medical and surgical discharges was 4.2 and 1.6 per 100 discharges, respectively.

Table 5.1 Characteristics of hospital admissions in Belgium, 2016-2018

	Medical population	Surgical population	Total population
N hospitals	101	101	101
Admissions			
N admissions	2,781,192	1,984,658	4,765,850
Yearly admissions per hospital, median (IQR)	9,600 (5,861-16,951)	6,647 (3,658-12,778)	8,339 (5,035-15,478)
Age, mean ± SD	61.0 ± 20.9	58.3 ± 18.3	59.9 ± 19.9
Sex			
Male (%)	44.8	45.3	45.1
Female (%)	55.2	54.7	54.9
Number of Elixhauser comorbidities			
0 (%)	31.1	44.7	36.8
1-4 (%)	57.8	50.4	54.7
≥5 (%)	11.1	4.9	8.5
Place before admission			
Home	94.8	96.5	95.5
Other hospital or nursing home	2.9	1.7	2.4
Other	2.3	1.8	2.1
Type of admission			
Elective	36.1	76.9	53.1
Emergency (%)	63.9	23.1	46.9
Year			
2016 (%)	33.3	33.3	33.3
2017 (%)	33.2	33.4	33.3
2018 (%)	33.5	33.3	33.4
Mortality, N (%)	117,911 (4.2%)	31,627 (1.6%)	149,538 (3.1%)
Length of stay, mean ± SD	6.8 ± 11.0	6.6 ± 13.5	6.7 ± 12.1

PSI rates across Belgian acute-care hospitals

We identified at least one PSI in 0.1% (n=3,082) of medical hospital stays and in 1.2% (n=23,993) of surgical hospital stays. Overall PSI rates ranged from 0.04 *(PSI 05-retained item)* to 3.1 *(PSI 09-hemorrhage)* and the failure-to-rescue rate was 23% (Table 5.2). Across PSIs applicable to both the medical and surgical population, surgical inpatients demonstrated consistently higher event rates.

In general, odds of a PSI were higher in men than in women except for PSIs *06-pneumothorax* and *08-in-hospital fall*, where the opposite relationship could be observed (Appendix A.4.2). Additionally,

Table 5.2 Patient Safety Indicators and their variability within Belgian hospitals, 2016-2018

Patient Safety Indicator	Crude rates per 1000 admissions			Inter Quartile Range (IQR) of risk-adjusted rates			Coefficient of variation (CV) of risk-adjusted rates		
	Medical (N cases /N at risk)	Surgical (N cases/N at risk)	Total (N cases/N at risk)	Medical	Surgical	Total	Medical	Surgical	Total
PSI 02 - Death Rate in Low-Mortality DRGs	0.4 (272/622,220)	0.6 (534/896,277)	0.5 (806/1,518,497)	0.2-0.6	0.4-0.8	0.4-0.7	81.9	47.7	42.2
PSI 03 - Pressure Ulcer Rate	1.2 (1,734/1,408,568)	2.6 (2,495/950,039)	1.8 (4,229/2,358,607)	0.3-1.5	1.5-3.8	0.8-2.5	116.1	74.9	89.7
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable Complications (failure-to-rescue)		225.8 (7,335/32,478)	225.8 (7,335/32,478)		192.1-258.2	192.1-258.2		23.0	23.0
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	0.0 (17/2,781,092)	0.1 (149/1,984,396)	0.04 (166/4,765,488)	0.0-0.0	0.0-0.2	0.0-0.1	314.3	111.6	105.5
PSI 06 - Iatrogenic Pneumothorax Rate	0.2 (558/2,347,147)	0.5 (873/1,775,238)	0.3 (1,431/4,122,385)	0.1-0.3	0.2-0.6	0.2-0.4	72.7	72.3	57.5
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	0.2 (251/1,483,197)	0.6 (593/1,048,991)	0.3 (844/2,532,188)	0.0-0.3	0.0-0.9	0.0-0.5	146.2	133.9	110.4
PSI 08 - In Hospital Fall with Hip Fracture Rate	0.1 (109/1,983,503)	0.5 (724/1,539,726)	0.2 (833/3,523,229)	0.0-0.1	0.3-0.7	0.1-0.3	138.0	74.4	76.0
PSI 09 - Perioperative Hemorrhage or Hematoma Rate		3.1 (5,339/1,730,623)	3.1 (5,339/1,730,623)		2.3-3.7	2.3-3.7		40.8	40.8
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate		0.7 (909/1,366,029)	0.7 (909/1,366,029)		0.3-0.9	0.3-0.9		79.5	79.5
PSI 11 - Postoperative Respiratory Failure Rate		1.2 (1,350/1,172,631)	1.2 (1,350/1,172,631)		0.8-1.6	0.8-1.6		48.8	48.8
PSI 12 – Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate		1.2 (2,070/1,777,535)	1.2 (2,070/1,777,535)		0.8-1.5	0.8-1.5		48.1	48.1
PSI 13 - Postoperative Sepsis Rate		2.5 (3,325/1,343,666)	2.5 (3,325/1,343,666)		1.7-3.1	1.7-3.1		57.4	57.4
PSI 14 - Postoperative Wound Dehiscence Rate	0.0 (0/25,780)	0.8 (282/341,795)	0.8 (282/367,575)	0.0-0.0	0.0-1.4	0.00-1.3		116.0	115.3
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	0.4 (148/387,837))	3.5 (2,335/671,646)	2.3 (2,483/1,059,483)	0.0-0.7	2.0-4.3	1.3-2.9	130.2	53.6	55.5

patients admitted through emergency wards or being admitted from any place other than home had higher odds of experiencing a PSI. The effect of discharge year was most often not withheld within the backward selection of the logistic regression model, but if it did, odds of a PSI were often lower over time. Proxy variables for coding practices had a significant impact on PSI rates, with higher means of secondary diagnoses and higher percentages of secondary diagnoses not registered as POA resulting in higher odds for PSIs. With the exception of some specific PSI and Elixhauser-covariate combinations (e.g. in blood loss anaemia or obesitas), the presence of an Elixhauser comorbidity led to increased odds of a PSI. Finally, the C-statistic of the PSI calculations ranged from 0.67 for *PSI 05-retained item* to 0.97 for *PSIs 08-in-hospital fall* and *10-kidney injury*. This confirms a strong model fit that is able to discriminate between patients with and without a PSI.[21]

Variability of risk-adjusted PSI rates across Belgian acute-care hospitals

Figures 5.1 and 5.2 show the variability of risk-adjusted PSI rates for medical and surgical PSIs, respectively. The graphs illustrate that, even after risk adjustment, all PSI rates vary greatly among Belgian acute-care hospitals. Some PSIs stand out by containing outlying hospitals that have rates up to eight (*PSI 03-PU* for medical patients and *PSI 07-CLABSI* for surgical patients), seven (*PSI 15-wound dehiscence* for medical patients and *PSI 05-retained item* for surgical patients), six (*PSI 14-wound dehiscence* for surgical patients) or five (PSIs *03-PU* and *13-sepsis* for surgical patients) times the average rate.

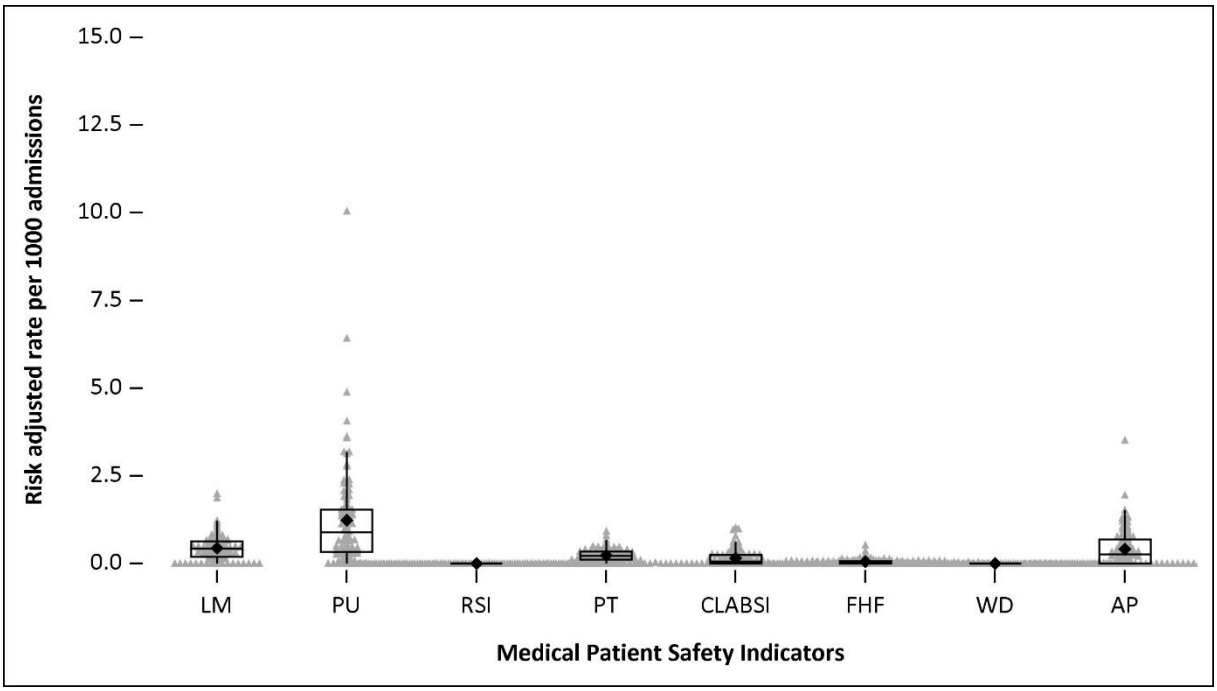

Figure 5.1 Patient Safety Indicator rates across Belgian acute-care hospitals among medical inpatients; 2016-2018

Distribution of risk-adjusted rates per 1000 admissions for eight Patient Safety Indicators. Each triangle represents one of 101 Belgian acute-care hospitals. Abbreviations: LM, Death Rate in Low-Mortality DRGs; PU, Pressure Ulcer Rate; RSI, Retained Surgical Item or Unretrieved Device Fragment Count; PT, Iatrogenic Pneumothorax Rate; CLABSI, Central Venous Catheter-Related Blood Stream Infection Rate; FHF, In Hospital Fall with Hip Fracture Rate; WD, Postoperative Wound Dehiscence Rate; AP, Abdominopelvic Accidental Puncture or Laceration Rate.

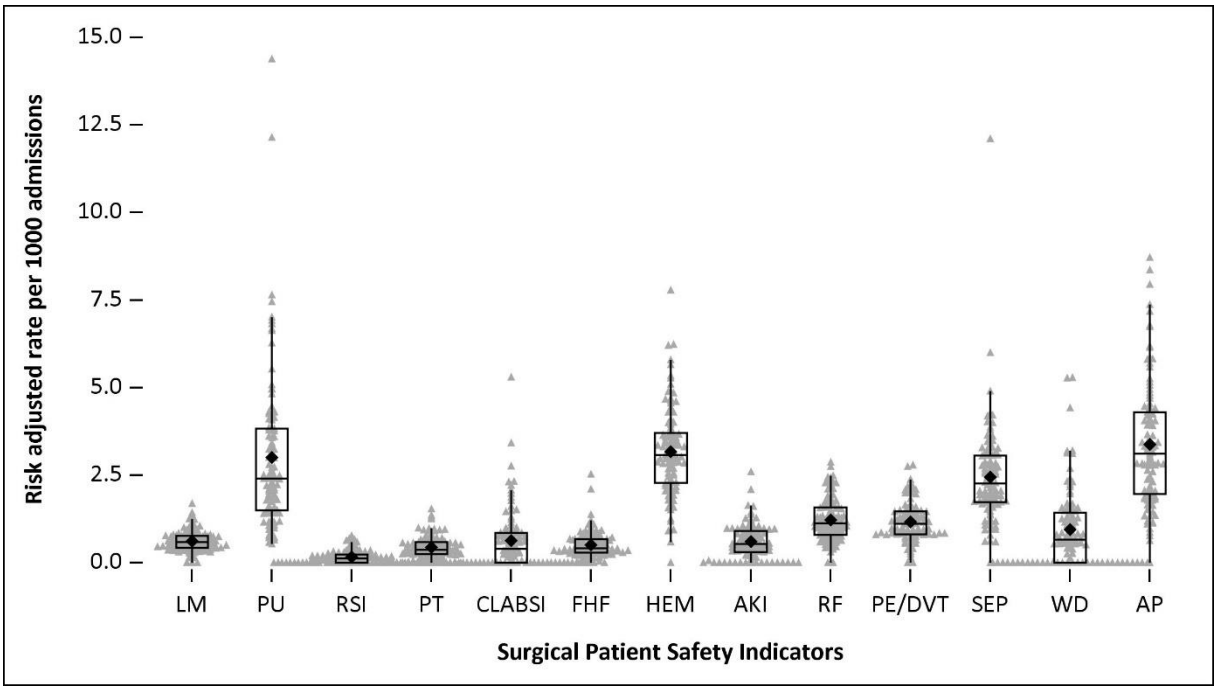

Figure 5.2 Patient Safety Indicator rates across Belgian acute-care hospitals among surgical inpatients; 2016-2018

Distribution of risk-adjusted rates per 1000 admissions for 13 Patient Safety Indicators. Each triangle represents one of 101 Belgian acute-care hospitals. Abbreviations: LM, Death Rate in Low-Mortality DRGs; PU, Pressure Ulcer Rate; RSI, Retained Surgical Item or Unretrieved Device Fragment Count; PT, Iatrogenic Pneumothorax Rate; CLABSI, Central Venous Catheter-Related Blood Stream Infection Rate; FHF, In Hospital Fall with Hip Fracture Rate; HEM, Perioperative Hemorrhage or Hematoma Rate; AKI, Postoperative Acute Kidney Injury Requiring Dialysis Rate; RF, Postoperative Respiratory Failure Rate; PE/DVT, Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate; SEP, Postoperative Sepsis Rate; WD, Postoperative Wound Dehiscence Rate; AP, Abdominopelvic Accidental Puncture or Laceration Rate.

Table 5.2 further highlights this variability, with large overall IQRs observed for failure-to-rescue (192.1-258.2), PSI *07-CLABSI* (0.0-0.5) and PSIs *14-wound dehiscence* (0.00-1.3), *03-PU* (0.8-2.5) and *10-kidney injury* (0.3-0.9). The largest CVs could be observed in the medical population, with the highest CV seen in PSI *05-retained item* (314.3) and in *07-CLABSI* (146.2). Across both the medical and surgical population, three PSIs reached a CV over 100: PSI *14-wound dehiscence* (115.3), *07-CLABSI* (110.4) and *05-retained item* (105.5).

Finally, how PSI rates evolve over time is also seen to vary between hospitals, as exemplified by the failure-to-rescue rates over time for each individual Belgian hospital (Figure 5.3). The exhibit is ranked from lowest overall failure-to-rescue rate (99/1000) to highest (415/1000) per hospital, highlighting the extensive between-hospital variation. Furthermore, the illustration demonstrates diversified longitudinal trajectories across hospitals, with e.g. stagnating PSI rates observed in hospital BK, improving rates in hospital AZ, deterioration in hospital BR or fluctuating rates in hospital DL.

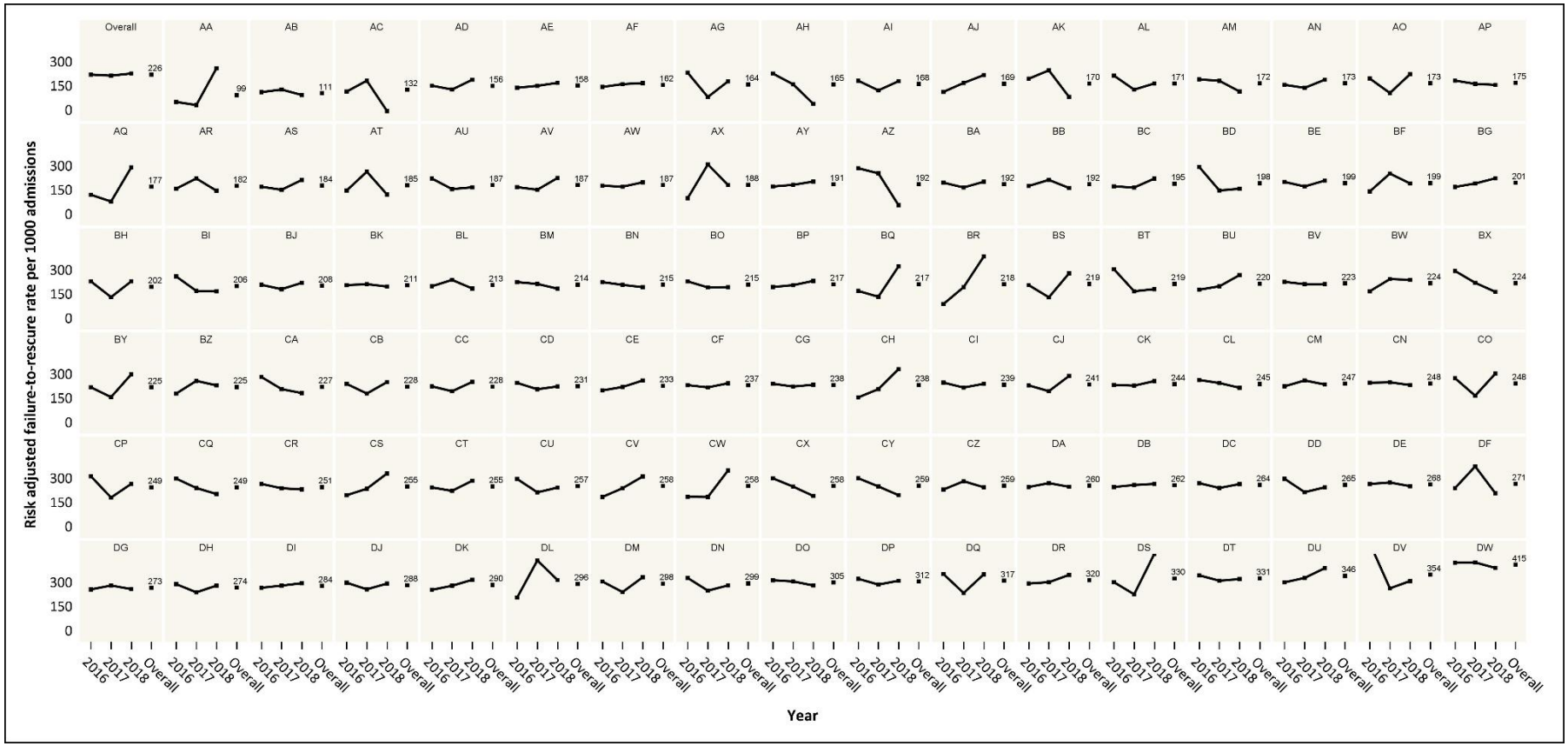

Figure 5.3 Temporal trends in failure-to-rescue rates for surgical inpatients across individual Belgian acute-care hospitals

Distribution of risk-adjusted rates per 1000 admissions. Each box represents one of 101 Belgian acute-care hospitals. The box in the upper left angle represents overall failure-to-rescue rates across 101 hospitals. Hospitals are ranked according to increasing average failure-to-rescue rates between 2016 and 2018. Failure-to-rescue is defined as a patient death that resulted from any of the following hospital-acquired complications: pulmonary emboly, pneumonia, sepsis, shock or cardiac arrest, gastro-intestinal bleeding or acute ulcers.

5.1.5 Discussion

PSI rates highlight important patient safety issues in Belgium

This study showed that the AHRQ PSIs are important metrics to evaluate patient safety for a high-income country such as Belgium. Even though individual PSI rates are low, they are generally higher than PSI rates reported for 4,252 US hospitals in 2019.[22] Out of the 13 PSIs reported, only four had lower rates than their US equivalents, i.e. PSIs *11-respiratory failure* (1.2 versus 6.3 in US), *12-PE/DVT* (1.2 versus 3.2), *13-sepsis* (2.5 versus 3.9) and *14-wound dehiscence* (0.8 versus 1.6). All other PSIs were seen to have higher rates in Belgium, with some PSIs exceeding double (*08-in-hospital fall* [0.2 versus 0.07] and *15-puncture* [2.3 versus 1.0]) or triple (*03-PU* [1.8 versus 0.6] and *07-CLABSI* [0.3 versus 0.1]) the PSI rates in the US. *PSI 05-retained item* was seen to occur 597 times across 35,612,694 US discharges, indicating that Belgian hospitals have twice as many cases across 4,765,850 patient stays.

While we cannot unambiguously compare rates across cultures and healthcare systems and slight adaptations were made to the US PSI calculations, the presented Belgian rates are cause for concern and highlight the potential of monitoring PSIs nationwide. Thanks to the inclusion of POA-information, time stamping of operating room procedures and stricter inclusion and exclusion criteria, earlier validity issues with PSIs have been eliminated.[15,16] The presented rates are accompanied by satisfactory c-statistics, indicating a strong model fit able to distinguish between patients with and without a PSI. Knowing their clinical relevance[8,9] and financial impact,[11,12] aiming to reduce PSI rates could potentially contribute to important quality of care benefits. What's more, the surveyed between-hospital variation is substantial across all PSIs even after corrections for patient risk, with heterogenous trajectories over and with CVs even surpassing the threshold of 100 in PSIs *05-retained item, 07-CLABSI* and *15-puncture*. While the high CVs are in part explained by low mean rates across PSIs, they do underline the improvement potential. Hospitals that manage to achieve lower PSI rates than others while admitting patients with similar risk profiles provide important learning opportunities. As hypothesized in previous research,[18] this urges further investigation of hospital context factors that might be contributing to this variation, including leadership characteristics, quality education, or quality culture.[23,24] Differences in hospital boards and front-line management across medical wards have been shown to be strongly related to clinical patient outcomes.[25] Additionally, staffing levels of physicians and nurses might also play a part in outcome disparities.[26]

High failure-to-rescue rates are worrisome

Failure-to-rescue is a particular PSI as it not only takes complications of care into account, but also relates to how well hospitals respond when they occur. Remarkably, 32,478 patient stays could be identified as obtaining either a pulmonary emboly, pneumonia, sepsis, shock or cardiac arrest, gastro-intestinal bleeding, or acute ulcer during their hospital admission, amounting to on average over 100 complications per year per hospital. Moreover, the response to these complications is worrisome and warranting of immediate attention of policy makers and hospital managers. Nearly one in four patients died when they encountered any of the aforementioned complications, which is significantly higher than the US equivalent rate of 14%.[22] While we cannot immediately compare our results to the Belgian population analyses of the year 2000 because POA-information was not taken into account,[13] it is troublesome how a failure-to-rescue rate of a similar size order with similar between-hospital variability was reported twenty years ago.[27] As failure-to-rescue correlates highly with overall in-hospital mortality, hospitals should not only focus on preventing complications of care, but they should improve the care

that patients receive once complications have occurred.[28] Such initiatives could focus on organisational factors, such as promoting minimum standards for nurse staffing, ICU re-organisation, or other attributes associated with proficiency in treating critical and unstable patients.[28] As patient care is increasingly more complex with multimorbidity and polypharmacy[29] and nurses' turnover and burnout rates are seen to rise,[30] this area will be specifically important post-covid.

Surgical patients have higher PSI rates, the medical population shows the highest variability

This study observed an overall PSI prevalence of 0.1% and 1.2% for medical and surgical inpatients respectively. While this is in part due to more PSIs being applicable to the surgical population, perioperative patients were also seen to have the highest individual PSI rates overall. Knowing the associated risks of mortality with PSIs,[8,9] reducing surgical PSIs should become an important strategy in reducing postoperative mortality.

The medical population, however, was the apparent driving force of between-hospital variation. In particular PSIs *03-PU, 07-CLABSI* and *15-puncture* were seen to have many outlying hospitals, large IQRs and large CVs. More often than surgical care, medical care is practiced within interdisciplinary teams and across both primary and secondary care. In order to reduce variability in care provision, strategies such as care pathways[31], bundled payments initiatives[32] or collaborative and peer-reviewed learning could be considered.[33]

Actionability of PSIs on policy and hospital level

This study confirmed the potential for monitoring PSIs in Belgium, as rates are high and vary substantially between hospitals even after patient risk adjustments. Additionally, individual hospitals were seen to evolve differently over time. Continued longitudinal monitoring of PSIs with our results serving as baseline is therefore highly recommended, especially with indications of rising hospital-acquired infections in the aftermath of the pandemic.[34] Both on overarching policy level as well as on individual hospital level, PSI monitoring could result in targeted quality improvement actions.

On a governmental policy level, surveillance of PSIs could aid in determining nationwide priorities. Based on our results, failure-to-rescue and *PSI 07-CLABSI* could e.g. be targeted first. We propose to incorporate them in regional inspections and clinical audits. Our individual-level analyses could help in determining which hospitals to visit first based on upward time trends or higher than average rates. Other initiatives to be considered include integration into public reporting or pay-for-performance (P4P) programs, which to date do not take any complications into account in Belgium. On the contrary, Belgium currently incentivises complication occurrence by rewarding higher financial reimbursements to more severely ill patients. On the opposite side of the spectrum, US Medicare policy employs a non-pay for non-performance system, with discontinued funding for 'never-events' such as the occurrence of *PSI 03-PU* or *12-PE/DVT*. Past inclusion of CLABSI within this policy was associated with spectacular and sustainable rate reductions.[35] Yet, the policy is not without controversy, especially as achieving zero harm is not always feasible.[36] Healthcare policies should refrain from promoting a punitive 'blame and shame' approach, but should instead stimulate a patient safety movement founded in confidentiality and legal protection from retribution.[37]

It should be up to individual hospitals to decide whether or not to share promising quality improvement strategies among other hospitals. Already, 20 Flemish acute-care hospitals have committed themselves to co-produce quality of care within the FlaQuM-consortium.[38] One of their core pillars involves

learning within inter-hospital collaboratives, which incorporates in-depth peer-review. A detailed feedback benchmark report of patient outcomes, among which PSIs, provides foundations for such peer-reviewed learning. The most successful interventions will involve a combination of a multidisciplinary team with actions involving education and standardisation, data provision providing accountability and a culture of safety.[39]

Limitations

Our analyses were subject to important limitations. First, this study was restricted to indicators derived from administrative data, which could therefore not take certain important quality concerns into account, such as adverse drug events. Ergo, this study is by no means an assessment of overall adverse event prevalence in hospital care, which has been estimated to involve up to one in five patients.[1] Second, while we accounted for numerous patient-related factors associated with disease severity, the lack of hemodynamic and laboratory parameters or information on inflammatory burden and kidney function might help explain some of the observed variation in care, especially in the more heterogeneous population of medical patients. Additionally, other patient-related factors such as ethnicity or economic status were not yet accounted for.[40] Finally, adjusting for coding practice variability between hospitals potentially risked over-adjustments, thereby possibly observing lower than true between-hospital variability. Nevertheless, we still surveyed abundant variation between hospitals and the adjustments made increased comparability between hospitals. Despite these limitations, our study revealed how PSIs are important patient safety metrics worthy of continued nationwide monitoring in Belgium.

5.1.6 Conclusions

This study assessed whether AHRQ PSIs are relevant indicators for quality purposes outside of the US setting. As overall Belgian PSI rates were high and varied substantially between hospitals, continued nationwide monitoring is warranted and actionable. Policy makers and hospital managers can prioritize those PSIs with high rates or large variability such as failure-to-rescue or central-line bloodstream infections. Initiating targeted initiatives towards reductions in PSIs is a promising strategy to improve hospital care quality for the Belgian population.

5.2 Rethinking and Reinvesting in Patient Safety

5.2.1 Seeing the wood for the trees in Bates' latest patient safety research: a plea for focusing on the core values of care

It was with great interest that we read Bates's and colleagues'[1] latest publication in NEJM. The paper is an important one that presents staggering numbers on patient safety and is backed by a sound methodology. Its clinical, scientific and societal impact is clearly evident. However, four reflections resonated with us that are deserving of some elaboration.

First, the numbers presented might cause some confusion for the patient safety narrative. We summarised a limited sample of often-cited landmark papers in Table 5.3. It demonstrates how a wide range of numbers have been reported on the topic of adverse events (AEs). How then do we translate these new results to young clinicians, hospital managers and our patients? Do we consider them to be underestimates when comparing to the numbers of Classen *et al* for example?[41] Or are they overestimates when comparing to the recurring accounts of 10% of patients experiencing an AE?[2,42–45] As accentuated by both Bates' manuscript[1] and Berwick's editorial on the topic[46], direct comparisons of AE rates are subject to a vast set of difficulties and challenges. Prominent differences in e.g. definitions, data collection methods, settings and inclusion and exclusion criteria across the evidence-base have culminated in an unclear and ambiguous hospital quality story.

Regardless of the exact number of patients suffering from hospital-induced harm, however, patient safety remains an important issue within hospital care, as is Bates' main takeaway. We would argue that even the lowest number depicted in Table 5.3 is problematic. The past two decades have been characterised by the development of numerous quality interventions,[27] yet the most recent numbers indicate they have failed to leave a durable impact. Continued efforts to monitor patient safety by means of continued refinements to measurement tools therefore remain required. The heavy workload involved in manual trigger methods along with a lack of sensitivity in certain areas[1], leads to the recommendation of further developing automated trigger tools[47] and utilising routinely-collected administrative data.[18,48] What's more, the lack of sustainable quality improvement observed, should lead to the reconsideration of quality development. It is high time quality of care takes every single healthcare stakeholder's perspective, from clinicians to patients, into account[49] and learns to co-create a sustainable quality management system bottom-up,[50] rather than imposing guidelines and quality standards top-down.

Third, Bates and colleagues only briefly touched upon the results concerning hospital variation, but as seen in Table 5.3, the disparities between organisations continue to be a reason for concern. Within our quality and patient safety research group at KU Leuven, Belgium, we recently published on this variation between Belgian hospitals both on a hospital-wide level[18] as well as on the urological department-level.[51] We discovered that variation in mortality, readmissions and length of stay is highly prominent. Remarkably, top-scoring hospitals predominantly remained top performers over our ten-year study period, while hospitals at the bottom remained there.[18] Our findings were suggestive of systemic hospital aspects influencing patient outcomes.[18] Furthermore, the impact of reducing variation is presumably quite sizeable. We estimated that over 400 urological lives could potentially be saved every year in the small country of Belgium (11 million inhabitants), should the mortality rates of the bottom 25% of hospitals fall to the median levels of care.[51] In the spirit of a Safety-II approach[52], we would encourage hospitals to engage in peer-review, where top performers could help identify areas of improvement for those struggling to improve patient safety.

Finally, we'd like to zero in on an aspect that is lacking in Bates' most recent study[1] and is often overlooked in general. While patient safety is without any doubt a vastly important aspect of hospital quality, it is but one factor in a complex and multidimensional system.[53,54] Focus on quality of care should expand to other technical quality dimensions, such as effectiveness, efficiency, accessibility and timeliness, equity and eco-friendliness.[53] Moreover, it should recognise and remember the core values of care. Treating both care receiver and care giver with dignity and respect, with a holistic approach, in partnership and co-production and with well-deserved kindness and compassion, might lead towards true person-centred care.[53,55] We hypothesise that acting from these core values might be the catalyst required to finally achieve genuine patient safety improvements in the future.

Table 5.3. Comparison of Adverse Event (AE) prevalence across sample of prominent studies for developed countries

	IOM, 2000[56]	**De Vries, Qual Saf Health Care, 2008[42]**	**Levinson, 2010[43]**	**Landrigan, NEJM, 2010[57]**	**Classen, Health Affairs, 2011[41]**	**WHO/OECD/World Bank, 2018[44]**	**Schwendimann, BMC HSR, 2018[45]**	**Panagioti, BMJ, 2019[2]**	**Bates, NEJM, 2023[1]**
Study population	30 195[58] in 1984 and 15 000 in 1992 US inpatient records[59]	8 studies including 74 485 patient records	838 US inpatient records in October 2008	2341 US inpatient records between 2002 and 2007	795 US inpatient records in October 2004	NA	25 studies across 27 countries and 6 continents	70 studies involving 337 025 patients	2800 US inpatient records in 2018
Study method	Medical record review according to the Harvard Medical Practice Study (Harvard) method[58]	Systematic literature review on in-hospital AEs	Medical record review according to the Global Trigger Tool[60] (GTT) method	Medical record review according to the Global Trigger Tool[60] (GTT) method	Medical record review according to GTT[60] method, AHRQ PSIs and voluntary incident reporting	Literature review	Literature scoping review for AE prevalence according to the Harvard[58] method, GTT[60] or similar	Systematic literature review and meta-analysis on preventable patient harm in primary and secondary care	Medical record review according to the Harvard[58] method
Overall AE/100 admissions	2.9-3.7%	9.2% (4.6 – 12.4)*[a]	13.5% (11.2-16.1)**	25.1% (23.1-27.2)**	49.4% (range: 43-56)	10% (range 3.7-16.6)	10%[a] (range 2.9-21.9)	12% (9-14)**	34.8 (29.2-40.5)**
Fatal adverse events	6.6-13.6%	7.4% (4.7-14.2)*	9.8%[$] (2.54-19.33)**	0,6%	2.0%	3.0-15.9%	7.3%[a] (range 0.6-30)	12%[$] (8-15)**	0.2% (0.0-0.5)**
Preventability of detected AE	53-58%	43.5% (39.4-49.6)*	44.1% (38.1-50.2)**	63.1%	NA	28-72%[61]	51.2% (range 34.3-83)	50%	22.7%
Most common types of AE	1. Medication related (19%) 2. Wound infections (14%) 3. Technical complications (13%)	1. Surgery related (39.6% [31.5-50.2]*) 2. Medication related (15.1% [11.9-20.4]*) 3. System-related or other (8.1%, [2.3-27.3]*)	1. Medication related (31.3% [34.7-49.5]**) 2. Patient care related (36.2% [29.1-43,9]**) 3. Surgery and other procedure related (18.4% [12.9-25.5]**)	1. Surgery related (31,6%) 2. Medication related (27,6%) 3. Healthcare associated infections (14,8%)	1. Medication related (38.2%) 2. Procedure related (27.7%) 3. Healthcare associated infections (18.3%)	Healthcare associated infections (7%, range 5-10%)[62]	1. Surgery related (40%, range 27-74.9); 2. Medication related (19.3%, range 4-73) 3. Healthcare associated infections and allergic reactions (17.7%, range 0.2-25.3)	1. Surgery related (31% [20-42]**) 2. Medication-related (26%, [19-34]**) 3. Procedure related (24% [17-31]**) 4. Healthcare associated infections (21%, [15-28]**)	1. Medication related (39.0%) 2. Surgery and other procedure related (30.4%) 3. Patient care related (15.0%)

*Inter Quartile Range; **95% Confidence Interval; [$]encompasses severe harm: includes both AE resulting in patient death and in permanent disability; NA: Not applicable; [a]Different definition of overall frequency: number represents percentage of patients with at least 1 AE

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Chapter 6

GENERAL DISCUSSION AND CONCLUSIONS

6.1 General overview

This PhD dissertation evaluated hospital quality of care across Belgian hospitals between 2008 and 2018. In chapter 2, a systematic literature search with narrative synthesis was presented on the impact that accreditation, public reporting and inspections have on patient outcomes. Chapter 3 set the scene of our research, by delineating the implementation of quality improvement initiatives within Flemish hospitals. Chapters 4 and 5 pursued a retrospective examination of how patient outcome measures evolved over time and varied across all Belgian acute-care hospitals. Chapter 4 gathered the research conducted on what we consider to be the *'vital few'* patient outcomes to be assessed: mortality, length of stay, readmissions and patient experiences. Finally, chapter 5 concluded the results section of this dissertation by investigating how a wide range of adverse events have evolved over time and vary between hospitals.

6.2 The research setting: poor evidence for current quality policy, but high commitment towards quality from hospitals

This research took place across all 99 Belgian acute-care hospitals. Belgium is a small high-income country with 11 million inhabitants that is organised within three regions. The northern region of Flanders includes the majority of acute-care hospitals (n=53) and is subject to the Flemish government quality policy for hospitals entitled the 'Quality-of-Care Triad', which was established in 2009.[1] Within this policy, hospitals were encouraged to enter into a hospital-wide accreditation programme and publicly report quality indicators on www.zorgkwaliteit.be, while regularly being inspected by the government. Yet, international evidence is not able to identify associations between these quality improvement initiatives and changes in patient outcome measures, as was highlighted in the narrative review displayed in Chapter 2. Even though accreditation surveys are frequently observed to positively influence adherence to process measures, impact of accreditation and the other initiatives within the Triad on other patient outcomes such as mortality, readmissions, length of stay, patient satisfaction, adverse events or failure-to-rescue, was found to be limited.

Despite the lacking evidence-base, Flemish hospitals demonstrated large commitment towards quality of care by adopting the Quality-of-Care Triad initiatives and additional internal strategies, as was underlined in Chapter 3. However, due to a lack of streamlining of initiatives and incremental increased and concomitant demands, hospitals have declared that current quality policy is no longer a sustainable approach. Already, multiple hospitals have publicly declared that renewal of accreditation status is no longer a primary concern. Instead, they are looking for a contemporary durable, well-coordinated and bottom-up approach, that still incorporates quality control by an independent – albeit national – organisation.[2] Recent developments within the Flanders Quality Model (FlaQuM) consortium, which is built around a shared quality vision, co-creation and innovation through learning, are perhaps a step in the right direction.[3] Within the latter FlaQuM pillar of 'learning', there is room for peer-reviewed assessments and benchmark reports of patient outcomes, an aspect that was greatly overlooked before. As accentuated within this PhD dissertation, monitoring patient outcome measures can reveal crucial shortcomings within the healthcare system.

6.3 Little improvement and unsettling variation in patient outcomes in Belgium

As disseminated across Chapters 4 and 5, all patient outcomes that were surveyed – ranging from mortality, readmissions, length of stay, patient experiences to adverse events – demonstrated only limited improvements over time and were prone to excessive between-hospital variation. The observed variability persisted even after elaborate adjustments for patient risk profiles and was far too large to be attributable to chance variation. Rather, it is suggestive of important systemic differences between Belgian hospitals. Targeting these unwarranted inter-hospital differences can have enormous benefits towards patient safety and quality of care.

Before the analyses displayed within this dissertation, a nationwide analysis of patient outcomes had not been realised before. As it turns out, these are of added value for our policy makers, hospital managers, clinicians and patients, by revealing important patient safety challenges. Laudably, some outcomes made some progress over the years. Examples include all-cause in-hospital mortality in Belgium decreasing from on average 3.4% to 3.1% or length of stay decreasing from an average length of 7.6 days to 6.5 days between 2008 and 2018. Additionally, patient experiences improved between the start of their measurements in 2014 and 2019, with the percentage of patients scoring the hospital 9 or 10 out of 10 increasing from 56% to 61%. Yet, these average scores are still about 11 percentage points removed from scores for equivalent measures used in the US.[4] Similarly, the prevalence of AHRQ Patient Safety Indicators (PSIs) might be low across Belgian hospitals, with a PSI detected in on average 0.1% (n=3,082) of medical and in 1.2% (n=23,993) of surgical hospital stays. Yet, they were observed to occur far more frequently than their US equivalent rates, with rates sometimes being double or even triple as high.[5] While we have to be careful with direct comparisons, they do highlight the existence of potential quality-related issues within Belgian hospitals. On top of this, a wide range of outcome measures had worrying average rates. Readmissions to the same hospital for example, increased from 4.8% to 5.2% between 2008 and 2018. Additionally, failure-to-rescue occurred in 23% of surgical inpatients. This indicates that out of the 32,478 patients between 2016 and 2018 that obtained either a pulmonary emboly, pneumonia, sepsis, shock or cardiac arrest, gastro-intestinal bleeding or acute ulcer during their hospital admission, one in four would not leave the hospital alive. An alarming narrative, especially considering these recent analyses are of a similar size order to failure-to-rescue calculations of two decades ago.[6]

Even more concerning than the observed average rates, is the fact that between-hospital variation in Belgium is disproportionate across every single measured patient outcome. First, this is true when we look at temporal trends. Across all measured outcomes, individual hospitals sometimes had improving temporal trends, while others deteriorated, stagnated or fluctuated over time, resulting in the overall limited progress we observed. Second, at any given moment in time, differences between patient outcome rates in high-achieving hospitals compared to bottom-performing hospitals were exceptionally large. For PSIs for example, some hospitals exceeded nationwide central-line bloodstream infections or pressure ulcer rates by a factor of 8. Both in urological and cardiovascular care, it was medical diagnoses rather than surgical procedures that exhibited the largest inter-hospital variability, with the odds of dying from a urinary tract infection or hypertension approximately being 50% and 150% larger, respectively, in a bottom-performing versus high-achieving hospital.

For mortality, readmissions and prolonged length of stay (defined as a length of stay that exceeds the duration of 90% of patients stays for a specific disease or procedure), we attempted to quantify the hypothetical effect of reducing this unwarranted variation. Should the upper-quartile, i.e. worst-performing hospitals, succeed in improving their patient outcomes to the median Belgian rate, how many deaths, readmissions and prolonged patient stays could potentially be avoided? When focusing on mortality alone, this amounted to 412 urological or 633 cardiovascular deaths potentially avoided every single year. Looking at the overall hospital-wide picture and calculating improvements across 20 disease groups, resulted in a total of 4,086 lives potentially saved every year. To put this into perspective, a common double-deck Airbus A380 aircraft commonly holds about 525 passengers. The general public would never accept eight fatal aeroplane crashes annually, and rightly so. Yet today, for Belgian hospital care, that is exactly what is happening. In fact, our analyses were on the conservative side, by only taking the upper-quartile performing hospitals into account. Should we demonstrate a higher level of ambition and aim to improve mortality for all hospitals performing above the median, 5,141 in-hospital deaths could potentially be avoided across those 20 disease groups each year. For your reference, that is the entire Lotto Arena capacity, a popular concert venue in Belgium.

Clearly, targeting those bottom-performing hospitals can generate the largest potential gains towards quality improvement. As such, we have dubbed these hospitals the '*high impact opportunity'* hospitals. We illustrated how the observed variability cannot be attributed to individual clinicians or hospital wards, but are instead most likely due to systemic hospital factors. As of now, what those factors are, is not yet fully understood. Within our analyses, we tested for commonly accepted contributors to between-hospital variability, i.e. hospital region,[7,8] teaching status[9,10] and admission volume per disease group.[11,12] Yet, while these helped explain the observed variation to some extent, highly significant variation remained. Also note that, as was to be expected based on the results derived from our narrative review, despite the implementation in Flanders of the 'Quality-of-Care Triad', Flemish hospitals did not consistently outperform those in other regions. In all likelihood, it is a combination of organisational factors that lie at the core of inter-hospital variability. Attributes such as quality education, quality culture, implementation of guidelines and standardisation of care (e.g. clinical pathways) or discharge policies and aftercare organisation have been demonstrated to influence patient outcomes.[13–19] Furthermore, differences in hospital boards and organisation of the c-suite, leadership characteristics, management practices and frontline management across medical wards have been shown to be strongly related to clinical patient outcomes.[20] Finally, staffing levels of physicians and nurses and their accompanying patient flow might play an important part in outcome disparities.[21,22] The latter is especially important in a post-covid era, that has been characterised by rising turnover and burnout rates among clinicians.[23,24] In order to evolve towards patient safety improvements, there is a need to detangle the aforementioned aspects and translate findings from research to policy and practice. Prospective monitoring of both patient outcomes in addition to mixed-method assessments of hospital culture,

leadership, and hospital structure in a controlled environment will be required. As is their intention, the FlaQuM Consortium provides the ideal opportunity for such measurements, an opportunity that was not seized at the time of Quality-of-Care Triad implementation.

6.4 The way forward with patient outcome assessments

Patient outcome measurements such as we propose within this dissertation, should be continued for maintaining monitoring of patient safety and hospital quality in the future. Jumbling outcome measures together in composite measures, as is increasingly becoming popular within policy[25] and in the literature,[26–28] might at first glance seem appealing to summarise the information and avoid an overload of performance indicators, but is subject to a wide range of disadvantages in clinical practice. Composite quality indicators might not provide sufficient detail to identify areas of need for improvement and might mask potentially important variations or unintended consequences in outcomes.[29] An example of the latter is the increased mortality induced after a readmission reduction programme in the US.[30] Furthermore, while composite indicators might help overcome problems associated with small sample sizes for individual quality indicators – such as we observed in our analyses on PSIs – the constituent indicators might have varying levels of robustness, making it hard to assess the validity of the measure.[29] Most importantly, different healthcare stakeholders might place different values on different aspects of care quality, making it difficult to generate a consensus on the weights that should be attached to individual indicators.[29]

Similar problems arise when considering the rising popularity of hospital rankings, such as the global rankings presented by Newsweek.[31] Frequently, these consider aspects of hospitals' reputation, such as recommendation by peers and hospital-wide accreditation results, which are relevant results and can provide a sense of transparency and accountability. However, their focus on hospital structure and processes fails to include outcome measures. While a healthy sense of competition might trigger hospitals to devote resources to hospital quality, in practice, it seems that rankings often set off defensive attitudes and result in resource spending on embellishments towards the aspects included in rankings rather than towards the unseen patient care. That is why within this dissertation, we refrained from establishing exact individual hospital rankings, but rather we opted to categorise hospitals within performance groups, highlighted with colours ranging from green to red. We feel this approach allows hospitals to point out their areas for improvement, without feeling the need to compare with hospitals directly above or below the ranking. As we have highlighted numerous times within the results section of this thesis, the patient outcome measures assessed should be considered as smoke signals to trigger further in-depth analysis within hospitals. There is a risk that individual hospital rankings might contribute to a 'blame and shame' culture, which might interfere with hospitals' openness to learn and willingness to improve.

Rather than using composite measures or rankings, we would recommend to always start with surveying the individual '*vital few'* patient outcome measures that relate to hospital-wide mortality, readmissions, patient length of stay and the patient's experience. Based on these hospital-wide assessments, priorities can be determined for specific disease groups. Based on our results, for example, cardiovascular care was seen to be one of the largest contributors of between-hospital variability and medical inpatients specifically are most prone to this variation. Further monitoring of PSIs within this medical cardiology population and other targeted interventions towards increased standardisation and interdisciplinary collaboration could, as such, potentially help improve overall hospital care.

When aiming for quality improvement, it is important to express adequate ambition. Recently, organisations such as the WHO have indicated they are aiming towards elimination of avoidable harm in healthcare altogether.[32] This ambition of striving towards "zero harm" is shared with both clinicians and policy makers alike.[33,34] Of course, such aspirations are difficult to attain, and should be targeted through smaller, incremental and continuous improvements. In fact, unintended patient harm will most likely always persist. But, as already stated by Philip Crosby back in 1979, "zero defects" is the only acceptable objective we should be aiming for.[35]

6.5 Applicability of administrative data

The bulk of this PhD research was conducted on the basis of routinely collected administrative data, the Minimum Hospital Dataset (MHD) of the Belgian federal government of Healthcare. The dataset was originally developed for financial reimbursement purposes and use for quality of care assessments is therefore a novel approach. Because the MHD was not intentionally designed towards quality monitoring, their application often gets subjected to – legitimate – concerns. A first concern relates to the lack of additional prognostic factors in the form of detailed clinical data or socio-economic status within the MHD, factors which might potentially help explain the observed variability between hospitals.[36] Examples of current missing information include the lack of hemodynamic parameters or information on inflammatory burden and kidney function. This problem could in part be solved by linking the administrative discharge dataset to other administrative databases or other clinical registries in existence. Better yet, we should move towards discharge databases that no longer rely on written discharge and nurses' notes, but instead increase the availability of structured electronic data within the patient file that can later be used for quality studies. This seamlessly brings us to the second concern, i.e. that of consternation regarding coding and registration practice variability. Our study tried to account for this variability to the best of our abilities. For our PSI calculations, which were dependent on registration of secondary diagnoses for their occurrence, we additionally adjusted for the average number of secondary diagnoses registered and for the percentage of patients that were registered as having secondary diagnoses present upon admission per hospital. Doing this increased comparability between hospitals and thus helped to open the quality conversation. However, there is a high probability that the adjustments made were overadjustments, possibly hiding even larger true variability between hospitals. It is therefore of critical importance that accuracy of registration and coding of patient stays improves over time. This is a shared responsibility among all healthcare stakeholders. Physicians and nurses are responsible for accurate and structured data entry, while governments should target undue coding practice variability through audits and clear coding guidelines. In addition, patients play an increasingly important and more active role in this through rising access to their records and higher levels of participation in their care.

Despite these shortcomings, it is important to realise that a database such as the MHD is at the moment the sole available data source at our disposal that provides the possibility of surveying hospital-wide and nationwide quality indicators in a standardised and comparable manner in Belgium. It provides us with indications, the aforementioned 'smoke signals', of certain patient groups or underachieving *'high impact opportunity'* hospitals that are worthy of further in-depth survey. Furthermore, application of administrative databases is sustainable for future use, as it requires no additional registration workload for clinicians, is inexpensive and readily available for study and encompasses large and comparable populations, both nationally and internationally.[36]

The enormous applicability and actionability of administrative databases such as the MHD lie at the core of our results Chapters 4 and 5. In what follows, this applicability is summarised according to Joseph Juran's Trilogy for managing quality.[37]

First, administrative databases are immensely useful for the purpose of **quality planning.** Overarching analyses can allow hospital management and quality policy makers to see the wood for the trees and establish priorities for future patient groups or hospitals to be targeted in particular. Based on the results presented in this dissertation for example, policy makers could prioritise the increasing readmission rates or medical patient groups such as patients entering the hospital with urinary tract infections or hypertension. The latter has received but a fraction of the attention awarded to surgical care organisation in the past. Concerning the PSI calculations, failure-to-rescue and central-line bloodstream infections stood out with their respective high rates and large variability. Additionally, we were able to identify a select set of *'high impact opportunity'* hospitals, which displayed poor performance across mortality, readmission and length of stay and across the majority of disease groups. Those hospitals can become prioritised for government inspections, clinical audits and root-cause analyses.

Second, the MHD has proven useful for **quality control**. No other data source to date can provide the possibility of monitoring patient outcomes on a hospital-wide and nationwide scale. That's why past quality monitoring within accreditation surveys or within public reporting were most often structure or procedure measures. The continuous registration within the MHD provides opportunities for regular and continued follow-up. However, for quality monitoring purposes, it is important that data become available as near real time as possible. To date, this often is not yet the case for the MHD, with availability of the data often lagging six months to a year behind on their occurrence. Again, this falls back to the shared responsibility towards registration and coding of hospitals and governments. It is up to hospitals to timely upload their registrations to the government, who in turn should increase the timeliness of their data quality checks and coding. In line with the recommendations provided in the PhD dissertation of Dr. Jonas Brouwers concerning the future of hospital quality management and policy,[38] the use of administrative data for quality control on a policy level provides tremendous potential. Incorporating the use of administrative data within governmental policy could enhance the current Quality-of-Care Triad policy in several regards. First, monitoring the MHD can help the governmental inspection body 'Vlaamse Zorginspectie'[39] to target specific hospitals with poor patient outcome performance, the so-called *high impact opportunity hospitals*, with prioritised in-depth audits and increased scrutiny. The current at random selection of hospitals for inspections might have allowed poor performers to have slipped through the net. As we have seen in Chapter 4, poor-performing hospitals persistently achieved poor quality performance over time. Finally being able to identify these poor performers in terms of patient outcomes such as mortality or complications could at long last trigger the necessary improvements. Furthermore, for hospitals lacking the necessary improvement potential, the government could ensure patient safety by retracting permits or providing financial repercussions. Secondly, including patient outcome measures derived from the MHD within the current public reporting initiative,[40] can help provide a more accurate representation of hospital quality for the general public. Today's publicly reported indicator set remains limited to primarily process measures such as the completion of a surgical checklist or percentage of patients with identification wristbands. Patient experience measures derived from the Flemish Patient Survey[41] are also incorporated within current public reporting and have been studied extensively within this dissertation. However, as stated before, the patient safety numbers that were revealed from these MHD analyses were staggering. Yet, they remain unknown. In light of full transparency and health equity, the general public has a right to know how a hospital is faring in terms of other 'hard' patient outcome measures such as mortality. While this requires appropriate and elaborate elucidation of results in order to avoid misinterpretation, moving towards public reporting of the results as presented in this dissertation is the only way forward in this

age of information and patient entitlement. Finally, the third pillar of the Quality-of-Care Triad is currently transitioning from encouraging hospital-wide accreditation towards stimulating the employment of an elaborate hospital quality management system. One example of such a system includes the participation to the FlaQuM-consortium.[3] Learning from hard objective data such as those derived from the MHD has a place within this consortium through their core pillar of 'innovation'. This pillar aims to generate external learning through benchmarking of both patient and organisational outcomes (e.g. staff retention) within the consortium. The focus of FlaQuM lies on the co-creation of quality with both patients and their loved ones as well as with care providers. We believe this collaboration to be vital to achieve a sustainable quality provision, which in turn will aid the other pillars (inspection and public reporting) of the Quality-of-Care Triad.

Finally, administrative databases provide large potential for generating **quality improvement.** First, this can occur by identifying and increasing the awareness of areas for improvements concerning specific patient groups or specific hospitals. Initiatives such as collaborative and peer-reviewed learning have been demonstrated as potentially successful for patient outcome improvements.[42] Belgian examples of these initiatives, such as the collaborative learning Flemish Hospital Network (FHN), or the peer-reviewed learning and dissemination of benchmark reports incorporated within FlaQuM, should therefore be encouraged and further expanded. Second, the results derived from administrative databases could be used to incentivise positive changes within hospitals on a government level. Patient outcome results could perhaps become incorporated into future Pay-for-Performance (P4P) programmes. However, thus far, the evidence for the effects of P4P on patient outcomes has been disappointing.[43–46] Many alterations to the programme have been proposed, such as increasing the incentive,[47] or moving away from rewarding towards penalising in non-pay-for-non-performance initiatives.[48] Important caveats should be considered when implementing payment programmes towards improving patient outcomes. For starters, it remains unsure whether or not government programmes should focus on rewarding 'achievement' of quality or rather 'improvement' in quality. As we have demonstrated in our temporal analyses of mortality, readmissions and prolonged length of stay, some hospitals consistently outranked others in their performance, while others were seen to consistently improve over time but not yet achieve top performance. When failing to account for these improvements, there is a risk that hospitals who are on the right track could be losing out on financial means that are highly necessary to remain on this improvement path. Perhaps it might well be more beneficial to increase their funding, which might in turn be detrimental for the consistent high-achieving hospitals. As such, this puts policy makers for tough choices. Furthermore, questions should be raised on whether or not the money received within P4P programmes actually reaches the patient bed. Today, the budget received in the context of P4P is integrated within high-level operating funds. Perhaps, it would be better to disseminate it towards targeted initiatives, such as towards interdisciplinary consultations like in Morbidity and Mortality (M&M) meetings,[49] or towards increased collaboration between hospital workers and increased integration between primary, secondary and long-term care, movements which we see encouraged in other countries such as Germany.[50] Finally, when financially incentivising hospitals, governments should be conscious of unintended consequences, such as hospitals opting to game the data registration in order to maximally receive money, rather than truly working towards quality improvement. Regular quality checks and audits by the government of the data provided by hospitals could aid in this regard.

6.6 Future directions

This dissertation has answered many research questions, such as how patient outcomes have evolved over time or how they vary among Belgian acute-care hospitals. Yet, as befits any investigation, it also raises multiple other questions and contributes to new research opportunities. First and foremost, this dissertation has revealed important patient safety numbers which highlight enormous improvement potential within Belgian hospitals. Awareness of the quality problem, however, does not suffice. Next steps should be taken towards improving quality within those bottom-performing hospitals identified and for those patient groups which were seen to demonstrate the highest outcome rates or between-hospital variability, such as for example medical inpatients, patients with a central line who are at risk for bloodstream infections or patients with complications obtained during their care that are at risk for failure-to-rescue. Which quality improvement initiatives to launch first and what research methods to apply to gather knowledge on the effects of the initiatives, remain unanswered and important questions. While the randomised controlled trial (RCT) is in general seen as the highest level of evidence,[51] it is not clear whether this approach is always the most appropriate to evaluate quality improvement. Our research has demonstrated that oftentimes, quality improvement initiatives are implemented concomitantly. It would be unethical to disallow hospitals to organise other initiatives in order to obtain a controlled environment for a RCT-study.

One improvement initiative that is recurringly seen to improve patient outcomes, is increasing the knowledge of patient safety results by means of collaborative learning efforts.[42] As such, the results presented in this dissertation have already been made available to a selection of Flemish hospitals within detailed feedback reports that allow identification of the individual hospital in relation to the Belgian benchmark. However, a research gap remains disclosing how hospitals actually get to work with this provided information in clinical practice. Our research group already made a first move towards discovering how adverse events indicators are used in day-to-day clinical practice.[52] This qualitative research brought to light that feedback reports only rarely reach nurses or physicians. True embedment of quality indicators based on administrative data can only occur on the precondition that coding and registration occurs accurately and a hospital culture is geared towards quality and as such provides adequate time and staff in a safe environment that is willing to learn (Figure 6.1). The presence of external factors such as (1) a government that provides coding regulations and financial incentives, (2) a trustworthy instance that develops quality indicators that are transparent, well-understood and adapted to clinical use and finally (3) that are backed by academic evidence, can trigger true embedment. Finally, it was found that usability depends on the quality indicator list being 'non-negotiable', by covering a large hospital-wide population, being prevalent and clinically relevant. An example of a non-negotiable indicator list could include the *'vital few'* patient outcome indicators that we surveyed within this thesis. Further research remains required on ways to increase the application of quality indicators within clinical practice in order for them to live up to their potential.

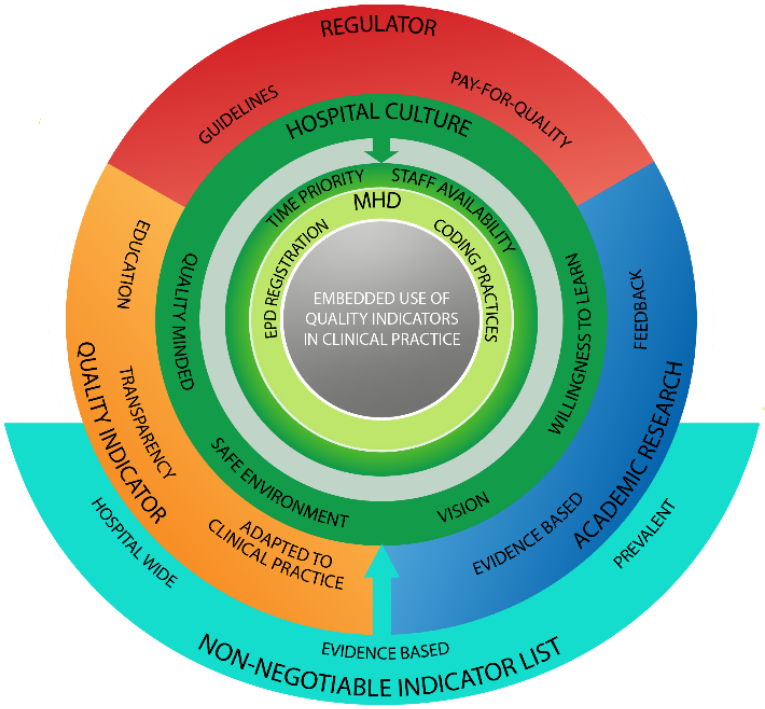

Figure 6.1 Model for embedded use of quality improvement indicators in clinical practice.[48]

This dissertation demonstrated the actionability of administrative databases such as the MHD. Future analyses could broaden the functionality of the database by expanding it with other clinically relevant indicators. When it comes to analyses of adverse events, for example, we are aware that limiting our study to AHRQ Patient Safety Indicators, prohibited from providing a comprehensive overview of patient harm occurring within our hospitals. Recent numbers have indicated that about one in four patients experience an adverse event during their hospital stay.[53] The majority of the harm inflicted involves medication errors.[53–56] However, as medication administration is to date not registered within the MHD, no information could be provided on this important aspect of patient safety. Recent developments in the literature increasingly point towards future application of automatable detection of triggers of IHI's Global Trigger Tool (GTT) within electronic health records and through ICD-10 coding, allowing for detection of adverse drug events and other important complications.[57–59] An ongoing exploratory pilot study in one hospital already looks promising for researching this matter in Belgian hospitals. Furthermore, recent societal developments such as the use of ChatGPT, deep learning or other artificial intelligence (AI) applications should be explored for use within the setting of hospital quality. Already, spectacular results could be achieved in the field of biology, exemplified by protein folding research aided by AI.[60] This provides perspective and allows for ambitious aspirations for future use in healthcare, including e.g. towards extracting knowledge from physicians' or nurses' notes, for which it is not possible to register all information under a structured electronic format. From personal communication with prof. DW Bates (Harvard Medical School), it has become clear this direction is indeed being explored right now.

In addition to broadening the functionality of administrative databases with supplemental quality indicators, we would recommend to broaden the scope of quality research by looking at other healthcare settings. Examples include the study of long-term care, rehabilitation, mental health care and primary care. The latter will become increasingly important within our healthcare organisation as more and more

patients are moving towards chronic rather than acute illness and policy decisions have been made to reduce inpatient hospital care in favour of stronger one-day clinics and primary care.[61–63]

Finally, as our population ages and patient care is increasingly becoming more complex with multimorbidity and polypharmacy,[64] resources for healthcare will increasingly become more limited. It has been shown that quality improvement initiatives such as hospital-wide accreditation[65] or even the measurement of not routinely collected quality indicators[66] can come with a hefty price tag. Yet, it is our hypothesis that the delivery of poor quality is linked to even larger, avoidable costs. For example, this research brought to light large between-hospital variation in prolonged length of stay. Should the 25% bottom-performing hospitals for this outcome manage to reduce their length of stay to the level observed at the median, over 16,000 hospital stays would no longer be classified as prolonged, i.e. above the 90th percentile. Evidently, such reductions would bring about great cost reductions as prolonged length of stay has been highly correlated with complications during care and with excess costs.[67,68] In order to increase value within hospital care, it is necessary to map out the costs associated with unsafety, misuse, underuse or overuse of our healthcare. After all, "quality is free" has never felt more appropriate and timely, despite being uttered over 40 years ago.[35]

6.7 Strengths and limitations

The research presented within this dissertation comes with its own strengths and limitations. Two types of **strengths** should be underlined. The first includes the technical merit of this work. For the first time, we were able to study a highly underused data source (MHD) for the purpose of quality monitoring, allowing us to discover important variation and high prevalence of patient outcome indicators in Belgium. Our work is strengthened by its nationwide and hospital-wide assessments, which are rare within the literature. US hospital quality analyses for example are often based on Medicare claims data, which limits analyses to a population of patients aged 65 and older. Our assessments of multiple patient outcomes, often in combined analyses to check for competing risks, allowed us to get a broad overview of the state of quality within Belgian hospitals. Our applied statistical methodology was well substantiated, as highlighted within our methods paper in Chapter 4 on hospital standardised mortality ratio (HSMR). As a result, we were capable of calculating reliable and valid quality metrics with adequate adjustments for patient risk and with high clinical relevance. A second major strength of this work relates to the societal value of our analyses. Our investigation resulted in striking patient safety numbers, including the 23% of surgical patients identified that died after obtaining a serious but treatable complications, or the 4,000 hospital deaths that could potentially be avoided every year should bottom-performing hospitals manage improvements to the median level of hospital care. Policy makers, hospital managers, clinicians and patients were up to now oblivious of these unacceptable quality issues. Now that they are, our results can hopefully serve as a wake-up call that spurs targeted action based on the priories determined within this thesis.

On the other hand, our research was also subject to important **limitations**. Study-specific limitations have been highlighted thoroughly within the results section of this dissertation. Overall though, we should remark that our study was not able to access information on what happened to patients after being discharged, due to patient identifiers being anonymised per hospital. This important nuance might for example partially help explain differences in mortality rates between hospitals, by exposing different discharge policies between hospitals. Some hospitals might for example opt for patients to be discharged quickly after it is clear death is imminent, allowing for patients to die within their own trusted home environment. For these hospitals, their lower observed mortality within our study is no true reflection

of reality. Additionally, lower readmission rates to the same hospital could for example be masking high readmissions to other hospitals. However, excessive variation persisted across the multiple outcomes surveyed and across both hospital-wide and disease-specific analyses. This makes our case of the presence of a prominent quality issue, despite these shortcomings. Secondly, our analyses were only available up until 2018 for mortality, readmissions, length of stay and PSIs and up until 2019 for patient experiences. As such, they are a couple of years removed from publication of this dissertation. Yet, as the COVID-19 pandemic has left its mark on hospital care for the years 2020 up to 2022, our dataset actually provides the latest available information that was not yet compromised by the pandemic. There are early indications that recent patient safety numbers are deteriorating in the post-pandemic era.[69] It is therefore of interest to keep monitoring the patient outcomes proposed within this dissertation in future MHD analyses as soon as those data become available. Third, while we accounted for important patient outcomes, our research failed to incorporate patient involvement beside the inclusion of patient experience measures. Future analyses should include additional patient reported outcome and experience measures and should incorporate their perspective on hospital quality and policy. Finally, while patient safety is without any doubt a vastly important aspect of hospital quality, it is but one factor in a complex and multidimensional system.[70,71] Our focus should expand to other technical quality dimensions, such as effectiveness, efficiency, accessibility and timeliness, equity and eco-friendliness.[70] Moreover, it should recognise the core values of care. Treating both care receiver and care giver with dignity and respect, within a holistic approach, in partnership and co-production and with well-deserved kindness and compassion, might lead towards true person-centred care.[70,72] We anticipate that acting from these core values might be the catalyst required to finally unlock genuine hospital quality improvements in the future.

6.8 Take home messages

As we're approaching the end of this dissertation, we'd like to leave you, the reader – whether you are a clinician, manager, policy maker, patient or loved one of a patient – with some key points to take away from this work.

1. Routinely collected administrative hospital data provide a valuable and actionable source for quality monitoring, determining policy priorities and instigating quality improvements. Even though their use is highly underutilised to date, we hope the results described in this thesis can motivate their continued application in the future.

2. Hospitals in Belgium are highly committed to deliver qualitative healthcare. However, some important patient safety metrics have not evolved favourably over time, exposing a large hospital quality issue. Readmissions for example increased over time, and nearly one in four surgical patients died during their hospital stay if they obtained any of six serious but treatable complications during their hospital admission.

3. It was revealed that differences in patient outcome measures vary at an alarming rate between Belgian hospitals that cannot be explained by patient or common hospital factors. Most likely, the observed variation is associated with how the overall hospital system is organised. The impact of this unwarranted variation is exceptionally large. Should we for example manage mortality reductions to the level of the median observed mortality rate in the 25% worst performing hospitals, over 4,000 lives could potentially be saved every single year. Presenting these numbers hopefully generates a sense of urgency that triggers the necessary action towards patient outcome improvements.

4. Continued monitoring over time and benchmarking across hospitals of patient outcome measures will be crucial for making progress in hospital quality in the future. This responsibility falls on every healthcare stakeholder involved. It is high time hospital quality is taken seriously across the healthcare spectrum, because, as this work has highlighted, the problems our hospital suffer from are serious indeed.

6.9 Conclusions

Qualitative healthcare is often referred to as the level of quality that is acceptable to receive for yourself or for your loved ones. To date, it was unsure what the level of quality within Belgian acute-care hospitals was. This PhD dissertation aimed to close this knowledge gap by providing an overview of how important patient outcomes such as mortality, readmissions, length of stay, patient experiences and adverse events evolved over time and how they varied between individual acute-care hospitals. The results revealed levels of patient outcomes and levels of variability that are deemed unacceptable when you consider them to concern your own care or that of a loved one. As such, hospitals in Belgium are exposed to suffer from major quality issues. This dissertation highlighted how hospitals in general were highly devoted to deliver quality of care and were motivated to adopt multiple quality improvement initiatives as encouraged by regional policies or of their own enterprise. Yet, frequently, the evidence towards the effectiveness of the implemented initiatives was ambiguous to say the least. Primarily based on analyses from routinely collected administrative data, we observed how hospitals today are seen to have worrying failure-to-rescue rates reaching 23% or increasing readmissions. Furthermore, extensive variation between hospitals that could not be explained by patient or known hospital factors uncovered potential issues related to the systemic organisation of the hospital. As specific patient groups such as medical inpatients or specific hospitals could be identified as being the largest contributors to between-hospital variation, the results presented in this thesis can be employed by policy makers and managers to determine priorities. It turns out that over 4,000 deaths could potentially be avoided annually, should the bottom 25% underachieving hospitals succeed in mortality reductions to the level of the median observed mortality rate. It is therefore our hope that this PhD dissertation can create a burning platform that will trigger the need for targeted quality improvement initiatives among all healthcare stakeholders involved.

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APPENDIX

A.1 Additional material to Chapter 2

A.1.1 Detailed transcript of search strategy

MEDLINE (PUBMED)

ACCREDITATION LITERATURE

Research question:

What associations can be observed between accreditation and quality and patient safety outcomes in hospital care?

PICO-dissection

Population (P) = hospital

Intervention (I) = accreditation

[Comparison (C) = with or without accreditation]

Outcome (O) = quality and patient safety outcomes

Search terms

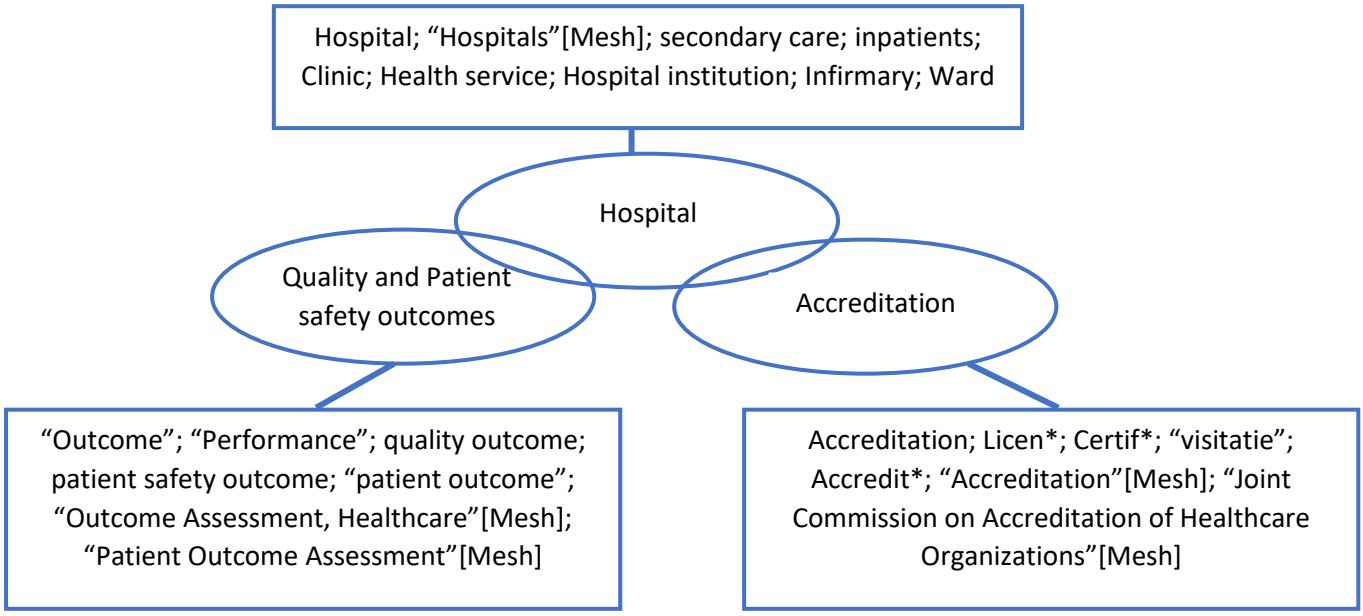

Figure 1. Identification of search for literature review on accreditation

Search results

Table 1. Medline search accreditation

SEARCH	SEARCH TERMS	ITEM FOUNDS	DATE
HOSPITAL			
#1	Hospital	4 878 102	26/02/2020
#2	“Hospitals”[Mesh]	270 127	26/02/2020
#3	Secondary care	108 226	26/02/2020
#4	Inpatients	51 032	26/02/2020
#5	Clinic	625 136	26/02/2020
#6	Hospital institution	614 428	26/02/2020
#7	Infirmary	61 488	26/02/2020
#8	Ward	82 077	26/02/2020
#9: (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8)	(((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward	5 419 784	26/02/2020
QUALITY AND PATIENT SAFETY OUTCOMES			
#10	“Outcome”	1 857 279	26/02/2020
#11	“Performance”	997 385	26/02/2020
#12	Quality outcome	197 090	26/02/2020
#13	Patient safety outcome	43 152	26/02/2020
#14	“Outcome Assessment, Healthcare”[Mesh]	1 102 858	26/02/2020
#15	“Patient Outcome Assessment”[Mesh]	9932	26/02/2020
#16: (#10 OR #11 OR #12 OR #13 OR #14 OR #15)	((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"	2 837 723	26/02/2020
ACCREDITATION			
#17	Accreditation	28 274	26/02/2020
#18	Licen*	53 933	26/02/2020
#19	Certif*	66 380	26/02/2020
#20	“visitatie”	12	26/02/2020
#21	Accredit*	34 382	26/02/2020
#22	“Accreditation”[Mesh]	18 695	26/02/2020
#23	“Joint Commission on Accreditation of Healthcare Organizations”[Mesh]	7449	26/02/2020
#24: (#17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23)	((((((Licen*) OR Certif*) OR "visitatie") OR Accredit*) OR "Accreditation") OR "Accreditation"[Mesh]) OR "Joint Commission on Accreditation of Healthcare Organizations"[Mesh]	147 883	26/02/2020
ALL FACETS AND TERMS COMBINED			
#9 AND #16 AND #24	((((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward)) AND (((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance")) AND (((((((Licen*) OR Certif*) OR "visitatie") OR Accredit*) OR "Accreditation") OR "Accreditation"[Mesh])	8176	26/02/2020

	OR "Joint Commission on Accreditation of Healthcare Organizations"[Mesh])		

Number of hits after search strategy: 8176

Number of hits after publication date filter (1/1/2009 – 26/2/2020): 5253

Number of hits after 'full text available' filter: 5081

Other filters applied: article types, languages: 5081

PUBLIC REPORTING

Research question:

What associations can be observed between public reporting and quality and patient safety outcomes in hospital care?

PICO-dissection

Population (P) = hospital

Intervention (I) = public reporting

[Comparison (C) = with or without accreditation]

Outcome (O) = quality and patient safety outcomes

Search terms

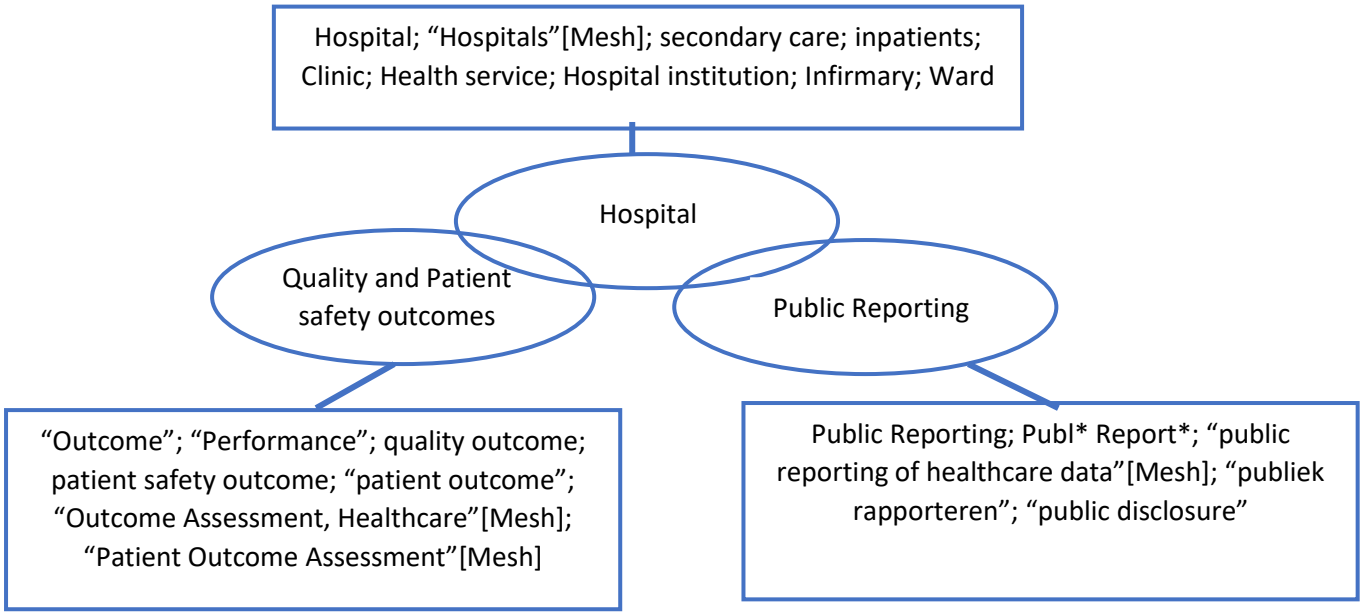

Figure 2. Identification of search for literature review on public reporting

Search results

Table 2. Medline search public reporting

SEARCH	SEARCH TERMS	ITEM FOUNDS	DATE
HOSPITAL			
#1	Hospital	4 878 102	26/02/2020

#2	“Hospitals”[Mesh]	270 127	26/02/2020
#3	Secondary care	108 226	26/02/2020
#4	Inpatients	51 032	26/02/2020
#5	Clinic	625 136	26/02/2020
#6	Hospital institution	614 428	26/02/2020
#7	Infirmary	61 488	26/02/2020
#8	Ward	82 077	26/02/2020
#9: (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8)	(((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward	5 419 784	26/02/2020
QUALITY AND PATIENT SAFETY OUTCOMES			
#10	“Outcome”	1 857 279	26/02/2020
#11	“Performance”	997 385	26/02/2020
#12	Quality outcome	197 090	26/02/2020
#13	Patient safety outcome	43 152	26/02/2020
#14	“Outcome Assessment, Healthcare”[Mesh]	1 102 858	26/02/2020
#15	“Patient Outcome Assessment”[Mesh]	9932	26/02/2020
#16: (#10 OR #11 OR #12 OR #13 OR #14 OR #15)	((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"	2 837 723	26/02/2020
PUBLIC REPORTING			
#17	Public Reporting	33 076	26/02/2020
#18	Publ* Report*	421 789	26/02/2020
#19	“public reporting of healthcare data”[Mesh]	4	26/02/2020
#20	“publiek rapporteren”	0	26/02/2020
#21	“public disclosure”	319	26/02/2020
#22: (#17 OR #18 OR #19 OR #20 OR #21)	((((public reporting) OR publ* report*) OR "Public Reporting of Healthcare Data"[Mesh]) OR "publiek rapporteren") OR "public disclosure"	421 995	26/02/2020
ALL FACETS AND TERMS COMBINED			
#9 AND #16 AND #22	((((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward))) AND ((((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"))) AND (((((public reporting) OR publ* report*) OR "Public Reporting of Healthcare Data"[Mesh]) OR "publiek rapporteren") OR "public disclosure")	35 312	26/02/2020

Number of hits after search strategy: 35 312

Number of hits after publication date filter (1/1/2009 – 26/2/2020): 28 632

Number of hits after ‘full text available’ filter: 28 075

Other filters applied: article types, languages: 28 075

INSPECTION

Research question:

What associations can be observed between inspection and quality and patient safety outcomes in hospital care?

PICO-dissection

Population (P) = hospital

Intervention (I) = inspection

[Comparison (C) = with or without accreditation]

Outcome (O) = quality and patient safety outcomes

Search terms

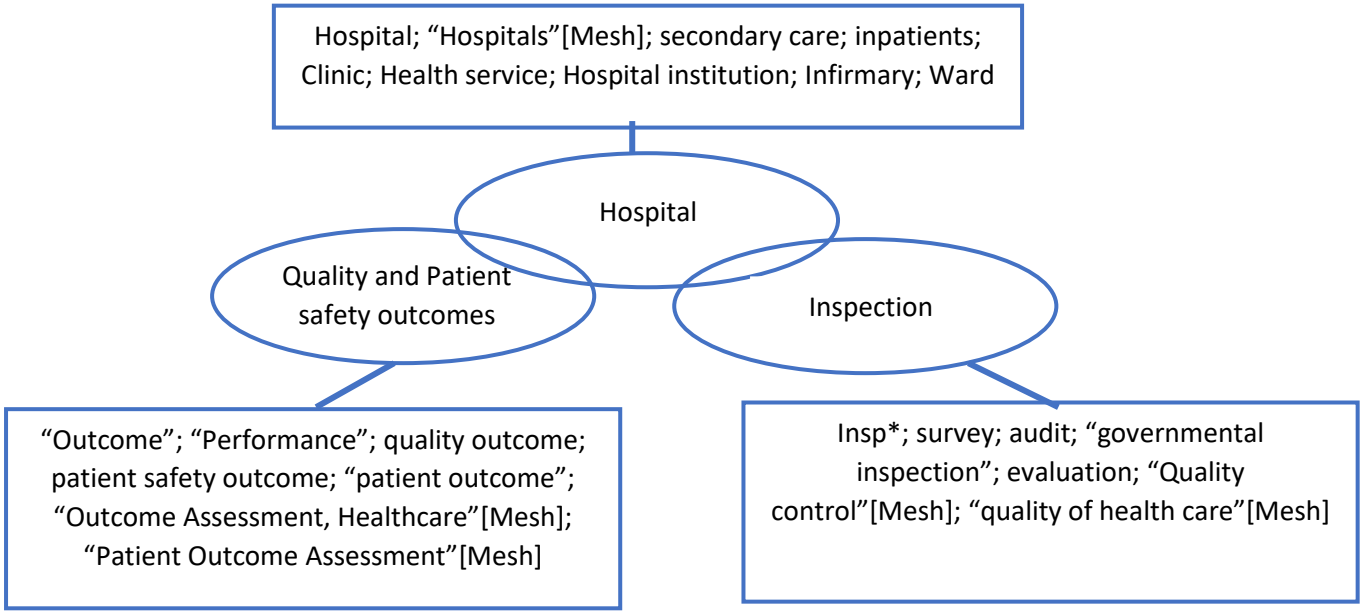

Figure 3. Identification of search for literature review on inspection

Search results

Table 3. Medline search inspection

SEARCH	SEARCH TERMS	ITEM FOUNDS	DATE
HOSPITAL			
#1	Hospital	4 878 102	26/02/2020
#2	“Hospitals”[Mesh]	270 127	26/02/2020
#3	Secondary care	108 226	26/02/2020
#4	Inpatients	51 032	26/02/2020
#5	Clinic	625 136	26/02/2020
#6	Hospital institution	614 428	26/02/2020
#7	Infirmary	61 488	26/02/2020
#8	Ward	82 077	26/02/2020
#9: (#1 OR #2 OR #3 OR #4 OR #5 OR #6	(((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward	5 419 784	26/02/2020

OR #7 OR #8)			
QUALITY AND PATIENT SAFETY OUTCOMES			
#10	“Outcome”	1 857 279	26/02/2020
#11	“Performance”	997 385	26/02/2020
#12	Quality outcome	197 090	26/02/2020
#13	Patient safety outcome	43 152	26/02/2020
#14	“Outcome Assessment, Healthcare”[Mesh]	1 102 858	26/02/2020
#15	“Patient Outcome Assessment”[Mesh]	9932	26/02/2020
#16: (#10 OR #11 OR #12 OR #13 OR #14 OR #15)	((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"	2 837 723	26/02/2020
INSPECTION			
#17	Inspec*	56 291	26/02/2020
#18	“survey”	518 593	26/02/2020
#19	“audit”	48 405	26/02/2020
#20	“governmental inspection”	4	26/02/2020
#21	“governmental evaluation”	1677	26/02/2020
#22	“Quality control”[Mesh]	48 640	26/02/2020
#23: (#17 OR #18 OR #19 OR #20 OR #21 OR #22)	(((((inspec*) OR "survey") OR "audit") OR "governmental inspection") OR "governmental evaluation") OR "Quality Control"[Mesh]	664 271	26/02/2020
ALL FACETS AND TERMS COMBINED			
#9 AND #16 AND #23	(((((((inspec*) OR "survey") OR "audit") OR "governmental inspection") OR "governmental evaluation") OR "Quality Control"[Mesh])) AND (((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"))) AND (((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward))	41 232	26/02/2020

Number of hits after search strategy: 41 232

Number of hits after publication date filter (1/1/2009 – 26/2/2020): 25 809

Number of hits after ‘full text available’ filter: 24 897

Other filters applied: article types, languages: 24 897

QUALITY OF CARE TRIAD

Table 4. Medline search accreditation, public reporting and inspection combined

SEARCH	SEARCH TERMS	ITEMS FOUND	DATE
# 1	((((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward))	302	26/02/2020

	AND (((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance")) AND (((((((Licen*) OR Certif*) OR "visitatie") OR Accredit*) OR "Accreditation") OR "Accreditation"[Mesh]) OR "Joint Commission on Accreditation of Healthcare Organizations"[Mesh]) AND ((((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward))) AND (((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"))) AND (((((public reporting) OR publ* report*) OR "Public Reporting of Healthcare Data"[Mesh]) OR "publiek rapporteren") OR "public disclosure") AND ((((((((inspec*) OR "survey") OR "audit") OR "governmental inspection") OR "governmental evaluation") OR "Quality Control"[Mesh])) AND ((((((("Patient Outcome Assessment"[Mesh]) OR "patient outcome") OR patient safety outcome) OR "Outcome Assessment, Health Care"[Mesh]) OR quality outcome) OR "Outcome") OR "performance"))) AND (((((((((hospital) OR "Hospitals"[Mesh]) OR secondary care) OR inpatients) OR clinic) OR hospital institution) OR infirmary) OR ward))		

Number of hits after search strategy: 302

Number of hits after publication date filter (1/1/2009 – 26/2/2020): 231

Number of hits after 'full text available' filter: 229

Other filters applied: article types, languages: 229

REPEATED SEARCH STRATEGY ON ACCREDITATION AS WAS PERFORMED BY THE BELGIAN HEALTH CARE KNOWLEDGE CENTER

Reference: Pierre G, Dirk C, Yolande A, Cock Jo D, Meyere Frank D, Ridder Henri D, et al. The Belgian Health Care Knowledge Centre Comparative study of hospital accreditation programmes in Europe KCE reports 70C. [cited 2019 Apr 2]; Available from: http://www.kce.fgov.be

As performed on 3/05/2019

1) "Outcome" [All Fields] (1 752 756 hits)
2) "Performance" [All Fields] (927 046 hits)
3) Licen* (51 400 hits)
4) Certif* (63 225 hits)
5) "visitatie" (12 hits)

6) Accredit* (32 866 hits)
7) #1 OR #2 (2 607 036 hits)
8) #3 OR #4 OR #5 OR #6 (141 008 hits)
9) #7 AND #8 (19 748 hits)

   Filters added:
   ➔ Article types: all
   ➔ Tekst availability: abstract and full text available
   ➔ Publication date: last 10 years
   ➔ 11 229 hits

10) Added “Hospital” [Mesh Term] (28 232 hits)
11) #9 AND #10 (243 hits)

As performed on 8/05/2019

1) “standards” limit 10 yrs (319 656 hits)
2) “quality indicators” [Mesh] (12 210 hits)
3) ‘outcome assessment (health care)” [Mesh] (567 391 hits)
4) #1 OR #2 OR #3 (872 692 hits)
5) “Licensure, Hospital” [Mesh] (32 hits)
6) “Certification” [Mesh] (5199 hits)
7) "Accreditation"[Mesh] OR "Joint Commission on Accreditation of Healthcare Organizations"[Mesh] (4666)
8) #5 OR #6 OR #7 (9416)
9) “Hospitals” [Mesh] (78 055)
10) #8 AND #9 (731)
11) #10 AND #4 **(566)**

((((((((("Accreditation"[Mesh] OR "Joint Commission on Accreditation of Healthcare Organizations"[Mesh]) AND "last 10 years"[PDat])) OR ("Certification"[Mesh] AND "last 10 years"[PDat])) OR ("Licensure, Hospital"[Mesh] AND "last 10 years"[PDat])) AND "last 10 years"[PDat])) AND ("Hospitals"[Mesh] AND "last 10 years"[PDat])) AND "last 10 years"[PDat])) AND (((((("standards" AND "last 10 years"[PDat])) OR ("Quality Indicators, Health Care"[Mesh] AND "last 10 years"[PDat])) OR ("Outcome Assessment (Health Care)"[Mesh] AND "last 10 years"[PDat])) AND "last 10 years"[PDat])

GOOGLE SCHOLAR

Search performed on 3/03/2020 for articles between 2009 and 2020

Hospital AND patient outcome AND accreditation: 17 000 items found

Hospital AND patient outcome AND public reporting: 17 800 items found

Hospital AND patient outcome AND inspection: 19 300 items found

A.1.2 Summary of excluded articles

	Author (year, journal)	Reason for exclusion
ACCREDITATION		
1	Al Faouri (2019, Nursing Forum)	No report on patient outcomes, but on stress levels in healthcare providers before and after accreditation survey.
2	Al Tehewy (2009, International Journal for Quality in Health Care)	Reported the impact of accreditation on patient satisfaction in a primary care setting.
3	Al-Awa (2012, Annals of Saudi Medicine)	No report on patient outcome, but on patient safety culture
4	Alkhenizan (2010, Annals of Saudi Medicine)	No impact on patient outcome, but assessment of developing accreditation standards against ISQua principles.
5	Alkhenizan (2011, Annals of Saudi Medicine)	No original research, but literature review
6	Awdishu (2019, Pharmacy)	Report on disease-specific accreditation (kidney disease)
7	Azagury (2016, Journal of the American College of Surgeons)	No original research, but literature review on disease-specific accreditation
8	Blondet (2015, Advances in Surgery)	No original research, but literature review on disease-specific accreditation
9	Braithwaite (2006, BMC Health Services Research)	No report on patient outcomes, but methods paper
10	Brubakk (2015, BMC Health Services Research)	No original research, but literature review
11	Chandra (2009, Annals of Emergency Medicine)	Report on disease-specific accreditation (chest pain center)
12	David (2015, American Journal of Surgery)	Report on disease-specific accreditation (breast cancer)
13	Dombradi (2019, BMJ Open)	No report on patient outcomes, but on the cost of accreditation
14	El-Jardali (2011, BMC Health Services Research)	No report on patient outcomes, but on patient safety culture
15	Elkins (2010, Clinical Nursing Research)	No report on patient outcomes, but on psychological cost (i.e. workload, stress) of accreditation on healthcare providers
16	Ettinger (2008, American Journal of Medical Quality)	Reports a single qualitative case study and has as such a level VI level of evidence, which was predetermined as an exclusion criterion
17	Fan (2019, Journal of the American Heart Association)	Report on disease-specific accreditation (chest pain center)
18	Flodgren (2011, Cochrane Database of Literature Reviews)	No original research, but literature review
19	Flodgren (2016, Cochrane Database of Literature Reviews)	No original research, but literature review
20	Gebhart (2014, Surgery for Obesity and Related Diseases)	Report on disease-specific accreditation (bariatrics)
21	Gratwohl (2011, Journal of Clinical Oncology)	Report on disease-specific accreditation (hematopoietic stem-cell transplantation)
22	Gratwohl (2014, Haematologica)	Report on disease-specific accreditation (hematopoietic stem-cell transplantation)

23	Greenfield (2008, International Journal for Quality in Health Care)	No original research, but literature review
24	Greperud (2015, International Journal of Health Planning and Management)	No original research, but opinion paper
25	Hinchcliff (2012, BMJ Quality and Safety)	No original research, but literature review
26	Ho (2014, Academic Medicine)	No report on patient outcomes, but on psychological cost (i.e. workload, stress) of accreditation on medical students
27	Jha (2018, Journal of the American Medical Association)	No original research, but opinion paper
28	Johnson (2014, Journal of the American Heart Association)	Report on disease-specific accreditation (stroke center)
29	Kilsdonk (2014, BMC Cancer)	Not concerning accreditation, but concerning a peer-review external assessment
30	Kilsdonk (2015, International Journal of Health Care Quality Assurance)	No original research, but literature review
31	Liao (2020, Journal of the Chinese Medical Association)	Report on disease-specific accreditation (acute myocardial infarction)
32	Lichtman (2011, Neurology)	Report on disease-specific accreditation (stroke center)
33	Lichtman (2011, Stroke)	Report on disease-specific accreditation (stroke center)
34	Man (2017, Stroke)	Report on disease-specific accreditation (stroke center)
35	Merkow (2014, Annals of Surgery)	Report on disease-specific accreditation (cancer center)
36	Mikami (2018, Journal of Gynecologic Oncology)	Report on disease-specific accreditation (cervical cancer)
37	Miller (2019, Annals of Surgical Oncology)	Report on disease-specific accreditation (breast cancer)
38	Mizuno (2020, Journal of Cardiology)	Report on disease-specific accreditation (cardiac and vascular diseases)
39	Morton (2014, Annals of Surgery)	Report on disease-specific accreditation (bariatrics)
40	Mumford (2013, International Journal for Quality in Health Care)	No original research, but literature review
41	Mumford (2015, BMJ Open)	No report on patient outcomes, but on cost of accreditation
42	Ng (2013, Hong Kong Medical Journal)	No original research, but literature review
43	Nicolaisen (2018, International Journal for Quality in Health Care)	No report on patient outcomes, but on managers' perceptions of accreditation
44	Pomey (2010, Implementation Science)	No report on patient outcomes, but on characteristics of accrediting hospitals
45	Pross (2018, BMC Health Services Research)	Report on disease-specific accreditation (stroke center)
46	Rajamani (2013, Journal of Stroke and Cerebrovascular Diseases)	Report on disease-specific accreditation (stroke center)
47	Sacks (2019, BMJ Open Quality)	Not concerning accreditation, but concerning a peer-review external assessment
48	Saleh (2013, International Journal for Quality in Health Care)	No report on patient outcomes, but on hospital's views on the worthiness of accreditation
49	Saut (2017, International Journal for Quality in Health Care)	No report on patient outcomes, but on organizational impact

50	Shen (2019, JAMA Network Open)	Report on disease-specific accreditation (stroke center)
51	Shkirkova (2020, Frontiers in Neurology)	Report on disease-specific accreditation (stroke center)
52	Snowden (2019, Bone Marrow Transplantation)	Report on disease-specific accreditation (bone marrow disease)
53	Spaulding (2018, Inquiry)	Report on disease-specific accreditation (cancer center)
54	Telem (2015, Surgery for Obesity and Related Diseases)	Report on disease-specific accreditation (bariatrics)
55	van Dam (2015, European Journal of Surgical Oncology)	Report on disease-specific accreditation (breast cancer)
56	Weissflog (2012, Onkologie)	Report on disease-specific accreditation (cancer center)
57	Wesselman (2014, Archives of Gynecology and Obstetrics)	No original research, but literature review on disease-specific accreditation
58	Yoneyama (2019, BMJ Open)	Reports on physician-specific accreditation
PUBLIC REPORTING		
1	Behrendt (2015, Health Policy)	No original research, but literature review
2	Berger (2013, Patient Education and Counselling)	No original research, but literature review
3	Blumenthal (2018, JAMA Cardiology)	No report on patient outcomes, but perceptions of healthcare professionals
4	Canaway (2017, BMC Health Services Research)	No report on patient outcomes, but perceptions of healthcare professionals and patients
5	Canaway (2017, Medical Journal of Australia)	No original research, but opinion paper
6	Canaway (2018, Australian Health Review	No report on patient outcome, but on perceptions of senior medical directors
7	Canaway (2018, Social Science & Medicine)	No report on patient outcome, but on perceptions of stakeholders
8	Chatterjee (2014, JAMA Cardiology)	No original research, but literature review
9	Chen (2010, the Sax Institute)	No original research, but literature review
10	De Cordova (2019, Journal of Cardiovascular Nursing)	No original research, but literature review
11	Dehmer (2018, JACC Cardiovascular Interventions)	No original research, but opinion paper
12	Dunt (2018, Medical Care)	No original research, but literature review
13	Emmert (2018, BMC Health Services Research)	Falls outside scope of research question, because it does not concern the impact of public reporting of quality indicators, but rather the impact of online patient ratings
14	Ettinger (2008, American Journal of Medical Quality)	Reports a single qualitative case study and has as such a level VI level of evidence, which was predetermined as an exclusion criterion
15	Fargen (2018, Journal of Neurointerventional Surgery)	No original research, but opinion paper
16	Feldman (2017, Circulation: Cardiovascular Quality and Outcomes)	No original research, but opinion paper
17	Fernandez (2017 Circulation: Cardiovascular Quality and Outcomes)	No report on patient outcomes, but perceptions of healthcare professionals
18	Fung (2008, Annals of Medicine)	No original research, but literature review
19	Garratt (2018, Circulation)	No original research, but opinion paper

20	Greenfield (2013, Health Policy)	No report on patient outcomes, but perceptions of healthcare professionals
21	Hafner (2011, International Journal for Quality in Health Care)	No report on patient outcomes, but perceptions of healthcare professionals
22	Ikkersheim (2013, BMC Family Practice)	Reported the impact of public reporting on general practitioner's referrals in primary care
23	Isaac (2010, Health Services Research)	Falls outside scope of research question, because it does not measure the impact of the intervention public reporting, but looks for associations between publicly reported measures and patient outcomes
24	Jha (2017, Journal of the American Medical Association)	No original research, but opinion paper
25	Ketelaar (2011, Cochrane Database of Systematic Reviews)	No original research, but literature review
26	Kim (2018, Journal of Interventional Cardiac Electrophysiology)	No original research, but discussion paper
27	Kontezka (2014, Journal of the American Geriatrics Society)	Reported the impact of public reporting in a nursing home setting
28	Liu (2016, Medicine)	Reported the impact of public reporting on prescribing behavior in primary care
29	Mannion (2012, Internal Medicine Journal)	No original research, but discussion paper
30	McDaniel (2011, Interventional Cardiology Clinics)	No originals research, but opinion paper
31	Metcalfe (2018, Cochrane Database of Systematic Reviews)	No original research, but literature review
32	Papanicolas (2017, Health Affairs)	Falls outside scope of research question, because it does not measure the impact of the intervention public reporting, but rather uses publicly reported data to look at associations between value-based purchasing and patient outcomes
33	Prang (2018, BMJ Open)	No report on patient outcomes, but perceptions of patients
34	Pross (2017, BMC Medical Informatics and Decision Making)	No report on patient outcomes, but looks at how patients behave on public reporting portals
35	Resnic (2009, Journal of the American College of Cardiology)	No original research, but discussion paper
36	Russo (2019, American Journal of Infection Control)	No report on patient outcomes, but perceptions of patients
37	Spray (2017, Seminars in Thoracic and Cardiovascular Surgery: Pediatric Cardiac Surgery Annual)	No original research, but opinion paper
38	Totten (AHRQ)	No original research, but literature review
39	Vukovic (2017, European Journal of Public Health	No original research, but literature review
40	Wadhera (2017, Current Heart Failure Reports)	No original research, but literature review
41	Wadhera (2017, JAMA)	No original research, but opinion paper
42	Wadhera (2018, JAMA Cardiology)	No original research, but opinion paper
43	Wadhera (2019, JAMA Cardiology)	No report on patient outcome, but on physician and financial burden
44	Wang (2018, Medical Journal of Australia)	No original research, but opinion paper

45	Welke (2018, Seminars in Thoracic and Cardiovascular Surgery)	No original research, but opinion paper
46	Welsh (2018, Canadian Journal of Cardiology	No original research, but opinion paper
47	Westert (2018, International Journal for Quality in Health Care)	No original research, but opinion paper
48	Zaga (2018, Australian Health Review)	No report on patient outcome, but rather on patient usage of public reporting
INSPECTION		
1	Griffiths (2017, BMJ Quality and Safety)	Outside scope of research question, as it assesses the ability of a new Intelligent Monitoring tool within inspection to predict quality of care
2	Hawkes (2018, British Medical Journal)	No original research, but opinion paper
3	Sheldon (2019, Journal of Health Services Research & Policy)	No original research, but opinion paper

A.1.3 Summary of included articles

	First author (publication year)	Journal	Countries *(setting and patient population if reported)*	Objectives	Design	Level of evidence*	Quality improvement initiative(s) *(reported programme with level of reporting if applicable)*	Studied patient outcome(s)	Reported impact of quality improvement initiative(s)
1	Aboshaiqah *et al.* (2016)	Journal of Advanced Nursing	Saudi Arabia *(4 accredited and 4 non-accredited public tertiary hospitals. Patient population: all adult patients to be discharged within 24-48 hours)*	1) Explore differences in patients' perceptions of quality of care in public tertiary hospitals with and without accreditation. 2) Determine association between accreditation status, selected patients' characteristics and quality of care. 3) Determine proportion of variance.	Comparative cross-sectional	IV	Accreditation *(national mandatory programme: Central Board of Accreditation for Healthcare Institutions)*	Patient satisfaction	Positive
2	Aghaei Hashjin *et al.* (2014)	BMC Health Services Research	Iran *(553 general and 143 specialized hospitals)*	1) To describe the development and process of implementation of a national hospital performance measurement programme 2) To explore the impact on hospital performance. 3) To look for associations between performance and hospital characteristics.	Mixed method study consisting of longitudinal data and qualitative document analysis from 2002 to 2008.	IV	Accreditation *(national mandatory programme: Hospital Performance Measurement Programme)*	Process measures *[functional domains of quality of care, e.g. safety, patient-centeredness, …]*	Positive
3	Allen *et al.* (2019)	Emergency Medicine Journal	UK *(118 hospitals. Patient population: emergency department patients)*	- To examine whether prior levels of performance on six indicators (of the emergency department) were associated with the ratings they received when inspected - To analyze whether levels of performance on those indicators changed	Retrospective observational study between 2013 and 2016	IV	Inspection *(executive non-departmental public body: Care Quality Commission)*	Process measures *[time to initial assessment, time to treatment, total time spent, left before seen for treatment, unplanned re-attendence]*, readmissions	Neutral

				following inspection and rating					
4	Almasabi *et al.* (2017)	The International Journal of Health Planning and Management	Saudi Arabia *(3 accredited public hospitals)*	To develop an understanding of the impact of accreditation on the quality of care by focus on (i) the perception of staff, (ii) the relationship between quality indicators and accreditation, and (iii) the perception of senior managers.	Mixed methods consisting of surveys, documentary analyses with comparative before-and-after design and semi-structured interviews.	IV	Accreditation *(national mandatory programme: Central Board of Accreditation for Healthcare Institutions)*	Mortality, length of stay, adverse outcomes *[infection]*	Neutral for mortality, and neutral** for both length of stay and adverse outcomes
5	Andres *et al.* (2019)	BMC Health Services Research	Hong Kong *(1 publicly-funded university teaching hospital. Patient population: acute-care inpatients aged 18 to 80 were recruited on the second day of hospital admission)*	To evaluate the longitudinal impact of hospital accreditation on patient experience.	Three cross-sectional patient surveys conducted at three time points.	IV	Accreditation *(international programme: Australian Council on Healthcare Standards)*	Patient satisfaction	Positive
6	Apolito *et al.* (2008)	American Heart Journal	USA *(220 acute myocardial infarction and cardiogenic shock patients in New York, compared to 325 from other states)*	To determine if operators whose operator-specific mortality for patients undergoing coronary artery bypass graft or percutaneous coronary intervention is made public, may deter from providing revascularization to high-risk cardiac patients compared to non-reporting states	Propensity-adjusted retrospective analysis	IV	Public reporting *(New York State Cardiac Surgery and Percutaneous Coronary Intervention Reporting System. Level of reporting: individual-level)*	Risk aversion	Negative
7	Barnett et *al.* (2017)	JAMA Internal Medicine	USA *(1984 hospitals. Patient population: Hospital-wide, all admissions during the business week of accreditation survey as well as all admissions occurring 3 weeks*	To assess whether heightened vigilance during survey weeks is associated with improved patient outcomes compared with non-survey weeks.	Quasi-randomized analysis of hospital admissions from 2008 through 2012 in the period from 3 weeks before to	III	Accreditation *(national programme: The Joint Commission)*	Mortality *[30-day mortality]*, adverse outcomes *[PSI 90, PSI 4, Clostridium difficile infections, in-hospital cardiac arrest mortality]*	Positive for mortality, neutral for adverse outcomes

			before and after each survey week.)		3 weeks after surveys.				
8	Bekelis *et al.* (2018)	British Journal of Neurosurgery	USA *(28 accredited hospitals compared to 148 non-Magnet accredited institutions. Patient population: neuro-surgical patient cohort)*	To investigate whether Magnet hospital accreditation is associated with higher quality of physicians performing neurosurgical procedures.	Cohort study of patients undergoing neurosurgical procedures from 2009-2013.	IV	Accreditation *(national programme: Magnet)*	Mortality, length of stay	Positive
9	Bogh *et al.* (2015)	International Journal for Quality in Health Care	Denmark *(all public hospitals, of which 6 accredited and 27 non-accredited. Patient population: all patients admitted for acute stroke, heart failure or ulcer)*	To examine whether performance measures improve more in accredited hospitals than in non-accredited hospitals.	A historical follow-up study using process of care data for all patients admitted for acute stroke, heart failure or ulcers.	IV	Accreditation *(international programme: Joint Commission International and national programme: Health Quality Service)*	Process measures *[21 processes covering stroke, heart failure, bleeding ulcer and perforated ulcer]*	Negative
10	Bogh *et al.* (2016)	International Journal for Quality in Health Care	Denmark *(25 public hospitals. Patient population: stroke, heart failure, ulcer, diabetes, breast cancer and lung cancer patients)*	To assess changes over time in quality of hospital care in relation to the first accreditation cycle of a mandatory national accreditation programme	A longitudinal nationwide study of process performance measures related to the introduction of a mandatory accreditation programme from 2008 to 2013.	IV	Accreditation *(national programme: The Danish Healthcare Quality Programmeme – mandatory)*	Process measures *[43 process performance measures on 6 conditions: stroke, heart failure, ulcer, diabetes, breast cancer and lung cancer]*	Positive
11	Bogh *et al.* (2017)	International Journal for Quality in	Denmark *(25 public hospitals. Patient population: stroke, heart failure, ulcers,*	To identify predictors of the effectiveness of hospital accreditation on process performance measures	A multi-level, longitudinal, stepped-wedge, nationwide study from 2008 to 2013	IV	Accreditation *(national programme: The Danish Healthcare Quality*	Process measures *[43 process performance measures on 6 conditions: stroke, heart failure,*	Neutral**

		Health Care	*diabetes, breast cancer and lung cancer patients)*				*Programmeme – mandatory)*	*ulcer, diabetes, breast cancer and lung cancer]*	
12	Boyden *et al.* (2015)	American Heart Journal	USA *(51 983 patients in New York [public reporting], compared to 53 528 patients in Michigan [collaborative quality improvement]. Patient population: patients undergoing percutaneous coronary intervention)*	To compare patient selection, quality of care, and patient outcomes in 2 US states with different approaches to the use and publication of quality data: New York (public reporting) vs Michigan (collaborative quality improvement)	Cohort study between 2011 and 2012	IV	Public reporting *(National Cardiovascular Data Registry CathPCI Registry. Level of reporting: individual-level and disease-specific)*	Risk aversion, mortality *[in-hospital]*, adverse outcomes *[10 outcomes]*	Negative for risk aversion, positive for mortality and adverse outcomes
13	Castro-Avila *et al.* (2019)	Journal of Health Services Research and Policy	UK *(155 acute-care NHS trusts. Patient population: hospital-wide)*	To evaluate the effect of Care Quality Commission external inspections of acute trusts on adverse event rates in the English National Health Service	Controlled interrupted time-series analysis from 2012 to 2016	III	Inspection *(executive non-departmental public body: Care Quality Commission)*	Adverse Outcomes	Negative
14	Dahlke *et al.* (2014)	Journal of the American College of Surgeons	USA *(452 hospitals, of which 80 decided to publicly report. Patient sample: surgical patients)*	To compare hospitals participating in voluntary public reporting of American College of Surgeons National Surgical Quality Improvement Programme surgical outcomes to hospitals that elected not to participate	Observational comparison study of 58 measures	IV	Public reporting *(Centers for Medicare and Medicaid Services Hospital Compare programme: American College of Surgeons National Surgery Quality Improvement Programme. Level of reporting: hospital-wide)*	Process measures *[32 measures]*, patient satisfaction *[10 measures]*, adverse outcomes *[9 measures]*, mortality, readmissions, failure to rescue	Neutral
15	Devkaran *et al.* (2015)	BMC Health Services Research	United Arab Emirates *(1 multispecialty hospital. Patient*	To examine the impact of healthcare accreditation on hospital quality measures.	Interrupted time series analysis	IV	Accreditation *(international programme: Joint*	Process measures *[26 measures]*, mortality	Positive for process measures,

			population: random sample of 12 000 patient records)				*Commission International)*		neutral for mortality
16	Devkaran *et al.* (2019)	BMJ Open	United Arab Emirates *(1 tertiary academic hospital. Patient population: random sample of 14 500 patient records)*	To evaluate whether hospital re-accreditation improves quality, patient safety and reliability over three accreditation cycles.	Interrupted time series analysis	IV	Accreditation *(international programme: Joint Commission International)*	Process measures *[27 measures]*	Positive
17	DeVore *et al.* (2016)	Journal of the American College of Cardiology	USA *(>4100 hospitals. Patient population: patients discharged after a hospitalization for acute myocardial infarction, heart failure or pneumonia)*	To assess trends of 30-day readmission rates and post-discharge care since the implementation of Centers for Medicare & Medicaid Services Public Reporting	Retrospective observational study between 2006 and 2012 for patients discharged with acute myocardial infarction, heart failure or pneumonia	IV	Public reporting *(Centers for Medicare and Medicaid Services Hospital Compare programme. Level of reporting: disease-specific)*	Readmissions	Neutral
18	Falstie-Jensen *et al.* (2015) [A]	International Journal for Quality in Health Care	Denmark *(31 public non-psychiatric hospitals. Patient population: inpatients diagnosed with one of 80 primary diagnoses accounting for 80% of all death within 30 days after admissions)*	To examine the association between compliance with hospital accreditation and 30-day mortality.	Nationwide population-based follow-up study from 2010 to 2012.	IV	Accreditation *(national programme: The Danish Healthcare Quality Programmeme – mandatory)*	Mortality	Positive
19	Falstie-Jensen *et al.* (2015) [B]	International Journal for Quality in Health Care	Denmark *(31 public non-psychiatric hospitals. Patient population: inpatients diagnosed with*	To examine the association between compliance with hospital accreditation and length of stay and acute readmission	Nationwide population-based follow-up study from 2009 to 2012	IV	Accreditation *(national programme: The Danish Healthcare Quality Programmeme – mandatory)*	Length of stay, readmissions	Positive for length of stay, neutral for readmissions

			one of 80 primary diagnoses accounting for 80% of all death within 30 days after admissions)						
20	Falstie-Jensen *et al.* (2017)	International Journal for Quality in Health Care	Denmark (*31 public non-psychiatric hospitals. Patient population: patients with acute stroke, chronic obstructive pulmonary disease, diabetes, heart failure, hip fracture and bleeding/perforated ulcers.)*	To examine the association between compliance with accreditation and recommended hospital care.	Nationwide population-based follow-up study from 2009 to 2012	IV	Accreditation *(national programme: The Danish Healthcare Quality Programmeme – mandatory)*	Process measures	Positive
21	Falstie-Jensen *et al.* (2018)	International Journal for Quality in Health Care	Denmark *(25 public non-psychiatric hospitals. Patient population: inpatients diagnosed with one of 80 primary diagnoses accounting for 80% of all death within 30 days after admissions))*	To examine the association between compliance with consecutive cycles of accreditation and patient-related outcomes	Nationwide population-based study from 2012 to 2015	IV	Accreditation *(national programme: The Danish Healthcare Quality Programmeme – mandatory)*	Mortality, length of stay, readmissions	Positive for both mortality and length of stay, neutral for readmissions
22	Flett *et al.* (2015)	Infection Control & Hospital Epidemiology	USA *(17 pediatric hospitals in 9 states with public reporting, 4 hospitals in 4 states without public reporting. Patient population*	To determine whether blood culture and antibiotic utilization changed after mandatory public reporting of central line-associated bloodstream infection	Interrupted time series analysis of pediatric and neonatal intensive care units	III	Public reporting *(state-based mandatory public reporting, programme undisclosed. Level of reporting: unit-based)*	Risk aversion	Neutral

			pediatric and neonatal intensive care unit patients)						
23	Friedberg *et al.* (2009)	The American Journal of Managed Care	USA *(13 042 emergency department visits. Patient population: adult emergency department patients with respiratory symptoms between 2001 and 2005)*	To determine whether public reporting has been associated with overdiagnosis of pneumonia, excessive antibiotic use, or inappropriate prioritization of patients with respiratory symptoms	Retrospective analyses	IV	Public reporting *(Hospital Quality Alliance. Level of reporting: unit-based)*	Risk aversion	Neutral
24	Friese *et al.* (2015)	Health Affairs	USA *(5222 hospitals. Patient population: surgical patients above 65 who had coronary artery bypass graft surgery, colectomy, or lower extremity bypass)*	1) To investigate patient outcomes in accredited and non-accredited hospitals over time. 2) To examine outcomes both before and after receiving recognition.	Matched comparison study of surgical patient cohorts across 13-year study period.	IV	Accreditation *(national programme: Magnet)*	Mortality, failure to rescue	Positive
25	Gokenbach *et al.* (2011)	Nursing Clinics of North America	USA *(1 academic hospital. Patient population: undisclosed)*	To describe the process of accreditation in one academic center.	Case study, with longitudinal control chart methodology between 2002 and 2010.	IV	Accreditation *(national programme: Magnet)*	Patient satisfaction	Positive
26	Goode *et al.* (2011)	Journal of Nursing Administration	USA *(19 Magnet and 35 non-Magnet hospitals. Patient population: hospital-wide)*	This study compared patient outcomes and staffing in Magnet-accredited and non-accredited hospitals.	Observational comparison study by looking at expected versus observed patient outcomes.	IV	Accreditation *(national programme: Magnet)*	Mortality, failure to rescue, adverse outcomes, length of stay	Neutral**
27	Greenfield *et al.* (2019)	Health Policy	Australia *(311 hospitals. Patient population: undisclosed)*	To establish whether longitudinal participation in an accreditation programme is translated into improvement in continuity of	Secondary data analysis of accreditation panel data.	IV	Accreditation *(national programme: ACHS Evaluation and*	Process measures	Positive

				quality patient care and human resource management process outcomes.			*Quality Improvement Programme – EquIP)*		
28	Groene *et al.* (2015)	PLOS One	Europe *(74 hospitals in Cech Republic, France, Germany, Poland, Portugal, Spain, Turkey. Patient population: patients with acute myocardial infarction, stroke, hip fracture and deliveries)*	To assess the effect of quality management systems on a range of patient-reported experience measures.	Cross-sectional, multi-level study in acute myocardial infarction, hip fracture, stroke and deliveries patients.	IV	Accreditation *(programme undisclosed)*	Patient satisfaction	Neutral
29	Gupta *et al.* (2018)	Jama Cardiology	USA *(416 hospitals. Patient population: patients aged 65 years or older hospitalized with heart failure)*	To examine the association of the Hospital Readmissions Reduction Programme with readmission and mortality outcomes among patients hospitalized with heart failure	Interrupted time-series and survival analysis from 2006 to 2014	IV	Public reporting *(Hospital Readmissions Reduction Programme. Level of reporting: disease-specific)*	Mortality, readmissions	Negative impact on mortality, positive impact on readmissions
30	Haj-Ali *et al.* (2014)	International Journal of Health Policy and Management	Lebanon *(6 hospitals. Patient population: patients between 18 and 80, literature, conscious, not critically ill and admitted to the medical and surgical wards)*	To explore the impact of the national accreditation system on patient satisfaction	Explanatory cross-sectional study.	IV	Accreditation *(national programme: accreditation system by Lebanese Ministry of Public Health)*	Patient satisfaction	Neutral**
31	Halasa *et al.* (2017)	Eastern Mediterranean Health Journal	Jordan *(2 private accredited acute general hospitals with 2 matched non-accredited hospitals. Patient population: undisclosed)*	To examine the economic impact of JCI hospital accreditation standards on selected structural and outcome of care measures of hospital performance.	4-year retrospective study using differences-in-differences	IV	Accreditation *(international programme: Joint Commission International)*	Process measures *[6 measures]*, readmission	Neutral**

32	Hayati *et al.* (2010)	Journal of Community Health	Malaysia *(4 district government hospitals, one accredited, 3 non-accredited. Patient population: patients between 18-70 admitted to any medical and surgical wards without mental illness and Malaysian citizens.)*	To compare the extent to which a patient's satisfaction is related to hospital accreditation status, to examine the relationship between patient satisfaction and hospital work load and to determine factors that influence patients' satisfaction.	Cross-sectional study between July and November 2005 of 150 patients in accredited and 150 in non-accredited hospital	IV	Accreditation *(programme undisclosed)*	Patient satisfaction	Neutral
33	Howell *et al.* (2014)	Journal of the American Medical Association	USA *(41 hospitals. Patient population: all delivery and newborn hospitalization in 2010)*	To examine whether 2 Joint Commission obstetric quality indicators are associated with maternal and neonatal morbidity	Population-based observational study from 2010 data	IV	Accreditation, public reporting *(national programme: the Joint Commission for accreditation; Centers for Medicare and Medicaid Services Hospital Compare programme for public reporting. Level of reporting: unit-based)*	Process measures *[2 measures]*	Neutral
34	Hua *et al.* (2017)	Anesthesiology	USA *(24 864 patients in Massachusetts and 63 323 in New York. Patient population: those undergoing coronary artery bypass graft)*	To examine whether timing of mortality after coronary artery bypass graft surgery significantly increases after day 30 in Massachusetts, a state that reports 30-day mortality, with New York as comparator state, which reports combined 30-day and all in-hospital mortality, irrespective of time since surgery.	Retrospective cohort study of patients undergoing coronary artery bypass graft surgery in hospitals between 2008 and 2013	IV	Public reporting *(Centers for Medicare and Medicaid Services Hospital Compare programme. Level of reporting: disease-specific)*	Mortality, risk aversion	Neutral
35	Jang *et al.* (2011)	Journal of Preventive Medicine	Korea *(1194 hospitals and clinics. Patient*	To evaluate the effect of repeated public releases for reducing cesarean section rates	Time-series autoregressive integrated	IV	Public reporting *(Health Insurance Review &*	Process measures	Positive

		and Public Health	*population: deliveries)*		moving average analysis		*Assessment Service. Level of reporting: unit-based)*		
36	Joynt *et al.* (2012)	Journal of the American Medical Association	USA *(49 660 patients from reporting states and 48 142 patients from nonreporting states. Patient population: patients above 65 admitted with acute MI)*	To determine whether public reporting for percutaneous coronary intervention (PCI) is associated with lower rates of PCI for patients with acute myocardial infarction or with higher mortality rates in this population	Retrospective observational study between 2002 and 2010	IV	Public reporting *(state-mandated public reporting, programme undisclosed. Level of reporting: disease-specific)*	Mortality, risk aversion	Neutral for mortality, negative for risk aversion
37	Joynt *et al.* (2016)	Annals of Internal Medicine	USA *(20 707 266 patients hospitalized from 2005 to 2012. Patient population: patients hospitalized between 2005 and 2012 with any of the 15 most common nonsurgical discharge diagnoses)*	To determine whether public reporting of mortality rates was associated with lower mortality rates for these conditions	Retrospective observational study between 2005 and 2012	IV	Public reporting *(Centers for Medicare and Medicaid Services Hospital Compare Programme. Level of reporting: hospital-wide)*	Mortality	Negative
38	Lake *et al.* (2010)	Research in Nursing & Health	USA *(108 Magnet-accredited and 528 non-accredited general acute-care hospitals. Patient population: hospital-wide)*	To examine the relationships among nurse staffing, RN composition, hospitals' Magnet status, and patient falls	Retrospective cross-sectional observational study of 2004 data	IV	Accreditation *(national programme: Magnet)*	Adverse outcomes	Positive
39	Lam *et al.* (2018)	British Medical Journal	USA *(4400 hospitals of which 3337 accredited and 1063 state-*	To determine whether patients admitted to US hospitals that are accredited have better outcomes than those admitted to hospitals	Observational study	IV	Accreditation *(national programme: the Joint Commission)*	Mortality, readmissions, patient satisfaction	Neutral for mortality, Positive for readmissions

			based review. Patient population: patients above 65 admitted for 15 common medical and six common surgical conditions.)	reviewed through state surveys, and whether accreditation by The Joint Commission confers any additional benefits for patients compared with other independent accrediting organizations					and Negative for patient satisfaction
40	Liu *et al.* (2017)	Health Services Research	USA *(947 hospitals. Patient population: ICU patients)*	To examine the effect of mandated state health care-associated infection reporting laws on central line-associated bloodstream infection rates in adult intensive care units	Quasi-experimental study design between 2006-2012	III	Public reporting *(state-based mandatory public reporting, programme undisclosed. Level of reporting: unit-based)*	Adverse outcomes	Positive
41	Lutfiyya *et al.* (2009)	International Journal for Quality in Health Care	USA critical access hospitals *(730, of which 525 non-accredited and 205 JCAHO accredited. Patient population: patients with acute myocardial infarction, heart failure, pneumonia and patients undergoing surgery)*	To determine whether quality measures differed for critical access hospitals based on Joint Commission on Accreditation of Healthcare Organizations accreditation status.	Cross-sectional study examining secondary data from 45 US states with critical access hospitals	IV	Accreditation *(national programme: the Joint Commission)*	Process measures *[16 measures]*	Positive
42	Mansi *et al.* (2010)	Journal of the National Medical Association	USA *(1 university hospital. Patient population: heart failure patients)*	To determine the effects of compliance with TJC core quality measures for heart failure on patient outcomes at a university hospital for high-risk patient populations	Retrospective cohort study	IV	Accreditation *(national programme: the Joint Commission)*	Mortality, readmissions	Neutral for mortality, negative for readmissions
43	McCabe *et al.* (2013)	JACC: Cardiovascular	USA *(4 institutions who were identified as*	To evaluate the impact of public reporting of hospitals as negative	Retrospective observational	IV	Public reporting *(state-based mandatory public*	Risk aversion	Negative

		Interventions (2013)	*negative outliers through public reporting. Patient population: 116 227 patients undergoing percutaneous coronary intervention)*	outliers on percutaneous coronary intervention case-mix selection	study from 2003 to 2010		*reporting to the National Cardiovascular Data Registry. Level of reporting: disease-specific)*		
44	Mumford *et al.* (2014)	BMJ Open	Australia *(96 acute public hospitals. Patient population: hospital-wide)*	- To investigate the suitability of hand hygiene as an indicator of accreditation outcomes - To test the hypothesis that hospitals with better accreditation outcomes achieve higher hand hygiene compliance rates	Retrospective, longitudinal, multisite comparative survey over the study period 2009-2013	IV	Accreditation (*national programme: ACHS Evaluation and Quality Improvement Programme – EquIP)*	Process measures	Neutral**
45	Mumford *et al.* (2015)	International Journal for Quality in Health Care	Australia *(77 acute public hospitals. Patient population: patients with hospital-acquired Staphylococcus aureus)*	To test our hypothesis that hospitals with higher accreditation scores, specifically in infection control, would be associated with lower Staphylococcus aureus bacteraemia rates	Retrospective cohort study	IV	Accreditation *(national programme: ACHS Evaluation and Quality Improvement Programme – EquIP)*	Adverse outcomes	Neutral**
46	Nathan *et al.* (2019)	Circulation: Cardiovascular Interventions	USA (*Patient population: 50 125 patients admitted with out-of-hospital cardiac arrest*)	To evaluate the association between public reporting and the performance of coronary angiography among patients resuscitated from an out-of-hospital arrest over a time period in which risk aversion in the performance of high-risk percutaneous coronary intervention has been demonstrated	Cross-sectional analysis between 2005 and 2011	IV	Public reporting *(state-based mandatory public reporting, programme undisclosed. Level of reporting: disease-specific)*	Risk aversion, mortality	Neutral
47	Renzi *et al.* (2012)	Health Services Research	Italy *(Patient population: 381 053 acute myocardial infarction patients, 250 712 hip fractures, and 1 736 970 women*	To evaluate whether reporting of hospital performance was associated with a change in quality indicators in Italian hospitals	Pre-post evaluation and comparative evaluation	IV	Public reporting *(Regional Outcome Evaluation Programme P.Re.Val.E. Level of reporting: disease-specific)*	Process measures	Positive

			who had given birth)						
48	Rinke *et al.* (2015)	Journal of Patient Safety	USA *(2066 hospitals across 18 states who never reported, 135 hospitals reporting from 2006 in 7 states and 1006 hospitals reporting since 2009. Patient population: pediatric patients, aged less than 20)*	To test if hospitals located in states with mandated, facility-identified, pediatric-specific public central line-associated blood stream infections reporting have lower rates of infections	Retrospective observational study between 2000 and 2009	IV	Public reporting *(mandatory public reporting of Kids' Inpatient Database. Level of reporting: unit-based)*	Adverse outcomes	Neutral
49	Ryan *et al.* (2012)	Health Affairs	USA *(Patient population: 2 330 637 heart attack patients, 5 218 728 heart failure patients and 4 832 721 pneumonia patients)*	To estimate the effect of 'Hospital Compare' public reporting on thirty-day mortality for heart attack, heart failure and pneumonia)	Interrupted time-series design	IV	Public reporting *(Centers for Medicare and Medicaid Hospital Compare programme. Level of reporting: disease-specific)*	Mortality	Neutral**
50	Sack *et al.* (2010)	BMC Health Services Research	Germany *(25 hospitals, of which 15 accredited. Patient population: cardiology-unit patients)*	To assess in a defined specialty (cardiology) the relationship between patient satisfaction (as measured by the recommendation rate) and accreditation status	Validated patient satisfaction questionnaire in consecutive patients discharged from 25 cardiology units	IV	Accreditation *(national programmes: Cooperation for Transparency and Quality in Hospitals and proCum Cert)*	Patient satisfaction	Neutral
51	Sack *et al.* (2011)	Internatio nal Journal for Quality in	Germany *(73 hospitals. Patient population: hospital-wide)*	To assess the relationship between patient satisfaction and accreditation status	Validated patient satisfaction questionnaire to patients discharged	IV	Accreditation *(national programmes: Cooperation for Transparency and*	Patient satisfaction	Neutral

		Health Care			between January and May 2007		*Quality in Hospitals and proCum Cert)*		
52	Schmaltz *et al.* (2011)	Journal of Hospital Medicine	USA *(3891 acute care and critical access hospitals. Patient population: acute myocardial infarction, heart failure and pneumonia patients)*	To examine the association between Joint Commission accreditation status and both absolute measures of, and trends in, hospital performance on publicly reported quality measures for common diseases	Retrospective observational study of performance data between 2004 and 2008	IV	Accreditation, public reporting *(national programme: the Joint Commission for accreditation; Centers for Medicare and Medicaid Services Hospital Compare programme for public reporting. Level of reporting: disease-specific)*	Process measures *[16 measures and 4 summary scores]*	Positive
53	Sekimoto *et al.* (2008)	American Journal of Infection Control	Japan *(335 teaching hospitals. Patient population: hospital-wide)*	- To characterize the current situation of hospital infection control programmes and activities - To assess the impact of accreditation and other factors on hospital infection control performance	Questionnaire survey based on accreditation standards sent to teaching hospitals in 2004 and 2005	IV	Accreditation *(national programme: Japan Council for Quality Health Care)*	Process measures	Positive
54	Shahian *et al.* (2019)	The Journal of Thoracic and Cardiovascular Surgery	USA *(39 400 patients in Massachusetts with mandatory public reporting and 1 815 234 patients across the nation. Patient population: coronary artery bypass graft patients)*	To determine whether longitudinal prevalences and trends in risk factors and observed and expected mortality differed between Massachusetts and the nation	Retrospective observational study between 2003 and 2014 of expected and observed coronary artery bypass graft mortality rates	IV	Public reporting *(mandatory public reporting of Society of Thoracic Surgeons National Database data. Level of reporting: individual-level and disease-specific)*	Mortality	Positive
55	Shaw *et al.* (2010)	International Journal for	Europe *(89 hospitals in 6 countries. Patient*	To identify systematic differences in quality management between hospitals that were accredited, or certificated, or neither	Analysis of compliance with measures of quality, assessed	IV	Accreditation *(programme undisclosed)*	Process measures	Positive

		Quality in Health Care	*population: undisclosed)*		by external auditors using a standardized tool				
56	Shaw *et al.* (2014)	International Journal for Quality in Health Care	Europe *(73 hospitals in 7 countries. Patient population: patients with acute myocardial infarction, hip fracture, stroke and obstetric deliveries)*	To investigate the relationship between ISO 9001 certification, healthcare accreditation and quality management in European hospitals	Mixed method multi-level cross-sectional design	IV	Accreditation *(programme undisclosed)*	Process measures	Positive
57	Smithson *et al.* (2018)	The King's Fund	UK *(acute care, mental health care, general practice and adult social care. Patient population for acute care: accident and emergency and maternity department)*	To examine the impact of the first cycle of Care Quality Commission inspections in acute care, mental health care, general practice and adult social care services	Mixed method study with quantitative analyses on routine data	IV	Inspection *(executive non-departmental public body: Care Quality Commission)*	Process measures, readmissions	Neutral**
58	Sousa *et al.* (2018)	International Journal for Quality in Health Care	Portugal *(9 acute public hospitals. Patient population: all patients over 18 years old who had a minimum stay in hospital of 24h.)*	To analyze the variation in the rate of adverse events between acute hospitals and explore the extent to which some patients and hospitals characteristics influence the differences in the rates of adverse events	Retrospective cohort study (chart review)	IV	Accreditation *(programme undisclosed)*	Adverse outcomes	Negative

59	Strom *et al.* (2017)	Circulation: Cardiovascular Interventions	USA *(Patient population: 26 379 acute myocardial infarction and cardiac arrest patients of which 5619 in New York)*	To evaluate the effects of excluding selected patients with cardiac arrest and coma from publicly reported mortality statistics after percutaneous coronary intervention on rates of coronary angiography, revascularization, and mortality among patients with acute myocardial infarction and cardiac arrest	Retrospective observational study between 2003 and 2013 with a difference-in-differences approach	IV	Public reporting *(state-based mandatory public reporting, programme undisclosed. Level of reporting: disease-specific and individual-level)*	Mortality, risk aversion	Neutral
60	Sunol *et al.* (2015)	PLOS One	Europe *(73 acute-care hospitals in 7 countries. Patient population: patients with acute myocardial infarction, hip fracture, stroke and deliveries)*	To assess variations in clinical practice and explore associations with hospital- and department-level quality management systems	Multicenter, multilevel cross-sectional study for 4 conditions	IV	Accreditation *(programme undisclosed)*	Process measures	Neutral
61	Thornlow *et al.* (2009)	Health Care Management Review	USA *(115 acute care hospitals. Patient population: hospital-wide)*	To examine the relationship between patient safety practices as measured by accreditation standards and patient safety outcomes as measures by hospital rates of infections, decubitus ulcers, postoperative respiratory failure and failure to rescue	Secondary data analysis from stratified probability sample of acute care hospitals	IV	Accreditation *(national programme: the Joint Commission)*	Adverse outcomes *[3 measures]*, failure to rescue	Neutral** for adverse outcomes, and neutral effect on failure to rescue
62	Tu *et al.* (2009)	Journal of the American Medical Association	Canada *(86 hospitals. Patient population: patients admitted for acute myocardial infarction or congestive heart failure)*	To evaluate whether the public release of data on cardiac quality indicators effectively stimulates hospitals to undertake quality improvement activities that improve health care process and patient outcomes	Population-based cluster randomized trial with patients admitted for acute myocardial infarction or congestive heart failure	II	Public reporting *(Enhanced Feedback for Effective Cardiac Treatment study. Level of reporting: disease-specific)*	Mortality, process measures	Neutral

63	Vallance *et al.* (2018)	British Medical Journal	UK *(Patient population: 111 431 patients diagnosed as having colorectal cancer between 2011 and 2015)*	To determine the effect of surgeon specific outcome reporting in colorectal cancer surgery on risk averse clinical practice, gaming of clinical data and 90-day postoperative mortality	National cohort study	IV	Public reporting *(data from National Bowel Cancer Audit, made publicly available on websites of Association of Coloproctology of Great-Britain and Ireland and on NHS Choices. Level of reporting: surgeon-specific)*	Mortality, risk aversion	Positive for mortality, neutral for risk aversion
64	Waldo *et al.* (2015)	Journal of the American College of Cardiology	USA *(Patient population: 81 121 patients hospitalized with acute myocardial infarction, of which 57 629 in publicly reporting facilities)*	To evaluate the association between public reporting with procedural management and outcomes among patients with acute myocardial infarction	Retrospective observational study between 2005 and 2011	IV	Public reporting *(state-based mandatory public reporting, programme undisclosed. Level of reporting: disease-specific)*	Mortality, risk aversion	Negative
65	Wardhani *et al.* (2019)	BMC Health Services Research	Indonesia *(346 hospitals, of which 2017 accredited. Patient population: hospital-wide)*	To explore the association of hospital characteristics and market competition with hospital accreditation status and to investigate whether accreditation status differentiate hospital performance	Retrospective observational study	IV	Accreditation *(national programme: Indonesia Commission on Accreditation of Hospitals – mandatory)*	Mortality, length of stay	Neutral

66	Werner *et al.* (2010)	Health Affairs	USA *(3476 acute care nonfederal hospital that publicly report. Patient population: patients with acute myocardial infarction, heart failure and pneumonia)*	- To examine whether hospital performance on key process indicators improved during the three years since public reporting began - To test whether these changes in performance were correlated with changes in hospital mortality rates, lengths-of-stay and readmission rates	Retrospective observational study between 2004 and 2006	IV	Public reporting *(Centers for Medicare and Medicaid Services Hospital Compare programme. Level of reporting: disease-specific)*	Mortality, length of stay, readmissions, process measures	Positive
67	Wright *et al.* (2017)	Infection control & Hospital Epidemiology	USA *(120 hospitals. Patient population: coronary artery bypass graft operations and knee prosthesis patients)*	To examine the correlation between infection preventionist staffing level and outcomes	Cross-sectional study	IV	Accreditation *(programme undisclosed)*	Adverse outcomes	Neutral
68	Yamana *et al.* (2018)	BMC Health Services Research	Japan *(135 reporting and 135 non-reporting hospitals, with a cohort of 30 220 patients. Patient population: acute myocardial infarction patients)*	To evaluate whether enrollment in a quality reporting project is associated with improvement in quality of care for patients with acute myocardial infarction	Quasi-experimental study using difference-in-differences analyses	III	Public reporting *(quality reporting project led by Ministry of Health, Labour and Welfare. Level of reporting: disease-specific)*	Mortality	Neutral
69	Yildiz *et al.* (2019)	International Journal of Health Planning and Management	Turkey *(350 hospitals. Patient population: hospital-wide)*	To better understand the value of external recognitions by looking at effects of certification and accreditation on hospital quality management system	Cross-sectional study design with structured questionnaire	IV	Accreditation *(programme undisclosed)*	Process measures	Positive

* according to Ackley, B. J., Swan, B. A., Ladwig, G., & Tucker, S. (2008). *Evidence-based nursing care guidelines: Medical-surgical interventions.* (p. 7). St. Louis, MO: Mosby Elsevier.

** The described neutral impact on this patient outcome is derived from the reporting of mixed results in this publication

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A.2 Additional material to Chapter 3

A.2.1 Data collection guide for requested variables concerning government-encouraged quality improvement initiatives along with their characteristics

Characteristics	Data sources for requested variables
General: Hospitals in Flanders	

- 62 acute-care hospitals in 2008
- 53 acute-care hospitals in 2019
- 9 hospital mergers took place between 2008-2019
- Anno 2019:
  o 4 university hospitals and 49 general hospitals
  o Number of beds ranges between 170 and 1955
  o Average number of beds: 542
	- Hospital characteristics (e.g. number of beds, teaching status): www.health.belgium.be
	- Hospital mergers: http://atlas.ima-aim.be/databanken

Accreditation	

- Voluntary.
- Hospitals opting for accreditation are exempt from one part of inspection process (see below).
- No national hospital-wide programme exists. Hospitals can opt for any recognised international accreditation body.
- Announced
- Promoted since 2009.
	- For Qualicor-accredited hospitals:
	  o Survey dates for all audits and re-audits between 2008 and 2019
	  o Edition of accreditation manual
	  o Accreditation scores
	  o Status of accreditation label (achieved, postponed or declined)
	  ➔ Information derived from Qualicor Europe after approval of each individual hospital provided in the Qualtrics© survey sent out to quality managers of all 53 hospitals.
	
	- For JCI-accredited hospitals:
	  o Survey dates for all audits and re-audits between 2008 and 2019
	  o Edition of accreditation manual
	  o Accreditation scores
	  o Status of accreditation label (achieved, postponed or declined)
	  ➔ Information derived from Qualtrics© survey sent out to quality managers of all 53 hospitals.
	
	- For hospitals who did not respond to the Qualtrics© survey sent out to quality managers of all 53 hospitals. (n=9)

	○ Accreditation body ○ Survey dates for all audits and re-audits between 2008 and 2019 ➔ Information derived from publicly available hospital websites [not disclosed here to safeguard anonymity]
Public reporting	
- Voluntary for each indicator. - Includes validated structure, process and outcome indicators across four overarching domains: ○ Cancer (breast cancer, rectum cancer and lung cancer survival) ○ Patient experiences ○ Patient safety (hand hygiene, patient identification, medicine prescription completeness and safe surgery checklist) ○ Website content - Measurement and internal benchmarking were introduced in 2013. The reporting to the general public started in 2016.	The Flemish Institute for the Quality of Care (VIKZ) provided the following information: - Participating hospitals to the measurement and internal benchmarking of each quality indicator within the 4 domains per year (2013-2019) - Participating hospitals to the public reporting of each quality indicator within the 4 domains per year (2013-2019) - For each quality indicator: dates of measurement, availability of benchmark and public reporting on www.zorgkwaliteit.be for each semester between 2013 and 2019 (the same dates for all participating hospitals)
Inspection	
- Organised by the Flemish government. - Consists of: ○ Compliance monitoring: ▪ Unannounced ▪ Compulsory for all hospitals ▪ Introduced in 2013 ▪ Examines patient pathways, concentrating on a different pathway every two years: surgery (2013-2014), internal medicine (2016) and cardiology (2018-2019), with a repeat inspection for surgery and internal medicine in 2018. ○ Systemic inspection: ▪ Announced ▪ Compulsory except for accredited hospitals ▪ Includes intensive self-assessments and risk analyses to study quality guarantees on the long term ○ Safety audits:	The Department of Health (Flemish Government) provided the following information: - Dates of compliance monitoring surveys, systemic inspections, safety audits and allocation inspections for all Flemish acute-care hospitals between 2008 and 2019. - Hospital mergers occurring between 2008-2019 missing from http://atlas.ima-aim.be/databanken

▪ Unannounced o Inspections for the purpose of allocating hospital beds: ▪ Announced	
Patient safety contracts / Pay-for-performance	
- Voluntary - A first contract was introduced in 2007 and asked for a yearly commitment between 2007 and 2012. The contract was built on three pillars: patient safety management system, transmural care and indicators. - A second contract for the period 2013-2017 focused on four general themes (safety management, leadership, communication, patient and family empowerment) and four specific themes (high-risk medication, safe surgery, transmural care, restrictive measures in psychiatric care). The criteria were determined based on international accreditation requirements to further support hospitals opting for an accreditation trajectory. - Hospitals entering the contract received a predominantly fixed budget after meeting the terms of the contract. - From 2008, the patient safety contract initiative was dismantled for acute-care hospitals and changed into a Pay-for-Performance initiative. Herein, hospitals are rewarded when they have demonstrated to have provided qualitative care. A variable budget, totaling to about 5 million on a total budget of 6.4 billion euros (Federal Public Service Health. Pay for performance-programma 2018 voor algemene ziekenhuizen. 2018) is rewarded depending on the indicators met. Indicators include hospital-wide structure and process indicators (e.g. accreditation achieved, patient experiences) as well as disease-specific process indicators (e.g. antibiotics prophylaxis).	The Federal Public Service for Health (federal government) provided the following information: - Participating hospitals per year to the patient safety contracts between 2008 and 2017 - Participating hospitals per year to the pay-for-performance programme between 2018 and 2019.

A.2.2 Statements surveyed to focus group

Question number	Statements asked to focus group	Related quality improvement initiative within hospital policy
A1	Every hospital should undergo a minimum of two external hospital accreditation cycles.	Accreditation
A2	Accreditation trajectories bring about a positive dynamic concerning the 'hospital quality' mindset.	Accreditation
A3	Accreditation trajectories are responsible for a decrease in time for patient care.	Accreditation
A4	Accreditation trajectories are responsible for an increase in quality and middle management staff.	Accreditation
A5	Discussions and actions on quality policy by hospital board members are triggered by accreditation trajectories.	Accreditation
PR1	Public reporting has led to doctors selecting healthier patients.	Public reporting
PR2	Data on mortality and readmission rates on a hospital-level should be made publicly available.	Public reporting
PR3	Data on mortality and readmission rates on an individual physician's level should be made publicly available.	Public reporting
PR4	Data on patient outcomes such as complications and quality-of-life on a hospital-level should be made publicly available.	Public reporting
PR5	Data on patient outcomes such as complications and quality-of-life on an individual physician's level should be made publicly available.	Public reporting
I1	Quality control of hospitals should involve unannounced quality checks.	Inspection
I2	Quality control of hospitals should involve mystery patients to assess care quality.	Inspection
I3	To assess quality of care, it is better to evaluate care programs and care trajectories than to evaluate hospital-wide quality.	Inspection
I4	Every hospital should meet a set of minimum requirements for qualitative hospital care (i.e. 'the vital few'), which are evidence-based and determined by both government and the care sector.	Inspection
I5	Should a hospital achieve good quality outcomes, the quality control of its processes and protocols will become less of a priority for the inspection body.	Inspection
PP1	Hospitals with good quality outcomes should be rewarded financially.	Pay-for-performance
PP2	Physicians with good quality outcomes should be rewarded financially.	Pay-for-performance

A.3 Additional material to Chapter 4

A.3.1 Trends in patient experience scores across Flemish acute-care hospitals (n=44)

		2014		2015		2016		2017		2018		2019	
Dimension of patient experience (Question)[1]	**Linear trend β[2] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**	**Top-box score (%)**	**β[3] (95% CI)**
Preparing for hospital stay	0.57	76	0	75	-1.19	76	-0.13	77	1.24	77	0.65	78	2.46
	(0.31; 0.82)**		/		(-2.67; 0.29)		(-1.61; 1.35)		(-0.25; 2.73)		(-0.85; 2.15)		(0.94; 3.97)**
Information about condition	0.50	51	0	50	-0.40	51	-0.15	51	0.32	52	1.06	53	2.45
	(0.28; 0.71)**		/		(-1.66; 0.86)		(-1.41; 1.11)		(-0.95; 1.59)		(-0.21; 2.34)		(1.16; 3.74)**
Information about treatment and procedures	0.29	54	0	52	-2.29	52	-2.78	53	-1.64	54	-0.35	55	0.41
	(0.06; 0.52)*		/		(-3.54; -1.03)**		(-4.03; -1.52)**		(-2.90; -0.37)*		(-1.62; 0.93)		(-0.87; 1.70)
Dealing with patients and collaboration between healthcare providers	0.30	76	0	76	0.06	76	-0.17	77	0.42	77	1.14	78	1.30
	(0.13; 0.47)**		/		(-0.96; 1.09)		(-1.19; 0.86)		(-0.61; 1.45)		(0.10; 2.18)*		(0.25; 2.35)*
Privacy	0.46	80	0	80	-0.08	81	0.56	81	1.09	82	1.78	82	1.94
	(0.26; 0.65)**		/		(-1.24; 1.08)		(-0.60; 1.72)		(-0.08; 2.25)		(0.60; 2.95)**		(0.75; 3.12)**
Safe care	2.65	52	0	53	0.57	56	4.06	61	8.65	62	10.16	64	11.69
	(2.37; 2.94)**		/		(-1.05; 2.18)		(2.44; 5.67)**		(7.02; 10.27)**		(8.52; 11.80)**		(10.03; 13.34)**
Pain management	0.60	75	0	74	-1.33	75	-0.07	76	1.08	77	1.52	77	2.07
	(0.39; 0.80)**		/		(-2.52; -0.13)*		(-1.26; 1.12)		(-0.12; 2.28)		(0.31; 2.72)*		(0.85; 3.29)**
Discharge	-0.09	89	0	88	-0.69	88	-1.16	88	-0.92	88	-0.82	88	-0.63
	(-0.18; 0.01)		/		(-1.23; -0.14)*		(-1.70; -0.62)**		(-1.47; -0.37)**		(-1.37; -0.27)**		(-1.19; -0.08)*
Global (Rating the Hospital)	1.10	56	0	56	0.00	57	1.15	58	2.30	60	3.65	61	5.19
	(0.80; 1.40)**		/		(-1.77; 1.78)		(-0.63; 2.93)		(0.51; 4.09)*		(1.84; 5.45)**		(3.36; 7.01)**
Global (Recommending the hospital)	0.39	67	0	68	0.97	68	0.64	69	1.38	69	1.71	70	2.19

	(0.15; 0.63)**	/	(-0.47; 2.41)	(-0.80; 2.08)	(-0.07; 2.82)	(0.25; 3.17)*	(0.72; 3.66)**

(1) For each dimension, the modelled outcome is the average of the top-box score percentages for all questions within that dimension, except for the two questions of the dimension global which are modelled separately. Questions and dimensions of the Flemish Patient Survey (FPS) are copyright protected. For further information on the usage of the FPS: contact info@vlaamspatientenplatform.be

(2) Linear estimate (with 95% confidence interval), i.e. the yearly change in percentage top-box scores.

(3) Estimate (with 95% confidence interval) treating year as categorical variable, i.e. the change in percentage top-box scores for a given year, relative to the reference year (2014).

* Statistically significant at an alpha level of 0.05. ** Statistically significant at an alpha level of 0.01.

A.3.2 Associations between quality improvement strategies and average top-box scores of the 8 patient experience dimensions in 2019

Surveyed quality improvement strategy	Dimension of patient experience[1]	β[2]	(95% CI)
FPS feedback to clinicians	Preparing for hospital stay	-2.32	(-6.96; 2.31)
	Information about condition	-2.87	(-7.77; 2.04)
	Information about treatment and procedures	-2.95	(-6.44; 0.54)
	Dealing with patients and collaboration	-1.79	(-5.35; 1.77)
	Privacy	0.06	(-3.75; 3.87)
	Safe care	-1.38	(-6.90; 4.14)
	Pain management	-3.80	(-8.18; 0.58)
	Discharge	-1.81	(-3.53; -0.08)*
Nursing ward interventions	Preparing for hospital stay	-0.89	(-5.22; 3.45)
	Information about condition	4.73	(0.36; 9.10)*
	Information about treatment and procedures	2.10	(-1.18; 5.38)
	Dealing with patients and collaboration	4.27	(1.22; 7.32)**
	Privacy	4.70	(1.50; 7.90)**
	Safe care	3.10	(-1.93; 8.13)
	Pain management	2.39	(-1.76; 6.53)
	Discharge	0.38	(-1.30; 2.06)
Hospital wide intervention	Preparing for hospital stay	1.37	(-2.95; 5.70)
	Information about condition	2.72	(-1.82; 7.26)
	Information about treatment and procedures	1.44	(-1.88; 4.76)
	Dealing with patients and collaboration	3.55	(0.41; 6.70)*
	Privacy	3.90	(0.60; 7.21)*
	Safe care	3.60	(-1.40; 8.60)
	Pain management	0.98	(-3.23; 5.18)
	Discharge	0.19	(-1.49; 1.87)
Board sets strategy	Preparing for hospital stay	-0.84	(-4.71; 3.03)
	Information about condition	1.49	(-2.61; 5.58)
	Information about treatment and procedures	1.11	(-1.86; 4.08)
	Dealing with patients and collaboration	1.08	(-1.88; 4.04)
	Privacy	2.03	(-1.05; 5.12)
	Safe care	2.96	(-1.52; 7.44)
	Pain management	-1.58	(-5.30; 2.15)
	Discharge	0.36	(-1.14; 1.86)
FPS targets	Preparing for hospital stay	0.75	(-2.63; 4.13)
	Information about condition	-1.41	(-4.98; 2.17)
	Information about treatment and procedures	-1.45	(-4.02; 1.12)
	Dealing with patients and collaboration	-0.27	(-2.87; 2.33)
	Privacy	0.08	(-2.67; 2.84)
	Safe care	2.20	(-1.74; 6.13)
	Pain management	-1.27	(-4.53; 1.98)
	Discharge	-0.84	(-2.12; 0.44)
Hospital wide education	Preparing for hospital stay	-0.09	(-3.26; 3.08)
	Information about condition	3.02	(-0.21; 6.25)
	Information about treatment and procedures	1.61	(-0.78; 4.00)
	Dealing with patients and collaboration	2.29	(-0.03; 4.61)

	Privacy	2.27 (-0.20; 4.74)
	Safe care	1.54 (-2.17; 5.25)
	Pain management	1.86 (-1.15; 4.87)
	Discharge	0.37 (-0.85; 1.59)
Discharge info on admission	Preparing for hospital stay	-1.12 (-4.27; 2.03)
	Information about condition	2.77 (-0.48; 6.02)
	Information about treatment and procedures	2.12 (-0.23; 4.47)
	Dealing with patients and collaboration	0.53 (-1.90; 2.96)
	Privacy	-0.27 (-2.84; 2.30)
	Safe care	0.14 (-3.59; 3.88)
	Pain management	0.16 (-2.91; 3.23)
	Discharge	0.23 (-0.99; 1.45)
Nursing rounds	Preparing for hospital stay	-1.03 (-4.12; 2.06)
	Information about condition	0.02 (-3.28; 3.33)
	Information about treatment and procedures	-0.88 (-3.26; 1.50)
	Dealing with patients and collaboration	-0.22 (-2.60; 2.17)
	Privacy	1.22 (-1.28; 3.71)
	Safe care	1.65 (-1.98; 5.28)
	Pain management	-0.27 (-3.28; 2.74)
	Discharge	-0.52 (-1.71; 0.67)
HR policy	Preparing for hospital stay	-1.15 (-4.23; 1.94)
	Information about condition	-0.43 (-3.72; 2.87)
	Information about treatment and procedures	-0.93 (-3.31; 1.44)
	Dealing with patients and collaboration	0.06 (-2.33; 2.44)
	Privacy	-0.20 (-2.72; 2.32)
	Safe care	1.29 (-2.35; 4.93)
	Pain management	1.80 (-1.16; 4.75)
	Discharge	0.34 (-0.85; 1.54)
Proactive discharge calls	Preparing for hospital stay	1.48 (-1.63; 4.58)
	Information about condition	3.51 (0.37; 6.66)*
	Information about treatment and procedures	1.60 (-0.76; 3.97)
	Dealing with patients and collaboration	1.56 (-0.80; 3.92)
	Privacy	1.09 (-1.43; 3.62)
	Safe care	3.25 (-0.31; 6.80)
	Pain management	-0.41 (-3.45; 2.63)
	Discharge	-0.37 (-1.58; 0.84)
Bedside briefing	Preparing for hospital stay	-0.74 (-3.90; 2.42)
	Information about condition	1.13 (-2.22; 4.48)
	Information about treatment and procedures	0.01 (-2.44; 2.45)
	Dealing with patients and collaboration	-0.94 (-3.35; 1.48)
	Privacy	-0.58 (-3.14; 1.99)
	Safe care	1.94 (-1.75; 5.63)
	Pain management	-0.81 (-3.86; 2.25)
	Discharge	-0.76 (-1.96; 0.44)
Social media follow-up	Preparing for hospital stay	1.34 (-2.22; 4.90)
	Information about condition	-2.24 (-5.99; 1.50)
	Information about treatment and procedures	-1.51 (-4.23; 1.21)
	Dealing with patients and collaboration	0.70 (-2.05; 3.44)
	Privacy	-1.46 (-4.33; 1.41)
	Safe care	-2.74 (-6.88; 1.40)
	Pain management	1.43 (-2.01; 4.87)
	Discharge	0.10 (-1.28; 1.49)
	Preparing for hospital stay	-1.06 (-4.52; 2.40)

	Information about condition	-0.60 (-4.29; 3.09)
	Information about treatment and procedures	-0.95 (-3.62; 1.71)
	Dealing with patients and collaboration	-0.59 (-3.26; 2.07)
	Privacy	0.43 (-2.38; 3.25)
	Safe care	-0.16 (-4.26; 3.95)
	Pain management	-2.13 (-5.43; 1.17)
FPS nursing ward rewards	Discharge	-0.45 (-1.79; 0.89)
Multidisciplinary discharge	Preparing for hospital stay	1.58 (-2.27; 5.43)
	Information about condition	0.97 (-3.14; 5.09)
	Information about treatment and procedures	0.98 (-2.00; 3.95)
	Dealing with patients and collaboration	0.75 (-2.22; 3.72)
	Privacy	-0.51 (-3.65; 2.64)
	Safe care	-2.57 (-7.07; 1.94)
	Pain management	0.80 (-2.95; 4.55)
	Discharge	0.97 (-0.50; 2.44)
External consultants	Preparing for hospital stay	-6.20 (-11.76; -
	Information about condition	3.30 (-2.88; 9.48)
	Information about treatment and procedures	0.92 (-3.61; 5.45)
	Dealing with patients and collaboration	-1.41 (-5.91; 3.10)
	Privacy	1.54 (-3.22; 6.30)
	Safe care	6.38 (-0.27; 13.04)
	Pain management	-4.71 (-10.22; 0.80)
	Discharge	-2.78 (-4.88; -0.67)*

(1) Questions and dimensions of the Flemish Patient Survey (FPS) are copyright protected. For further information on the usage of the FPS: contact info@vlaamspatientenplatform.be

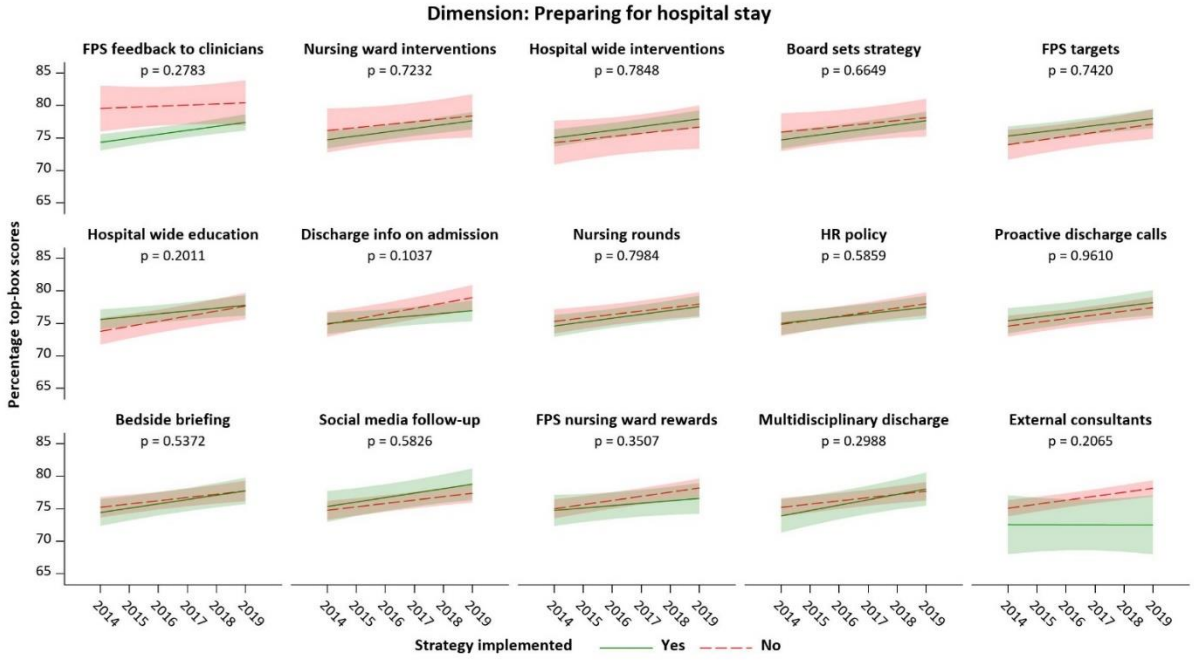
(2) The difference (with 95% confidence interval) in percentage top-box scores between hospitals with and without the improvement strategy.

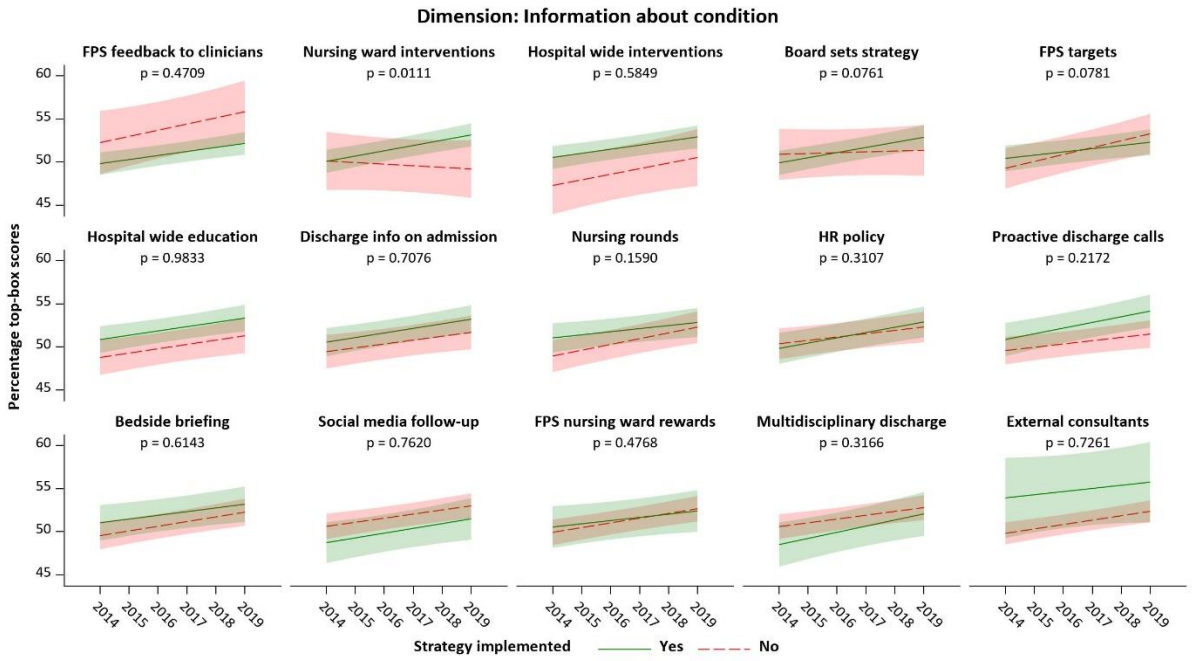
* Statistically significant at an alpha level of 0.05. ** Statistically significant at an alpha level of 0.01.

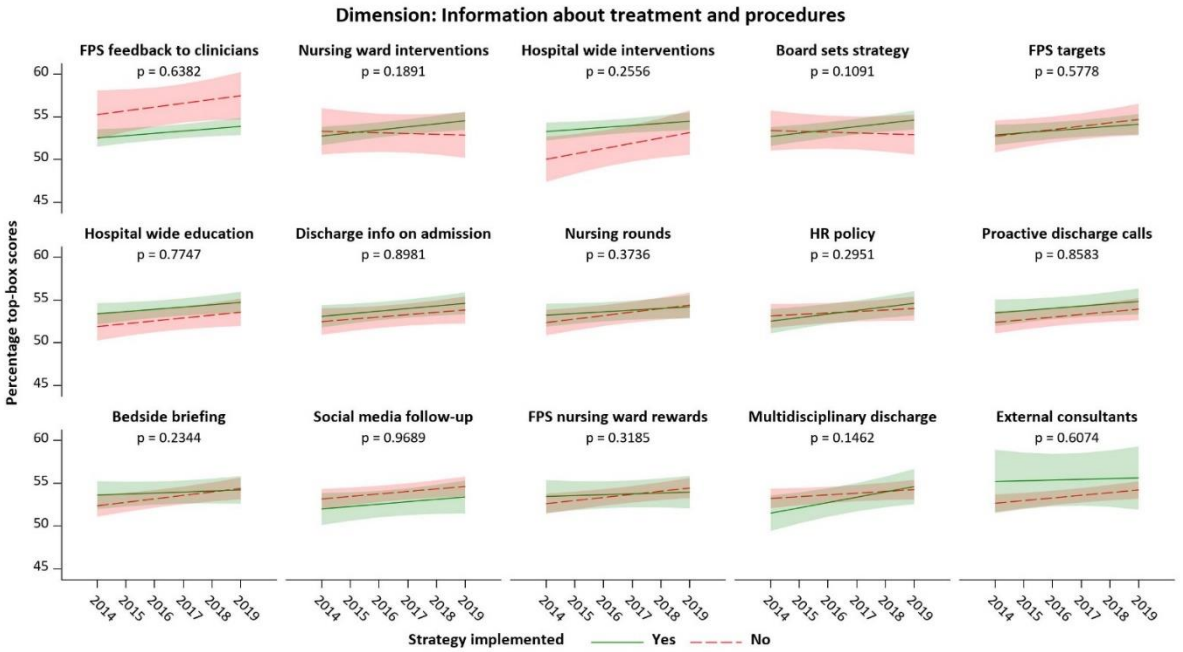
None of the estimates were significant after Bonferroni correction.

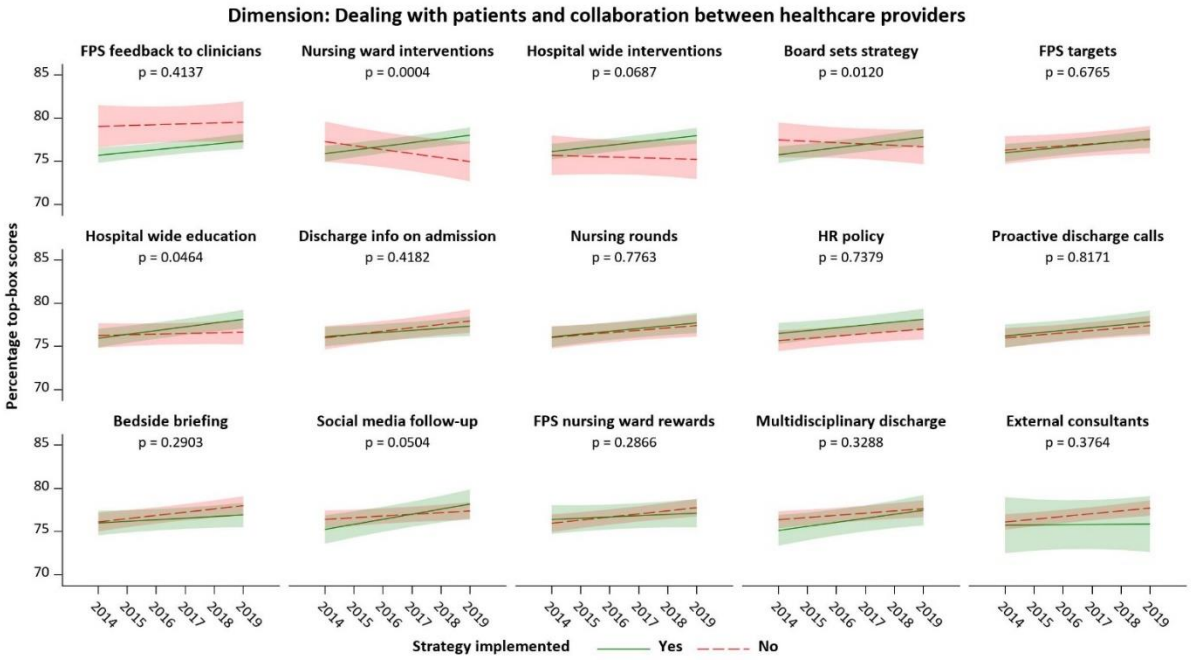
A.3.3 Associations between quality improvement strategies and time trends in average top-box scores of the 8 patient experience dimensions.

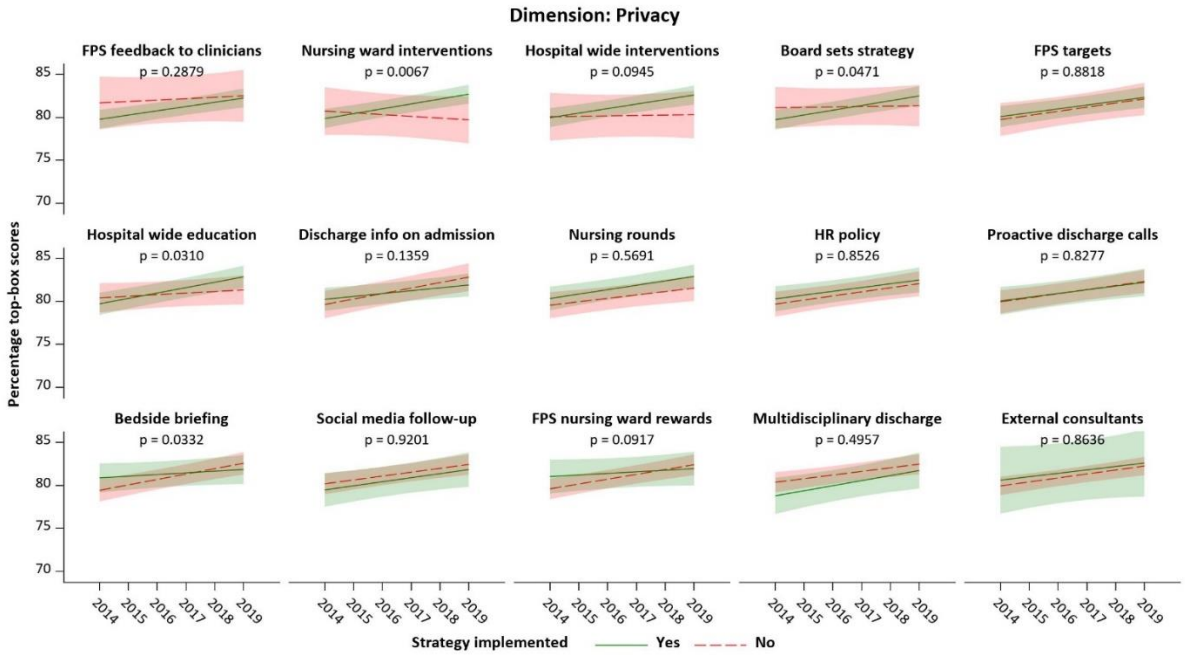
The plotted time trends are the predictions from multilevel regression models containing a binary indicator for strategy implementation, a linear variable for year, and an interaction between these variables. The p-value represents the significance of the interaction term and indicates whether time trends are significantly different between hospitals with and without a given strategy.

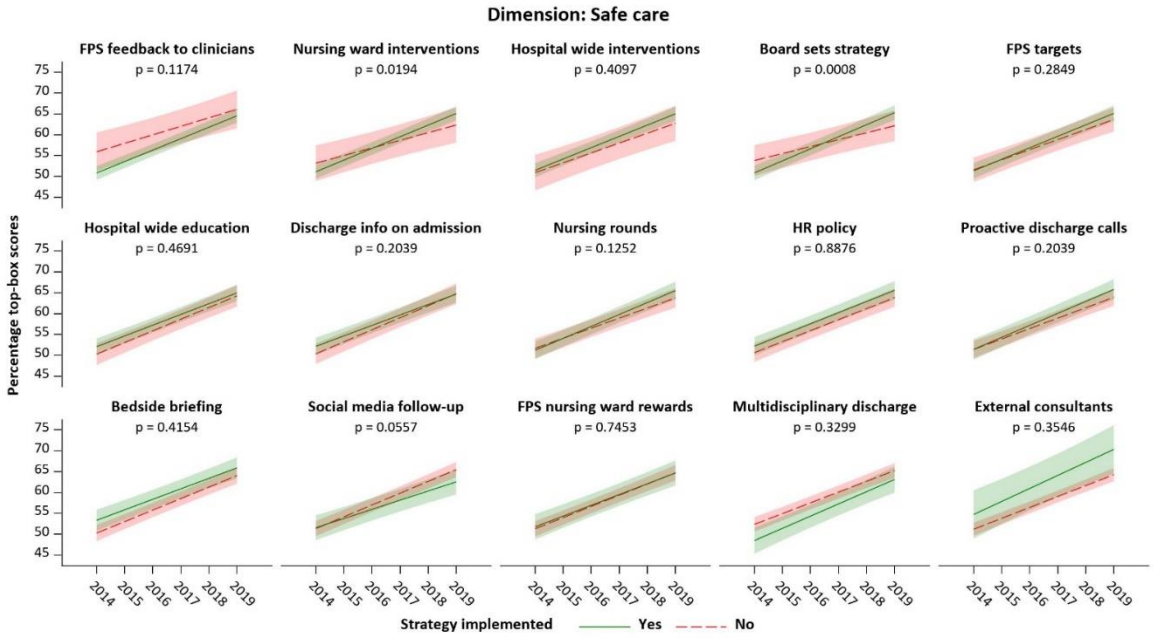


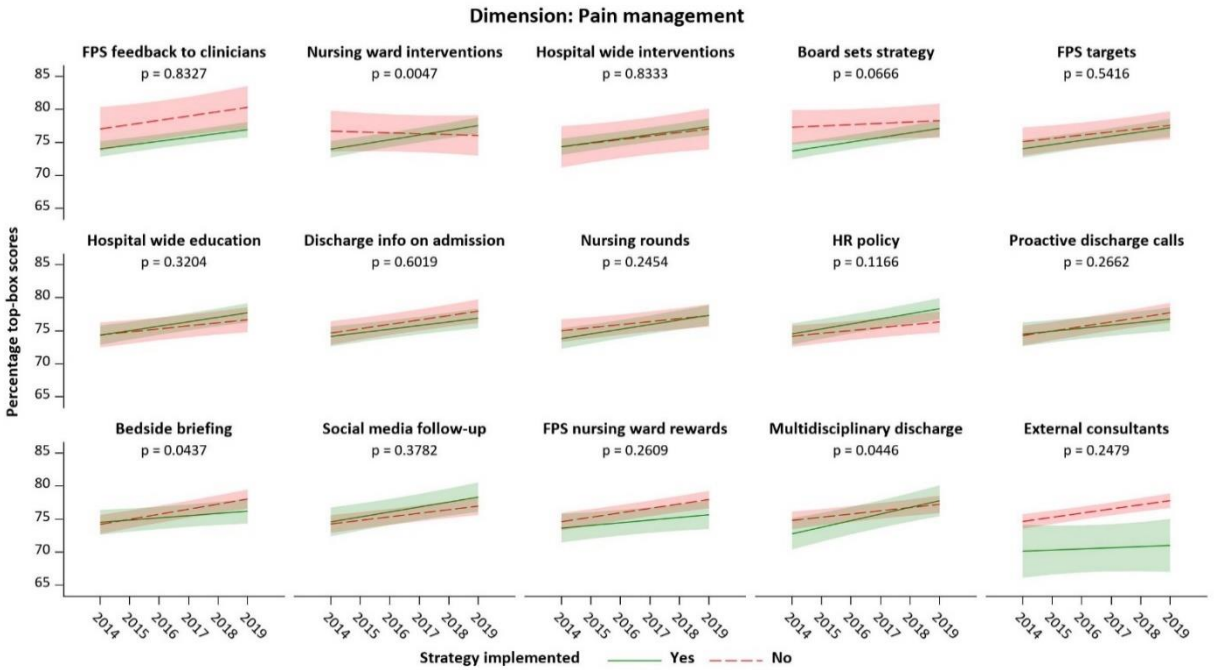


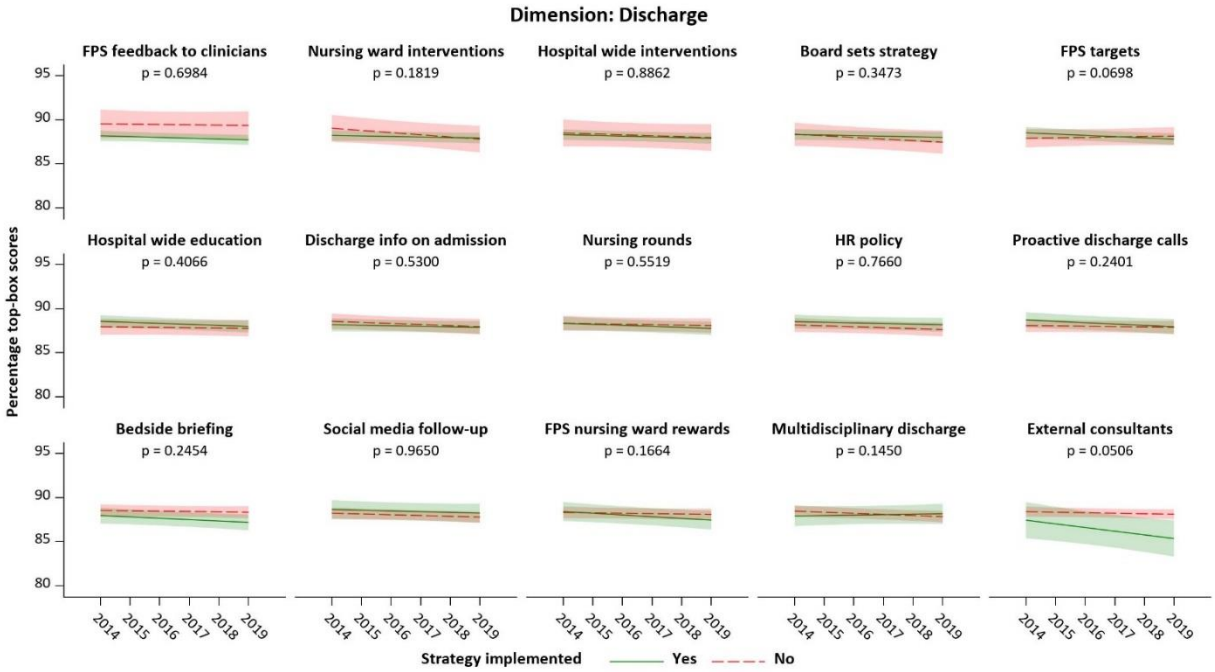

Dimension: Information about treatment and procedures
FPS feedback to clinicians
p = 0.6382
Nursing ward interventions
p = 0.1891
Hospital wide interventions
p = 0.2556
Board sets strategy
p = 0.1091
FPS targets
p = 0.5778
Hospital wide education
p = 0.7747
Discharge info on admission
p = 0.8981
Nursing rounds
p = 0.3736
HR policy
p = 0.2951
Proactive discharge calls
p = 0.8583
Bedside briefing
p = 0.2344
Social media follow-up
p = 0.9689
FPS nursing ward rewards
p = 0.3185
Multidisciplinary discharge
p = 0.1462
External consultants
p = 0.6074
Percentage top-box scores
60
55
50
45
2014
2015
2016
2017
2018
2019
Strategy implemented
Yes
No


Dimension: Dealing with patients and collaboration between healthcare providers
FPS feedback to clinicians
p = 0.4137
Nursing ward interventions
p = 0.0004
Hospital wide interventions
p = 0.0687
Board sets strategy
p = 0.0120
FPS targets
p = 0.6765
Hospital wide education
p = 0.0464
Discharge info on admission
p = 0.4182
Nursing rounds
p = 0.7763
HR policy
p = 0.7379
Proactive discharge calls
p = 0.8171
Bedside briefing
p = 0.2903
Social media follow-up
p = 0.0504
FPS nursing ward rewards
p = 0.2866
Multidisciplinary discharge
p = 0.3288
External consultants
p = 0.3764
Percentage top-box scores
85
80
75
70
2014
2015
2016
2017
2018
2019
Strategy implemented
Yes
No


Dimension: Privacy
FPS feedback to clinicians
p = 0.2879
Nursing ward interventions
p = 0.0067
Hospital wide interventions
p = 0.0945
Board sets strategy
p = 0.0471
FPS targets
p = 0.8818
Hospital wide education
p = 0.0310
Discharge info on admission
p = 0.1359
Nursing rounds
p = 0.5691
HR policy
p = 0.8526
Proactive discharge calls
p = 0.8277
Bedside briefing
p = 0.0332
Social media follow-up
p = 0.9201
FPS nursing ward rewards
p = 0.0917
Multidisciplinary discharge
p = 0.4957
External consultants
p = 0.8636
Percentage top-box scores
Strategy implemented
Yes
No


Dimension: Safe care
FPS feedback to clinicians
p = 0.1174
Nursing ward interventions
p = 0.0194
Hospital wide interventions
p = 0.4097
Board sets strategy
p = 0.0008
FPS targets
p = 0.2849
Hospital wide education
p = 0.4691
Discharge info on admission
p = 0.2039
Nursing rounds
p = 0.1252
HR policy
p = 0.8876
Proactive discharge calls
p = 0.2039
Bedside briefing
p = 0.4154
Social media follow-up
p = 0.0557
FPS nursing ward rewards
p = 0.7453
Multidisciplinary discharge
p = 0.3299
External consultants
p = 0.3546
Percentage top-box scores
Strategy implemented
Yes
No


Dimension: Pain management
FPS feedback to clinicians
p = 0.8327
Nursing ward interventions
p = 0.0047
Hospital wide interventions
p = 0.8333
Board sets strategy
p = 0.0666
FPS targets
p = 0.5416
Hospital wide education
p = 0.3204
Discharge info on admission
p = 0.6019
Nursing rounds
p = 0.2454
HR policy
p = 0.1166
Proactive discharge calls
p = 0.2662
Bedside briefing
p = 0.0437
Social media follow-up
p = 0.3782
FPS nursing ward rewards
p = 0.2609
Multidisciplinary discharge
p = 0.0446
External consultants
p = 0.2479
Percentage top-box scores
Strategy implemented
Yes
No


Dimension: Discharge
FPS feedback to clinicians
p = 0.6984
Nursing ward interventions
p = 0.1819
Hospital wide interventions
p = 0.8862
Board sets strategy
p = 0.3473
FPS targets
p = 0.0698
Hospital wide education
p = 0.4066
Discharge info on admission
p = 0.5300
Nursing rounds
p = 0.5519
HR policy
p = 0.7660
Proactive discharge calls
p = 0.2401
Bedside briefing
p = 0.2454
Social media follow-up
p = 0.9650
FPS nursing ward rewards
p = 0.1664
Multidisciplinary discharge
p = 0.1450
External consultants
p = 0.0506
Percentage top-box scores
Strategy implemented
Yes
No

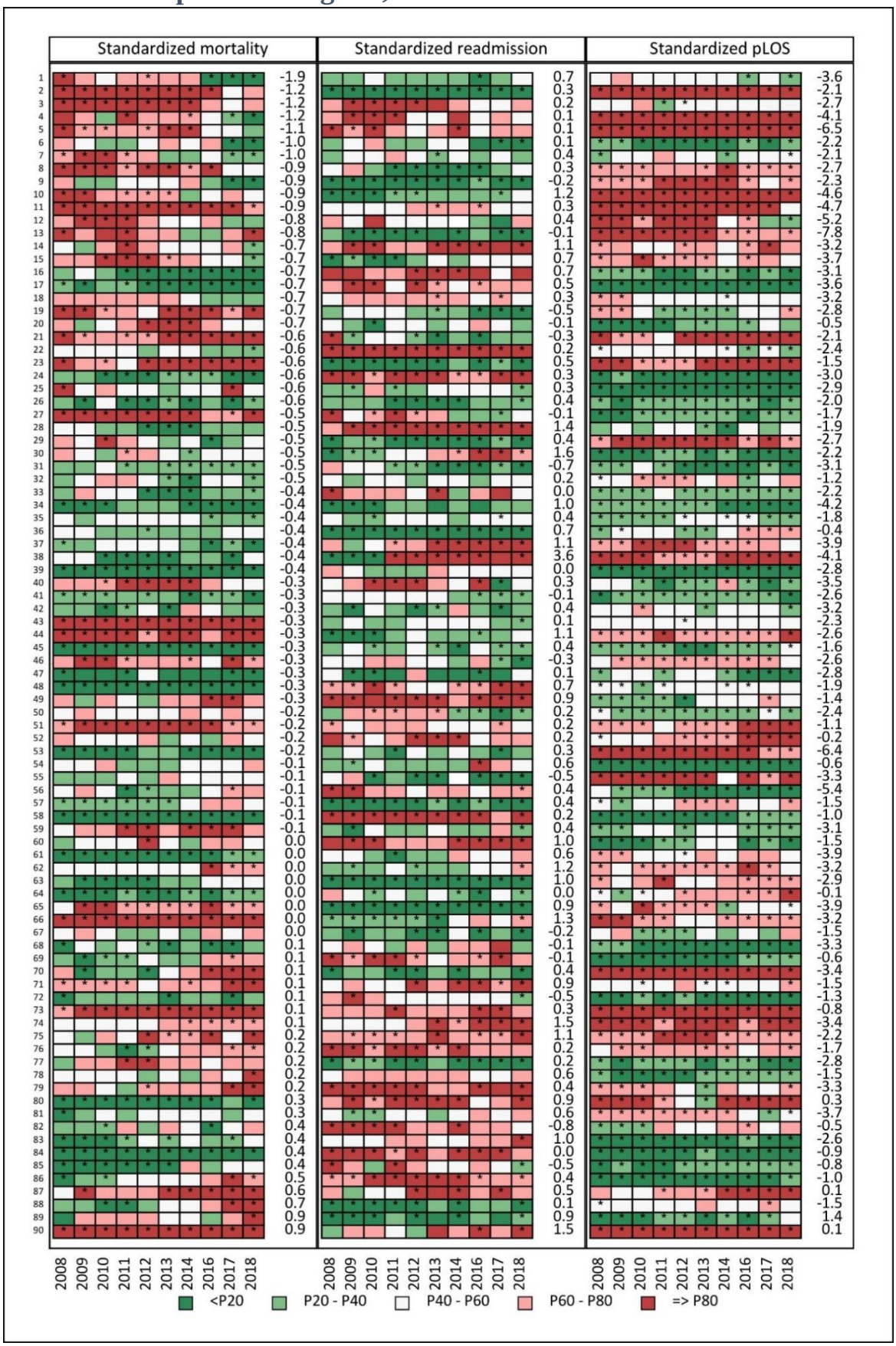
A.3.4 Patient characteristics and outcomes (N (%) or Mean (SD))

Characteristic / outcome		2008	2009	2010	2011	2012	2013	2014	2016	2017	2018
All admissions		**1319661**	**1332360**	**1342179**	**1354949**	**1369765**	**1367037**	**1358062**	**1402320**	**1403741**	**1410113**
Sex	Male	650111	658288	660533	668075	677376	678167	670525	695780	697725	699271
		(49.3)	(49.4)	(49.2)	(49.3)	(49.5)	(49.6)	(49.4)	(49.6)	(49.7)	(49.6)
Age	<10 years	67408	68429	65140	66778	66580	66231	63502	67972	65106	67251
		(5.1)	(5.1)	(4.9)	(4.9)	(4.9)	(4.8)	(4.7)	(4.8)	(4.6)	(4.8)
	10-19 years	49013	49663	48614	47680	46133	45621	45709	47016	47036	46835
		(3.7)	(3.7)	(3.6)	(3.5)	(3.4)	(3.3)	(3.4)	(3.4)	(3.4)	(3.3)
	20-29 years	67938	68442	68772	69000	69607	68737	67527	68630	67584	67814
		(5.1)	(5.1)	(5.1)	(5.1)	(5.1)	(5.0)	(5.0)	(4.9)	(4.8)	(4.8)
	30-39 years	96770	96758	96685	95890	95688	94693	92816	94930	92872	92990
		(7.3)	(7.3)	(7.2)	(7.1)	(7.0)	(6.9)	(6.8)	(6.8)	(6.6)	(6.6)
	40-49 years	150860	151317	150566	150940	150567	148693	145214	143013	140075	138232
		(11.4)	(11.4)	(11.2)	(11.1)	(11.0)	(10.9)	(10.7)	(10.2)	(10.0)	(9.8)
	50-59 years	196927	200153	204301	207167	209058	208525	208371	213228	211351	209281
		(14.9)	(15.0)	(15.2)	(15.3)	(15.3)	(15.3)	(15.3)	(15.2)	(15.1)	(14.8)
	60-69 years	213872	218347	223795	231645	239914	242503	245039	253331	255316	255600
		(16.2)	(16.4)	(16.7)	(17.1)	(17.5)	(17.7)	(18.0)	(18.1)	(18.2)	(18.1)
	70-79 years	258681	256999	252608	247306	242501	239848	238889	250850	255065	258323
		(19.6)	(19.3)	(18.8)	(18.3)	(17.7)	(17.5)	(17.6)	(17.9)	(18.2)	(18.3)
	80-89 years	190226	193593	198861	202169	208325	208089	205589	211767	214836	217289
		(14.4)	(14.5)	(14.8)	(14.9)	(15.2)	(15.2)	(15.1)	(15.1)	(15.3)	(15.4)
	=>90 years	27966	28659	32837	36374	41392	44097	45406	51583	54500	56498
		(2.1)	(2.2)	(2.4)	(2.7)	(3.0)	(3.2)	(3.3)	(3.7)	(3.9)	(4.0)
Comorbidity index		2,3	2,3	2,4	2,4	2,5	2,7	2,8	3,3	3,4	3,7
		(6.2)	(6.3)	(6.5)	(6.6)	(6.8)	(7.1)	(7.4)	(7.7)	(8.0)	(8.2)
Admission source	Home	1185204	1200343	1205637	1218384	1232942	1230868	1227937	1269438	1270467	1277033
		(89.8)	(90.1)	(89.8)	(89.9)	(90.0)	(90.0)	(90.4)	(90.5)	(90.5)	(90.6)
	Other hospital	41558	39254	39450	38081	37796	37459	35968	35718	35873	34694
		(3.1)	(2.9)	(2.9)	(2.8)	(2.8)	(2.7)	(2.6)	(2.5)	(2.6)	(2.5)
	Nursing home	42281	41186	42004	42028	44347	44747	44612	46868	48635	48548
		(3.2)	(3.1)	(3.1)	(3.1)	(3.2)	(3.3)	(3.3)	(3.3)	(3.5)	(3.4)
	Public space	36763	36014	36446	36444	34439	34651	34254	35514	35442	34994
		(2.8)	(2.7)	(2.7)	(2.7)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)	(2.5)
	Unknown or other	13855	15563	18642	20012	20241	19312	15291	14782	13324	14844
		(1.0)	(1.2)	(1.4)	(1.5)	(1.5)	(1.4)	(1.1)	(1.1)	(0.9)	(1.1)
Admission type	Elective	700218	708532	719629	724741	726510	718179	720896	737200	736206	735160
		(53.1)	(53.2)	(53.6)	(53.5)	(53.0)	(52.5)	(53.1)	(52.6)	(52.4)	(52.1)
	Emergency	606388	610542	607036	617139	630798	636965	626673	656433	659573	667176

		(46.0)	(45.8)	(45.2)	(45.5)	(46.1)	(46.6)	(46.1)	(46.8)	(47.0)	(47.3)
	Other	13055	13286	15514	13069	12457	11893	10493	8687	7962	7777
		(1.0)	(1.0)	(1.2)	(1.0)	(0.9)	(0.9)	(0.8)	(0.6)	(0.6)	(0.6)
Major Diagnostic Category (MDC)	1: Nervous System	102764	107698	109109	110083	109830	111684	110839	118903	117225	117162
		(7.8)	(8.1)	(8.1)	(8.1)	(8.0)	(8.2)	(8.2)	(8.5)	(8.4)	(8.3)
	2: Eye	16115	15661	15424	15639	15335	14969	14167	14413	14103	13565
		(1.2)	(1.2)	(1.1)	(1.2)	(1.1)	(1.1)	(1.0)	(1.0)	(1.0)	(1.0)
	3: Ear, Nose, Mouth, and Throat	83694	85450	85359	87916	93289	95330	95836	108626	109579	115057
		(6.3)	(6.4)	(6.4)	(6.5)	(6.8)	(7.0)	(7.1)	(7.7)	(7.8)	(8.2)
	4: Respiratory System	114192	117741	115194	119018	123695	121400	116994	120564	121480	124001
		(8.7)	(8.8)	(8.6)	(8.8)	(9.0)	(8.9)	(8.6)	(8.6)	(8.7)	(8.8)
	5: Circulatory System	191821	191961	191669	189956	191442	189652	186374	190496	191208	188889
		(14.5)	(14.4)	(14.3)	(14.0)	(14.0)	(13.9)	(13.7)	(13.6)	(13.6)	(13.4)
	6: Digestive System	165730	162747	162652	163023	164103	163886	162770	165269	166287	163487
		(12.6)	(12.2)	(12.1)	(12.0)	(12.0)	(12.0)	(12.0)	(11.8)	(11.8)	(11.6)
	7: Hepatobiliary System and Pancreas	47265	47464	48308	49658	50747	51469	51251	52481	52831	53116
		(3.6)	(3.6)	(3.6)	(3.7)	(3.7)	(3.8)	(3.8)	(3.7)	(3.8)	(3.8)
	8: Musculoskeletal System and Connective Tissue	229100	231301	236367	234927	233241	231909	231603	234184	235124	233710
		(17.4)	(17.4)	(17.6)	(17.3)	(17.0)	(17.0)	(17.1)	(16.7)	(16.7)	(16.6)
	9: Skin, Subcutaneous Tissue, and Breast	57888	57837	57530	58800	58149	58088	58024	57387	56448	57272
		(4.4)	(4.3)	(4.3)	(4.3)	(4.2)	(4.2)	(4.3)	(4.1)	(4.0)	(4.1)
	10: Endocrine, Nutritional, and Metabolic System	42513	44020	44822	45951	46838	46757	46576	48827	47604	48686
		(3.2)	(3.3)	(3.3)	(3.4)	(3.4)	(3.4)	(3.4)	(3.5)	(3.4)	(3.5)
	11: Kidney and Urinary Tract	65930	68009	68955	70854	70976	71398	71726	75203	74830	77922
		(5.0)	(5.1)	(5.1)	(5.2)	(5.2)	(5.2)	(5.3)	(5.4)	(5.3)	(5.5)
	12: Male Reproductive System	22871	22171	22060	21896	21350	20621	20218	21157	21855	22083
		(1.7)	(1.7)	(1.6)	(1.6)	(1.6)	(1.5)	(1.5)	(1.5)	(1.6)	(1.6)
	13: Female Reproductive System	41356	39752	38730	38520	37439	35666	34867	30761	30038	29345
		(3.1)	(3.0)	(2.9)	(2.8)	(2.7)	(2.6)	(2.6)	(2.2)	(2.1)	(2.1)
	16: Blood and Blood Forming Organs and Immunological Disorders	15255	14886	14826	15067	15078	15186	14695	15339	15108	15359
		(1.2)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)
	17: Myeloproliferative Diseases and Disorders (Poorly Differentiated Neoplasm)	37973	37793	39303	38300	37442	35500	35793	34089	33366	32317
		(2.9)	(2.8)	(2.9)	(2.8)	(2.7)	(2.6)	(2.6)	(2.4)	(2.4)	(2.3)
	18: Infectious and Parasitic Diseases and Disorders	20248	22382	22354	23251	24040	24986	25056	29156	30018	32392
		(1.5)	(1.7)	(1.7)	(1.7)	(1.8)	(1.8)	(1.8)	(2.1)	(2.1)	(2.3)
	19: Mental Diseases and Disorders	4874	2175	2017	1939	1910	1961	2230	3330	3319	3738
		(0.4)	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.3)
	20: Alcohol/Drug Use or Induced Mental Disorders	7	3	1	0	1	2	1	2	2	0
		(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

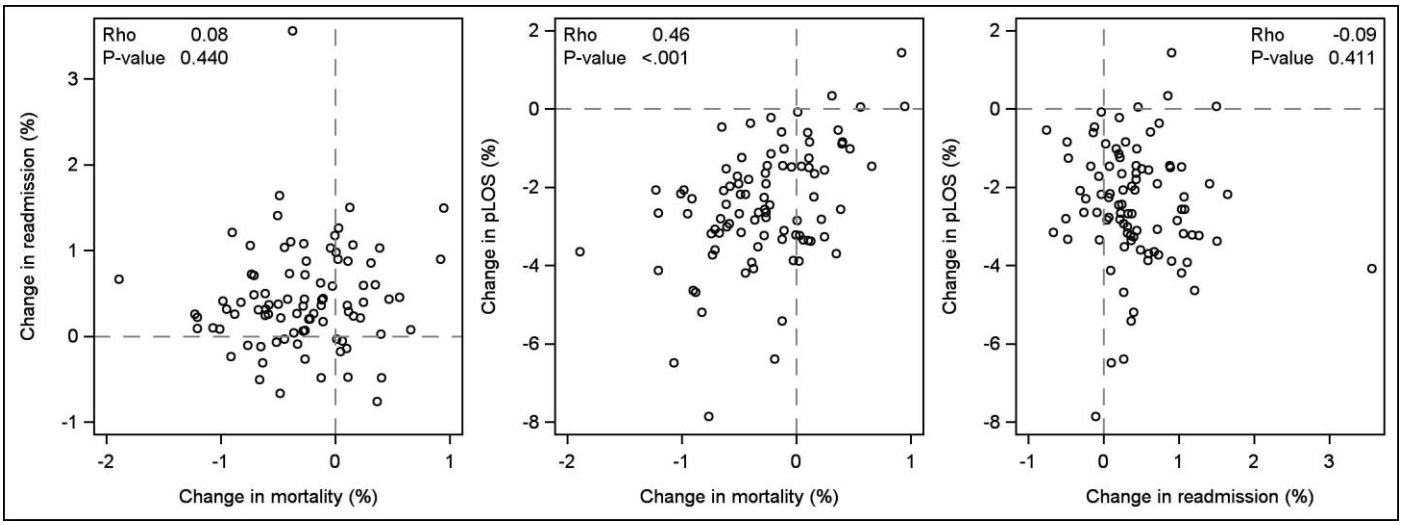
	21: Injuries, Poison, and Toxic Effect of Drugs	22358	22322	22527	22689	23207	23178	22420	22407	21678	22466
		(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.7)	(1.6)	(1.5)	(1.6)
	23: Factors Influencing Health Status	35408	38800	42786	45168	49433	51235	54450	56955	58960	56752
		(2.7)	(2.9)	(3.2)	(3.3)	(3.6)	(3.7)	(4.0)	(4.1)	(4.2)	(4.0)
	25: Multiple Significant Trauma	2299	2187	2186	2294	2220	2160	2172	2771	2678	2794
		(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
Medical/ surgical	Medical	771705	780592	784422	794638	809485	812501	805760	828439	827336	834363
		(58.5)	(58.6)	(58.4)	(58.6)	(59.1)	(59.4)	(59.3)	(59.1)	(58.9)	(59.2)
	Surgical	547956	551768	557757	560311	560280	554536	552302	573881	576405	575750
		(41.5)	(41.4)	(41.6)	(41.4)	(40.9)	(40.6)	(40.7)	(40.9)	(41.1)	(40.8)
In-hospital mortality		45049	45162	45481	45321	46454	46310	43509	43779	44431	44301
		(3.4)	(3.4)	(3.4)	(3.3)	(3.4)	(3.4)	(3.2)	(3.1)	(3.2)	(3.1)
Length-of-stay (days)		7,6	7,4	7,3	7,3	7,1	7,0	6,9	6,7	6,6	6,5
		(13.0)	(12.8)	(12.7)	(12.8)	(12.6)	(12.4)	(12.4)	(12.2)	(12.0)	(11.8)
Prolonged length-of-stay (upper decile)		138268	134600	132135	131608	128733	126261	119491	119069	115274	113631
		(10.5)	(10.1)	(9.8)	(9.7)	(9.4)	(9.2)	(8.8)	(8.5)	(8.2)	(8.1)
	Admissions at risk for readmission	**1126614**	**1137644**	**1143649**	**1156197**	**1176675**	**1173666**	**1166465**	**1204793**	**1208567**	**1218019**
30-day readmissions		54095	54091	55050	57192	59100	60536	60103	62623	63550	64274
		(4.8)	(4.8)	(4.8)	(4.9)	(5.0)	(5.2)	(5.2)	(5.2)	(5.3)	(5.3)

A.3.5 Standardised mortality, readmission, and prolonged length of stay rates for individual hospitals in Belgium, 2008-2018



Rates are categorised according to quintiles (calculated by year). The numbers at the right of each figure represent the change in standardised rates from 2008 to 2018. Hospitals are ordered by the change in standardised mortality. Standardised values significantly lower or higher than expected are indicated with a *.

A.3.6 Associations between trends in outcomes (calculated as the change in standardised rates between 2008 and 2018), with Pearson correlations (Rho) and significance (P-value)



A.3.7 Overview of APR-DRGs with pronounced between-hospital variation, as shown in Figure 4.7

					% of hospitals significantly deviating from the benchmark						% hospitals significantly deviating from the benchmark higher than the cut-off in at least one of both periods[a]		
					Mortality		Readmission		pLOS				
MDC	MDC Description	APR-DRG	APR-DRG Description	DRG Type[b]	2008-2009	2017-2018	2008-2009	2017-2018	2008-2009	2017-2018	Mortality	Readmission	pLOS
1	Diseases & disorders of the nervous system	41	Nervous system malignancy	M	**20,0**	**22,2**	1,1	1,1	14,4	7,8	X		
1	Diseases & disorders of the nervous system	42	Degenerative nervous system disorders except multiple sclerosis	M	12,2	13,5	**10,1**	**11,1**	**57,8**	**59,6**		X	X
1	Diseases & disorders of the nervous system	45	CVA & precerebral occlusion w infarct	M	17,8	11,1	6,7	5,6	**60,0**	**60,0**			X
1	Diseases & disorders of the nervous system	58	Other disorders of nervous system	M	4,4	5,6	7,8	2,2	16,7	**42,2**			X
3	Diseases & disorders of the ear, nose, mouth & throat	93	Sinus & mastoid procedures	S	2,2	0,0	1,1	2,2	**45,6**	25,0			X
3	Diseases & disorders of the ear, nose, mouth & throat	97	Tonsil & adenoid procedures	S	0,0	0,0	**13,3**	**13,3**	23,3	17,8		X	
3	Diseases & disorders of the ear, nose, mouth & throat	98	Other ear, nose, mouth & throat procedures	S	1,1	2,2	4,4	5,6	**42,2**	20,0			X
3	Diseases & disorders of the ear, nose, mouth & throat	115	Other ear, nose, mouth, throat & cranial/facial diagnoses	M	2,2	3,3	**12,2**	3,3	**54,4**	**61,1**		X	X
4	Diseases & disorders of the respiratory system	136	Respiratory malignancy	M	**33,3**	**30,0**	4,4	**11,1**	25,6	33,3	X	X	
4	Diseases & disorders of the respiratory system	139	Other pneumonia	M	**20,0**	15,6	7,8	**12,2**	37,8	36,7	X	X	
4	Diseases & disorders of the respiratory system	140	Chronic obstructive pulmonary disease	M	15,6	16,7	**15,6**	7,8	38,9	**55,6**		X	X
5	Diseases & disorders of the circulatory system	163	Cardiac valve procedures w/o ami or complex pdx	S	**22,2**	17,9	3,6	**18,5**	33,3	32,1	X	X	
5	Diseases & disorders of the circulatory system	166	Coronary bypass w/o ami or complex pdx	S	3,0	10,7	**14,3**	6,7	18,2	**42,9**		X	X
5	Diseases & disorders of the circulatory system	190	Acute myocardial infarction	M	**20,0**	14,4	2,2	2,2	12,2	18,9	X		
5	Diseases & disorders of the circulatory system	192	Cardiac catheterization for other non-coronary conditions	M	2,4	1,2	4,9	9,8	**45,2**	39,5			X

5	Diseases & disorders of the circulatory system	194	Heart failure	M	**26,7**	17,8	5,6	**13,3**	40,0	40,0	X	X		
6	Diseases & disorders of the digestive system	228	Inguinal, femoral & umbilical hernia procedures	S	2,2	0,0	3,3	**11,1**	**56,7**	24,4		X	X	
6	Diseases & disorders of the digestive system	240	Digestive malignancy	M	**25,6**	**35,6**	7,8	6,7	18,9	15,6	X			
6	Diseases & disorders of the digestive system	249	Other gastroenteritis, nausea & vomiting	M	3,3	4,4	8,9	**11,1**	13,3	22,2		X		
6	Diseases & disorders of the digestive system	254	Other digestive system diagnoses	M	5,6	4,4	7,8	**11,1**	16,7	24,4		X		
7	Diseases & disorders of the hepatobiliary system & pancreas	263	Laparoscopic cholecystectomy	S	0,0	4,4	4,4	**12,2**	37,8	32,2		X		
7	Diseases & disorders of the hepatobiliary system & pancreas	281	Malignancy of hepatobiliary system & pancreas	M	**21,1**	**28,9**	3,3	3,3	14,4	16,7	X			
8	Diseases & disorders of the musculoskeletal system & conn tissue	301	Hip joint replacement	S	6,7	7,8	10,0	6,7	**74,4**	**71,1**			X	
8	Diseases & disorders of the musculoskeletal system & conn tissue	302	Knee joint replacement	S	2,2	1,1	6,7	6,7	**66,7**	**75,6**			X	
8	Diseases & disorders of the musculoskeletal system & conn tissue	308	Hip & femur fracture repair	S	8,9	14,4	4,4	4,4	**56,7**	**57,8**			X	
8	Diseases & disorders of the musculoskeletal system & conn tissue	313	Knee & lower leg procedures except foot	S	2,2	1,1	3,3	**11,1**	40,0	38,9		X		
8	Diseases & disorders of the musculoskeletal system & conn tissue	315	Shoulder, upper arm & forearm procedures except joint replacement	S	2,2	1,1	5,6	4,4	**47,8**	**41,1**			X	
8	Diseases & disorders of the musculoskeletal system & conn tissue	347	Other back & neck disorders, fractures & injuries	M	3,3	5,6	8,9	**15,6**	28,9	**46,7**		X	X	
9	Diseases & disorders of the skin, subcutaneous tissue & breast	363	Breast procedures except mastectomy	S	1,1	0,0	4,4	5,6	**43,3**	**44,4**			X	
10	Endocrine, nutritional & metabolic diseases & disorders	403	Procedures for obesity	S	1,1	0,0	**12,5**	**14,4**	**48,9**	36,4		X	X	
11	Diseases & disorders of the kidney & urinary tract	440	Kidney transplant	S	12,5	0,0	0,0	0,0	25,0	**71,4**			X	
11	Diseases & disorders of the kidney & urinary tract	446	Urethral & transurethral procedures	S	2,2	0,0	**11,1**	3,3	35,6	25,6		X		
11	Diseases & disorders of the kidney & urinary tract	463	Kidney & urinary tract infections	M	10,0	10,0	10,0	5,6	24,4	**42,2**			X	
12	Diseases & disorders of the male reproductive system	480	Major male pelvic procedures	S	1,1	0,0	**10,3**	2,2	32,2	16,1		X		
13	Diseases & disorders of the female reproductive system	513	Uterine & adnexa procedures for non-malignancy except leiomyoma	S	1,1	1,1	8,9	5,6	**47,8**	18,9			X	
13	Diseases & disorders of the female reproductive system	514	Female reproductive system reconstructive procedures	S	1,1	0,0	2,2	3,3	**44,4**	12,2			X	

17	Myeloproliferative diseases & disorders, poorly differentiated neoplasm	693	Chemotherapy	M	10,0	6,7	**19,1**	**20,0**	**58,9**	**42,2**		X	X
18	Infectious & parasitic diseases, systemic or unspecified sites	720	Septicemia & disseminated infections	M	17,8	**22,2**	8,9	3,3	16,7	25,6	X		
23	Factors influencing hlth stat & othr contacts with hlth servcs	860	Rehabilitation	M	15,5	1,5	6,1	7,1	**42,9**	30,3			X
23	Factors influencing hlth stat & othr contacts with hlth servcs	861	Signs, symptoms & other factors influencing health status	M	11,1	**23,3**	**15,6**	5,6	**43,3**	38,9	X	X	X
23	Factors influencing hlth stat & othr contacts with hlth servcs	862	Other aftercare & convalescence	M	14,4	**22,2**	**14,4**	8,9	**43,3**	**47,8**	X	X	X

[a] The cut-offs are 18%, 10%, and 40% for mortality, readmission, and pLOS, respectively and roughly correspond to the middle of the range of observed values for each outcome. [b] S: Surgical; M: Medical

A.3.8 List of diagnoses and procedures (grouped within ICD-10-CM) that represent over 80% of diagnoses and procedures within urological APR-DRG codes

ICD-10-CM Code	Description	Percent representation within APR-DRG	Cumulative percent representation within APR-DRG
APR-DRG 440 – Kidney Transplant (KTr)			
0TY	Urinary System, Transplantation	27,29	27,29
0T7	Urinary System, Dilation	9,57	36,86
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	8,4	45,26
302	Administration, Circulatory, Transfusion	8,05	53,31
0TB	Urinary System, Excision	7,17	60,48
0T9	Urinary System, Drainage	5,31	65,79
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	4,79	70,59
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	1,86	72,45
BT4	Imaging, Urinary System, Ultrasonography	1,84	74,28
0TT	Urinary System, Resection	1,54	75,83
6A5	Extracorporeal or Systemic Therapies, Physiological Systems, Pheresis	1,49	77,31
02H	Heart and Great Vessels, Insertion	1,11	78,43
0DB	Gastrointestinal System, Excision	1,11	79,54
0TP	Urinary System, Removal	0,98	80,53
APR-DRG 441 – Major bladder procedures (MBP)			
0TT	Urinary System, Resection	11,46	11,46
0T1	Urinary System, Bypass	9,7	21,16
0VT	Male Reproductive System, Resection	9,51	30,67

3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	7,88	38,55
0TB	Urinary System, Excision	7,53	46,08
0DB	Gastrointestinal System, Excision	5,21	51,29
07T	Lymphatic and Hemic Systems, Resection	5,21	56,50
302	Administration, Circulatory, Transfusion	4,44	60,94
0UT	Female Reproductive System, Resection	3,62	64,56
0T7	Urinary System, Dilation	3,12	67,68
07B	Lymphatic and Hemic Systems, Excision	2,51	70,19
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	2,17	72,36
0T9	Urinary System, Drainage	2,04	74,40
0DT	Gastrointestinal System, Resection	1,96	76,36
8E0	Other Procedures, Physiological Systems and Anatomical Regions, Other Procedures	1,85	78,21
0TR	Urinary System, Replacement	1,81	80,01
APR-DRG 442 – Kidney & urinary tract procedures for malignancy (UTM)			
0TT	Urinary System, Resection	22,82	22,82
0TB	Urinary System, Excision	17,17	40,00
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	7,81	47,81
8E0	Other Procedures, Physiological Systems and Anatomical Regions, Other Procedures	6,56	54,37
302	Administration, Circulatory, Transfusion	4,68	59,04
0T9	Urinary System, Drainage	4,41	63,45
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	3,77	67,21
0GT	Endocrine System, Resection	3,07	70,29
0T7	Urinary System, Dilation	2,31	72,60
07B	Lymphatic and Hemic Systems, Excision	2,03	74,62
07T	Lymphatic and Hemic Systems, Resection	1,64	76,27
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	1,48	77,75
0TP	Urinary System, Removal	1,44	79,19
0T5	Urinary System, Destruction	1,31	80,49

APR-DRG 443 – Kidney & urinary tract procedures for non-malignancy (UTNM)			
0T9	Urinary System, Drainage	19,36	19,36
0TP	Urinary System, Removal	15,5	34,86
0T7	Urinary System, Dilation	14,31	49,17
0TC	Urinary System, Extirpation	13,23	62,40
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	5,56	67,96
0TF	Urinary System, Fragmentation	4,5	72,46
0TB	Urinary System, Excision	3,08	75,54
0TT	Urinary System, Resection	2,71	78,25
302	Administration, Circulatory, Transfusion	1,89	80,13
APR-DRG 444 – Renal dialysis access device procedure only (DIAL)			
31	Upper Arteries, Bypass	55,94	55,94
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	16,14	72,08
0W1	Anatomical Regions, General, Bypass	7,97	80,04
APR-DRG 445 – Other bladder procedures (OBI)			
0TP	Urinary System, Removal	16,32	16,32
0T9	Urinary System, Drainage	13,2	29,52
0TH	Urinary System, Insertion	7,3	36,83
0TU	Urinary System, Supplement	6,31	43,14
0TS	Urinary System, Reposition	5,86	48,99
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	5,56	54,55
0W3	Anatomical Regions, General, Control	4,65	59,21
0TB	Urinary System, Excision	4,6	63,81
0TC	Urinary System, Extirpation	4,29	68,10
0TQ	Urinary System, Repair	3,47	71,56
302	Administration, Circulatory, Transfusion	2,45	74,01
0TJ	Urinary System, Inspection	2,41	76,42
0T7	Urinary System, Dilation	1,94	78,36

3E1	Administration, Physiological Systems and Anatomical Regions, Irrigation	1,94	80,29
APR-DRG 446 – Urethral & transurethral procedures (TUP)			
0TB	Urinary System, Excision	33,78	33,78
0TC	Urinary System, Extirpation	21,18	54,96
0T7	Urinary System, Dilation	12,2	67,16
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	8,21	75,38
0T9	Urinary System, Drainage	4,43	79,81
0TU	Urinary System, Supplement	2,67	82,48
APR-DRG 447 – Other kidney, urinary tract & related procedures (OUT)			
47	Lower Arteries, Dilation	13,61	13,61
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	7,81	21,42
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	6,34	27,76
302	Administration, Circulatory, Transfusion	4,94	32,70
31	Upper Arteries, Bypass	3,57	36,27
0W9	Anatomical Regions, General, Drainage	3,5	39,78
0WJ	Anatomical Regions, General, Inspection	2,93	42,71
02H	Heart and Great Vessels, Insertion	2,81	45,52
0DB	Gastrointestinal System, Excision	2,8	48,32
B41	Imaging, Lower Arteries, Fluoroscopy	2,5	50,81
05H	Upper Veins, Insertion	2,35	53,16
0GT	Endocrine System, Resection	1,81	54,97
0DN	Gastrointestinal System, Release	1,75	56,72
0DJ	Gastrointestinal System, Inspection	1,7	58,42
0WP	Anatomical Regions, General, Removal	1,35	59,77
4A0	Measurement and Monitoring, Physiological Systems, Measurement	1,25	61,03
04L	Lower Arteries, Occlusion	1,13	62,16
0T9	Urinary System, Drainage	1,1	63,26
0GB	Endocrine System, Excision	1,06	64,33

0VP	Male Reproductive System, Removal	1	65,32
04V	Lower Arteries, Restriction	0,97	66,29
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	0,95	67,24
0JH	Subcutaneous Tissue and Fascia, Insertion	0,93	68,17
BW2	Imaging, Anatomical Regions, Computerized Tomography (CT Scan)	0,91	69,08
B21	Imaging, Heart, Fluoroscopy	0,9	69,98
3E1	Administration, Physiological Systems and Anatomical Regions, Irrigation	0,89	70,87
0WH	Anatomical Regions, General, Insertion	0,85	71,72
0TB	Urinary System, Excision	0,8	72,52
0W1	Anatomical Regions, General, Bypass	0,79	73,31
07B	Lymphatic and Hemic Systems, Excision	0,68	73,99
0VU	Male Reproductive System, Supplement	0,68	74,68
0UT	Female Reproductive System, Resection	0,67	75,34
00H	Central Nervous System and Cranial Nerves, Insertion	0,63	75,97
0WB	Anatomical Regions, General, Excision	0,56	76,53
057	Upper Veins, Dilation	0,55	77,08
0T7	Urinary System, Dilation	0,55	77,62
B24	Imaging, Heart, Ultrasonography	0,55	78,17
F07	Physical Rehabilitation and Diagnostic Audiology, Rehabilitation, Motor Treatment	0,55	78,71
04C	Lower Arteries, Extirpation	0,53	79,24
05B	Upper Veins, Excision	0,52	79,76
0Y6	Anatomical Regions, Lower Extremities, Detachment	0,49	80,25
APR-DRG 460 – Renal failure (RF)			
N179	Acute kidney failure, unspecified	34,79	34,79
I120	Hypertensive chronic kidney disease with stage 5 chronic kidney disease or end stage renal disease	16,64	51,44
T795XXA	Traumatic anuria, initial encounter	10,97	62,41
N186	End stage renal disease	8,28	70,69
N178	Other acute kidney failure	7,87	78,56

N170	Acute kidney failure with tubular necrosis	4,84	83,39
APR-DRG 461 – Kidney & urinary tract malignancy (UTMD)			
C679	Malignant neoplasm of bladder, unspecified	25,86	25,86
C642	Malignant neoplasm of left kidney, except renal pelvis	11,85	37,71
C641	Malignant neoplasm of right kidney, except renal pelvis	11,8	49,50
C672	Malignant neoplasm of lateral wall of bladder	10,39	59,89
C678	Malignant neoplasm of overlapping sites of bladder	9,33	69,22
C671	Malignant neoplasm of dome of bladder	3,41	72,63
C670	Malignant neoplasm of trigone of bladder	2,91	75,54
C661	Malignant neoplasm of right ureter	2,75	78,28
C675	Malignant neoplasm of bladder neck	2,64	80,93
APR-DRG 462 – Nephritis & nephrosis (NEPH)			
N049	Nephrotic syndrome with unspecified morphologic changes	15,16	15,16
N028	Recurrent and persistent hematuria with other morphologic changes	12,26	27,42
N009	Acute nephritic syndrome with unspecified morphologic changes	7,46	34,88
N040	Nephrotic syndrome with minor glomerular abnormality	6,25	41,13
N141	Nephropathy induced by other drugs, medicaments and biological substances	5,89	47,02
N059	Unspecified nephritic syndrome with unspecified morphologic changes	5,77	52,78
N042	Nephrotic syndrome with diffuse membranous glomerulonephritis	5,56	58,35
N041	Nephrotic syndrome with focal and segmental glomerular lesions	3,63	61,98
N048	Nephrotic syndrome with other morphologic changes	3,15	65,12
N051	Unspecified nephritic syndrome with focal and segmental glomerular lesions	3,02	68,15
N029	Recurrent and persistent hematuria with unspecified morphologic changes	2,86	71,01
N159	Renal tubulo-interstitial disease, unspecified	2,7	73,71
N058	Unspecified nephritic syndrome with other morphologic changes	2,62	76,33
N052	Unspecified nephritic syndrome with diffuse membranous glomerulonephritis	2,58	78,91
N023	Recurrent and persistent hematuria with diffuse mesangial proliferative glomerulonephritis	2,5	81,41
APR-DRG 463 – Kidney & urinary tract infections (UTI)			

N390	Urinary tract infection, site not specified	48,69	48,69
N10	Acute pyelonephritis	30	78,69
N3000	Acute cystitis without hematuria	6,38	85,07
APR-DRG 465 – Urinary stones & acquired upper urinary tract obstruction (USO)			
N201	Calculus of ureter	34,85	34,85
N132	Hydronephrosis with renal and ureteral calculous obstruction	33,94	68,79
N200	Calculus of kidney	11,93	80,72
APR-DRG 466 – Malfunction, reaction, complication of genitourinary device or procedure (DEV)			
N9989	Other postprocedural complications and disorders of genitourinary system	18,81	18,81
T8613	Kidney transplant infection	7,06	25,87
T827XXA	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts, initial encounter	5,2	31,07
T83098A	Other mechanical complication of other urinary catheter, initial encounter	5,01	36,08
T8384XA	Pain due to genitourinary prosthetic devices, implants and grafts, initial encounter	4,17	40,25
T8611	Kidney transplant rejection	3,78	44,03
T83090A	Other mechanical complication of cystostomy catheter, initial encounter	3,49	47,52
T8612	Kidney transplant failure	3,31	50,82
T83511A	Infection and inflammatory reaction due to indwelling urethral catheter, initial encounter	3,27	54,09
T8619	Other complication of kidney transplant	2,99	57,08
T8383XA	Hemorrhage due to genitourinary prosthetic devices, implants and grafts, initial encounter	2,97	60,05
T8351XA	Infection and inflammatory reaction due to urinary catheter, initial encounter	2,65	62,71
T8571XA	Infection and inflammatory reaction due to peritoneal dialysis catheter, initial encounter	2,47	65,18
T83518A	Infection and inflammatory reaction due to other urinary catheter, initial encounter	2,08	67,25
T83510A	Infection and inflammatory reaction due to cystostomy catheter, initial encounter	2	69,25
T8249XA	Other complication of vascular dialysis catheter, initial encounter	1,82	71,07
T82898A	Other specified complication of vascular prosthetic devices, implants and grafts, initial encounter	1,59	72,67

T8389XA	Other specified complication of genitourinary prosthetic devices, implants and grafts, initial encounter	1,58	74,25
T83091A	Other mechanical complication of indwelling urethral catheter, initial encounter	1,48	75,73
N99522	Malfunction of incontinent external stoma of urinary tract	1,35	77,07
N99528	Other complication of incontinent external stoma of urinary tract	1,32	78,39
N99511	Cystostomy infection	1,2	79,59
T83028A	Displacement of other urinary catheter, initial encounter	1,01	80,60
APR-DRG 468 – Other kidney & urinary tract diagnoses, signs & symptoms (OUTD)			
N289	Disorder of kidney and ureter, unspecified	10,57	10,57
R310	Gross hematuria	8,35	18,91
I129	Hypertensive chronic kidney disease with stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease	7,47	26,39
R392	Extrarenal uremia	7,05	33,44
R339	Retention of urine, unspecified	6,96	40,40
N359	Urethral stricture, unspecified	6,78	47,18
R338	Other retention of urine	5,3	52,48
Z466	Encounter for fitting and adjustment of urinary device	4,16	56,64
N3289	Other specified disorders of bladder	3,48	60,11
D090	Carcinoma in situ of bladder	2,46	62,57
R319	Hematuria, unspecified	2,18	64,75
N3281	Overactive bladder	2,03	66,78
N320	Bladder-neck obstruction	1,98	68,76
D414	Neoplasm of uncertain behavior of bladder	1,81	70,57
N3041	Irradiation cystitis with hematuria	1,74	72,31
N2889	Other specified disorders of kidney and ureter	1,67	73,98
E1122	Type 2 diabetes mellitus with diabetic chronic kidney disease	1,54	75,52
N358	Other urethral stricture	1,49	77,01
N135	Crossing vessel and stricture of ureter without hydronephrosis	1,08	78,08
Z435	Encounter for attention to cystostomy	0,98	79,07

N280	Ischemia and infarction of kidney	0,9	79,97
N3941	Urge incontinence	0,79	80,76
APR-DRG 480 – Major male pelvic procedures (MMPP)			
0VT	Male Reproductive System, Resection	50,57	50,57
8E0	Other Procedures, Physiological Systems and Anatomical Regions, Other Procedures	15,75	66,33
07T	Lymphatic and Hemic Systems, Resection	11,95	78,28
07B	Lymphatic and Hemic Systems, Excision	4,07	82,35
APR-DRG 481 – Penis procedures (PENP)			
0VB	Male Reproductive System, Excision	13,84	13,84
0TS	Urinary System, Reposition	12,73	26,57
0VQ	Male Reproductive System, Repair	12,7	39,27
0VU	Male Reproductive System, Supplement	12,6	51,87
0VT	Male Reproductive System, Resection	7,64	59,51
0VN	Male Reproductive System, Release	3,85	63,37
0VH	Male Reproductive System, Insertion	3,21	66,58
0WH	Anatomical Regions, General, Insertion	3,18	69,76
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	3,05	72,81
0T9	Urinary System, Drainage	3,01	75,82
0V9	Male Reproductive System, Drainage	2,7	78,52
0VP	Male Reproductive System, Removal	2,64	81,16
APR-DRG 482 – Transurethral prostatectomy (TURP)			
0VB	Male Reproductive System, Excision	58,91	58,91
0T9	Urinary System, Drainage	7,62	66,53
0VT	Male Reproductive System, Resection	6,78	73,31
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	3,32	76,63
0V5	Male Reproductive System, Destruction	3,08	79,71
0T7	Urinary System, Dilation	2,71	82,42
APR-DRG 483 – Testes & scrotal procedures			
0VB	Male Reproductive System, Excision	33,27	33,27
0VT	Male Reproductive System, Resection	20,47	53,74

0VS	Male Reproductive System, Reposition	18,09	71,83
0VQ	Male Reproductive System, Repair	4,72	76,55
0V1	Male Reproductive System, Bypass	3,18	79,73
0VR	Male Reproductive System, Replacement	2,86	82,59
APR-DRG 484 – Other male reproductive system & related procedures (OMRP)			
0VB	Male Reproductive System, Excision	25,16	25,16
0VT	Male Reproductive System, Resection	12,4	37,56
8E0	Other Procedures, Physiological Systems and Anatomical Regions, Other Procedures	8,31	45,87
0VH	Male Reproductive System, Insertion	7,65	53,51
0T9	Urinary System, Drainage	5,63	59,14
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	5,59	64,73
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	4,47	69,20
07B	Lymphatic and Hemic Systems, Excision	4,34	73,54
0TB	Urinary System, Excision	3,14	76,67
302	Administration, Circulatory, Transfusion	2,51	79,19
DV1	Radiation Therapy, Male Reproductive System, Brachytherapy	2,33	81,52
APR-DRG 500 – Malignancy, male reproductive system (MMRSD)			
C61	Malignant neoplasm of prostate	93,08	93,08
APR-DRG 501 – Male reproductive system diagnoses except malignancy (MRSD)			
N410	Acute prostatitis	31,47	31,47
N401	Benign prostatic hyperplasia with lower urinary tract symptoms	22,91	54,38
N453	Epididymo-orchitis	5,96	60,34
N419	Inflammatory disease of prostate, unspecified	5,19	65,53
N451	Epididymitis	4,33	69,86
N471	Phimosis	3,76	73,62
N492	Inflammatory disorders of scrotum	2,85	76,47
N400	Benign prostatic hyperplasia without lower urinary tract symptoms	2,27	78,74
N413	Prostatocystitis	1,96	80,69

Dark grey indicates a surgical APR-DRG, while light grey indicates a medical APR-DRG

A.3.9 Estimates of the random effects variance (standard error) and median odds ratio (95% confidence interval) from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length of stay for urological APR-DRGs in 2016-2018.

APR-DRG	Model 1: patient characteristics[a]		Model 2: patient and hospital characteristics[b]	
	Random effects variance (SE)	Median odds ratio (95% CI)[c]	Random effects variance (SE)	Median odds ratio (95% CI)[c]
Mortality				
440-Kidney transplant	NA	NA	NA	NA
441-Major bladder procedures	0.133 (0.162)	1.42 (0.66-1.90)	0.066 (0.142)	1.28 (0.64-1.75)
442-Kidney & urinary tract procedures for malignancy	0.415 (0.202)	1.85 (1.14-2.36)	0.200 (0.162)	1.53 (0.72-1.99)
443-Kidney & urinary tract procedures for non-malignancy	0.196 (0.110)	1.53 (0.88-1.84)	0 (NE)	NE
444-Renal dialysis access device procedure only	NA	NA	NA	NA
445-Other bladder procedures	NA	NA	NA	NA
446-Urethral & transurethral procedures	0.112 (0.147)	1.38 (0.67-1.83)	0.062 (0.140)	1.27 (0.64-1.74)
447-Other kidney, urinary tract & related procedures	0.062 (0.167)	1.27 (0.61-1.81)	0.009 (0.169)	1.10 (0.58-1.75)
460-Renal failure	0.039 (0.018)	1.21 (1.06-1.30)	0.017 (0.015)	1.13 (0.90-1.23)
461-Kidney & urinary tract malignancy	0.421 (0.086)	1.86 (1.62-2.08)	0.297 (0.067)	1.68 (1.47-1.87)
462-Nephritis & nephrosis	0.260 (0.445)	1.63 (0.47-2.76)	0 (NE)	NE
463-Kidney & urinary tract infections	0.099 (0.025)	1.35 (1.24-1.44)	0.049 (0.018)	1.24 (1.12-1.32)
465- Urinary stones & acquired upper urinary tract obstruction	0.614 (0.370)	2.11 (0.73-3.01)	0.402 (0.337)	1.83 (0.62-2.67)
466-Malfunction, reaction, complication of genitourinary device or procedure	0.196 (0.117)	1.53 (0.84-1.86)	0.092 (0.095)	1.34 (0.75-1.65)
468-Other kidney & urinary tract diagnoses, signs & symptoms	0.128 (0.040)	1.41 (1.24-1.54)	0.079 (0.032)	1.31 (1.13-1.43)
480-Major male pelvic procedures	NA	NA	NA	NA
481-Penis procedures	NA	NA	NA	NA
482-Transurethral prostatectomy	0 (NE)	NE	0 (NE)	NE
483-Testes & scrotal procedures	NA	NA	NA	NA
484-Other male reproductive system & related procedures	NA	NA	NA	NA
500-Malignancy, male reproductive system	0.200 (0.060)	1.53 (1.32-1.71)	0.159 (0.052)	1.46 (1.25-1.63)
501-Male reproductive system diagnoses except malignancy	0.078 (0.136)	1.31 (0.66-1.75)	0.060 (0.131)	1.26 (0.66-1.71)

Readmission				
440-Kidney transplant	0.008 (0.037)	1.09 (0.78-1.31)	0 (NE)	NE
441-Major bladder procedures	0.047 (0.034)	1.23 (0.88-1.38)	0.031 (0.032)	1.18 (0.84-1.34)
442-Kidney & urinary tract procedures for malignancy	0.048 (0.035)	1.23 (0.87-1.39)	0.027 (0.033)	1.17 (0.83-1.33)
443-Kidney & urinary tract procedures for non-malignancy	0.048 (0.016)	1.23 (1.13-1.31)	0.039 (0.015)	1.21 (1.09-1.28)
444-Renal dialysis access device procedure only	0.045 (0.069)	1.23 (0.75-1.50)	0.056 (0.070)	1.25 (0.76-1.52)
445-Other bladder procedures	0 (NE)	NE	0 (NE)	NE
446-Urethral & transurethral procedures	0.059 (0.016)	1.26 (1.17-1.33)	0.049 (0.014)	1.24 (1.15-1.30)
447-Other kidney, urinary tract & related procedures	0.121 (0.113)	1.39 (0.74-1.75)	0.070 (0.105)	1.29 (0.70-1.65)
460-Renal failure	0.020 (0.018)	1.14 (0.89-1.25)	0.003 (0.017)	1.05 (0.84-1.20)
461-Kidney & urinary tract malignancy	0.010 (0.036)	1.10 (0.79-1.31)	0.004 (0.035)	1.06 (0.78-1.29)
462-Nephritis & nephrosis	0 (NE)	NE	0 (NE)	NE
463-Kidney & urinary tract infections	0.028 (0.008)	1.17 (1.11-1.22)	0.021 (0.007)	1.15 (1.08-1.19)
465- Urinary stones & acquired upper urinary tract obstruction	0.058 (0.015)	1.26 (1.18-1.32)	0.047 (0.013)	1.23 (1.15-1.29)
466-Malfunction, reaction, complication of genitourinary device or procedure	0.002 (0.016)	1.04 (0.85-1.19)	0.000 (0.016)	1.02 (0.85-1.18)
468-Other kidney & urinary tract diagnoses, signs & symptoms	0.016 (0.008)	1.13 (1.02-1.19)	0.009 (0.007)	1.10 (0.94-1.16)
480-Major male pelvic procedures	0.287 (0.083)	1.67 (1.40-1.90)	0.278 (0.081)	1.65 (1.39-1.88)
481-Penis procedures	0.118 (0.134)	1.39 (0.70-1.80)	0.051 (0.121)	1.24 (0.66-1.67)
482-Transurethral prostatectomy	0.024 (0.013)	1.16 (0.97-1.23)	0.022 (0.012)	1.15 (0.96-1.23)
483-Testes & scrotal procedures	0.038 (0.100)	1.21 (0.69-1.59)	0 (NE)	NE
484-Other male reproductive system & related procedures	0 (NE)	NE	0 (NE)	NE
500-Malignancy, male reproductive system	0.033 (0.060)	1.19 (0.76-1.45)	0.004 (0.058)	1.06 (0.73-1.39)
501-Male reproductive system diagnoses except malignancy	0.079 (0.032)	1.31 (1.13-1.43)	0.045 (0.027)	1.23 (0.92-1.35)
Prolonged Length of Stay				
440-Kidney transplant	0.348 (0.227)	1.75 (0.74-2.34)	0.295 (0.200)	1.68 (0.74-2.21)
441-Major bladder procedures	0.134 (0.058)	1.42 (1.14-1.61)	0.072 (0.047)	1.29 (0.87-1.47)
442-Kidney & urinary tract procedures for malignancy	0.200 (0.063)	1.53 (1.30-1.72)	0.159 (0.055)	1.46 (1.24-1.64)
443-Kidney & urinary tract procedures for non-malignancy	0.187 (0.038)	1.51 (1.38-1.63)	0.166 (0.036)	1.48 (1.34-1.59)
444-Renal dialysis access device procedure only	0.690 (0.240)	2.21 (1.56-2.79)	0.643 (0.237)	2.15 (1.50-2.73)
445-Other bladder procedures	0.284 (0.101)	1.66 (1.32-1.94)	0.245 (0.094)	1.60 (1.27-1.87)
446-Urethral & transurethral procedures	0.267 (0.047)	1.64 (1.49-1.77)	0.192 (0.036)	1.52 (1.39-1.63)

447-Other kidney, urinary tract & related procedures	0.133 (0.109)	1.42 (0.76-1.75)	0.113 (0.104)	1.38 (0.75-1.71)
460-Renal failure	0.181 (0.046)	1.50 (1.33-1.65)	0.139 (0.039)	1.43 (1.27-1.56)
461-Kidney & urinary tract malignancy	0.057 (0.040)	1.26 (0.87-1.42)	0 (NE)	NE
462-Nephritis & nephrosis	0.081 (0.100)	1.31 (0.72-1.65)	0.019 (0.104)	1.14 (0.66-1.57)
463-Kidney & urinary tract infections	0.213 (0.036)	1.55 (1.43-1.66)	0.174 (0.030)	1.49 (1.38-1.59)
465- Urinary stones & acquired upper urinary tract obstruction	0.190 (0.034)	1.52 (1.40-1.62)	0.155 (0.029)	1.46 (1.35-1.55)
466-Malfunction, reaction, complication of genitourinary device or procedure	0.290 (0.077)	1.67 (1.43-1.88)	0.245 (0.070)	1.60 (1.37-1.80)
468-Other kidney & urinary tract diagnoses, signs & symptoms	0.193 (0.035)	1.52 (1.40-1.63)	0.138 (0.027)	1.42 (1.32-1.52)
480-Major male pelvic procedures	1.392 (0.251)	3.08 (2.47-3.71)	1.193 (0.222)	2.84 (2.29-3.38)
481-Penis procedures	0.649 (0.202)	2.16 (1.62-2.65)	0.337 (0.138)	1.74 (1.28-2.10)
482-Transurethral prostatectomy	0.553 (0.095)	2.03 (1.78-2.27)	0.438 (0.078)	1.88 (1.66-2.08)
483-Testes & scrotal procedures	0.140 (0.055)	1.43 (1.18-1.61)	0.117 (0.052)	1.39 (1.13-1.56)
484-Other male reproductive system & related procedures	0.447 (0.124)	1.89 (1.54-2.21)	0.368 (0.113)	1.78 (1.44-2.08)
500-Malignancy, male reproductive system	0.308 (0.103)	1.70 (1.36-1.98)	0.247 (0.093)	1.61 (1.27-1.87)
501-Male reproductive system diagnoses except malignancy	0.256 (0.052)	1.62 (1.45-1.77)	0.131 (0.034)	1.41 (1.28-1.53)

Abbreviations: NA, not applicable; NE, not estimable; CI, confidence interval

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge

[b]Additionally adjusted for region, hospital type, and annual volume

[c]The odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

Note: Median odds ratios are not presented for models with <30 cases (indicated as NA) and for models in which the random hospital effect was estimated to be zero (indicated as NE).

A.3.10 Adjusted odds ratios (95% confidence intervals) for patient characteristics from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length of stay[a]

	Sex	Comorbidity index		Place before admission		Admission type	Year of discharge	
APR-DRG	Male (vs female)	1-4 (vs 0)	≥5 (vs 0)	Other hospital or nursing home (vs home)	On the road or other (vs home)	Emergency (vs elective)	2016 (vs 2018)	2017 (vs 2018)
Mortality								
440-Kidney transplant	1.37 (0.83-2.28)	**9.22 (3.34-25.45)**	**26.66 (9.24-76.96)**	1.52 (0.64-3.60)		**2.48 (1.51-4.09)**	0.84 (0.51-1.38)	1.14 (0.71-1.82)
441-Major bladder procedures	1.27 (0.83-1.97)	**5.03 (2.39-10.62)**	**17.97 (7.90-40.85)**	**3.16 (1.21-8.21)**	0.90 (0.10-7.84)	**3.85 (2.41-6.16)**	**2.39 (1.46-3.90)**	1.44 (0.85-2.45)
442-Kidney & urinary tract procedures for malignancy	0.81 (0.60-1.09)	**26.30 (10.62-65.14)**	**72.20 (28.16-185.1)**	1.09 (0.68-1.75)	1.30 (0.51-3.33)	**4.94 (3.48-7.01)**	1.21 (0.84-1.75)	1.25 (0.88-1.78)
443-Kidney & urinary tract procedures for non-malignancy	**1.79 (1.07-2.99)**	**8.35 (4.31-16.18)**	**40.39 (19.53-83.52)**	**1.99 (1.06-3.75)**		**5.70 (3.84-8.45**	1.04 (0.67-1.61)	0.90 (0.57-1.41)
444-Renal dialysis access device procedure only	0.95 (0.61-1.46)	**2.32 (1.06-5.07)**	**3.75 (1.65-8.53)**	1.67 (0.85-3.29)	0.47 (0.06-3.64)	**5.56 (3.44-8.99)**	0.99 (0.58-1.68)	0.98 (0.58-1.65)
445-Other bladder procedures	**1.16 (1.03-1.30)**	**1.59 (1.19-2.11)**	**1.77 (1.32-2.36)**	**1.80 (1.56-2.09)**	1.01 (0.68-1.50)	**1.62 (1.39-1.89)**	1.02 (0.89-1.17)	0.97 (0.84-1.12)
446-Urethral & transurethral procedures	1.04 (0.88-1.23)	**6.64 (4.86-9.08)**	**8.22 (5.77-11.71)**	**3.15 (2.47-4.03)**	0.74 (0.36-1.49)	**2.02 (1.71-2.37)**	0.90 (0.74-1.08)	1.12 (0.93-1.34)
447-Other kidney, urinary tract & related procedures	1.23 (0.61-2.46)	**12.22 (1.60-93.01)**	**24.18 (3.01-194.2)**	**4.03 (1.68-9.66)**	3.30 (0.66-16.60)	1.41 (0.68-2.92)	0.76 (0.32-1.80)	1.02 (0.47-2.22)

460-Renal failure	**1.40 (1.27-1.55)**	**3.11 (2.53-3.84)**	**4.78 (3.84-5.95)**	**2.05 (1.85-2.27)**	0.99 (0.67-1.48)	**1.23 (1.00-1.51)**	0.98 (0.87-1.11)	1.04 (0.93-1.16)
461-Kidney & urinary tract malignancy	1.01 (0.55-1.86)	**29.58 (8.83-99.05)**	**104.2 (26.44-410.7)**	**5.33 (2.51-11.32)**		1.39 (0.65-2.97)	0.78 (0.37-1.65)	1.08 (0.55-2.15)
462-Nephritis & nephrosis	1.06 (0.73-1.54)	**5.89 (2.84-12.23)**	**13.30 (6.20-28.51)**	**2.09 (1.44-3.05)**	1.34 (0.48-3.78)	1.33 (0.87-2.05)	1.20 (0.81-1.77)	1.09 (0.74-1.62)
463-Kidney & urinary tract infections	**1.20 (1.03-1.41)**	**5.57 (3.99-7.78)**	**10.14 (7.15-14.37)**	**1.97 (1.63-2.38)**	1.28 (0.82-1.99)	**3.10 (2.45-3.91)**	1.11 (0.93-1.33)	1.05 (0.87-1.26)
465- Urinary stones & acquired upper urinary tract obstruction		**2.91 (1.37-6.21)**	3.20 (0.82-12.49)	**4.18 (1.32-13.26)**	**18.89 (3.68-96.85)**	**5.14 (2.41-10.96)**	1.20 (0.51-2.83)	1.88 (0.85-4.16)
466-Malfunction, reaction, complication of genitourinary device or procedure		**9.06 (5.99-13.71)**	**9.42 (5.97-14.87)**	**2.52 (1.94-3.28)**	1.38 (0.72-2.64)	1.07 (0.90-1.27)	0.83 (0.68-1.02)	**0.76 (0.63-0.93)**
468-Other kidney & urinary tract diagnoses, signs & symptoms		**6.83 (3.35-13.94)**	**15.75 (7.25-34.21)**	**3.12 (1.97-4.95)**	0.69 (0.09-5.03)	0.89 (0.55-1.46)	1.01 (0.62-1.64)	1.34 (0.86-2.10)
Readmission								
440-Kidney transplant	1.00 (0.67-1.48)	0.80 (0.46-1.40)	1.74 (0.82-3.67)	1.92 (0.23-16.09)		1.26 (0.81-1.97)	1.30 (0.83-2.06)	1.11 (0.69-1.77)
441-Major bladder procedures	**1.47 (1.17-1.85)**	**1.35 (1.09-1.67)**	**1.68 (1.17-2.40)**	0.87 (0.38-1.98)	1.38 (0.49-3.84)	1.14 (0.82-1.59)	1.04 (0.83-1.30)	0.92 (0.73-1.16)
442-Kidney & urinary tract procedures for malignancy	**1.27 (1.01-1.59)**	**1.74 (1.36-2.23)**	**2.76 (1.86-4.10)**			**1.78 (1.25-2.54)**	1.23 (0.96-1.59)	1.23 (0.95-1.59)
443-Kidney & urinary tract procedures for non-malignancy	0.99 (0.89-1.09)	**1.72 (1.54-1.93)**	**2.53 (2.03-3.14)**	1.18 (0.89-1.56)	0.76 (0.49-1.18)	**1.84 (1.65-2.04**	0.97 (0.86-1.10)	1.02 (0.91-1.15)

444-Renal dialysis access device procedure only	0.98 (0.70-1.36)	1.57 (0.87-2.84)	2.00 (0.99-4.05)	1.61 (0.52-4.95)	3.19 (0.79-12.84)	**1.87 (1.09-3.21)**	1.47 (0.98-2.20)	1.19 (0.79-1.81)
445-Other bladder procedures	**2.07 (1.43-2.99)**	1.33 (0.99-1.78)	**2.34 (1.45-3.80)**	0.86 (0.49-1.53)	1.62 (0.44-5.91)	**2.75 (2.05-3.69)**	1.14 (0.82-1.59)	1.03 (0.74-1.43)
446-Urethral & transurethral procedures	**1.42 (1.28-1.58)**	**1.49 (1.36-1.63)**	**2.01 (1.59-2.53)**	1.09 (0.77-1.55)	1.18 (0.84-1.66)	**1.99 (1.80-2.20)**	0.99 (0.89-1.09)	0.99 (0.89-1.09)
447-Other kidney, urinary tract & related procedures	1.09 (0.74-1.60)	1.14 (0.69-1.89)	**2.72 (1.51-4.93)**	0.41 (0.12-1.36)	0.37 (0.05-2.85)	**1.82 (1.20-2.74)**	1.14 (0.72-1.80)	0.94 (0.59-1.49)
460-Renal failure	**1.30 (1.13-1.50)**	1.23 (0.92-1.65)	**1.64 (1.21-2.21)**	0.93 (0.74-1.16)	0.69 (0.41-1.16)	**1.31 (1.11-1.53)**	1.16 (0.98-1.37)	1.12 (0.94-1.33)
461-Kidney & urinary tract malignancy	1.16 (0.92-1.47)	**1.66 (1.28-2.16)**	**1.95 (1.35-2.81)**	0.96 (0.58-1.57)	0.28 (0.07-1.16)	**1.94 (1.56-2.41)**	1.09 (0.85-1.40)	1.03 (0.80-1.32)
462-Nephritis & nephrosis	1.15 (0.80-1.66)	1.34 (0.87-2.06)	1.19 (0.60-2.36)	0.55 (0.19-1.59)	1.68 (0.55-5.11)	**1.55 (1.07-2.26)**	0.70 (0.45-1.09)	0.71 (0.46-1.08)
463-Kidney & urinary tract infections	**1.35 (1.26-1.44)**	**1.59 (1.46-1.73)**	**2.13 (1.91-2.38)**	1.03 (0.94-1.12)	0.91 (0.73-1.14)	**1.28 (1.14-1.45)**	0.98 (0.91-1.06)	1.02 (0.94-1.10)
465- Urinary stones & acquired upper urinary tract obstruction	1.04 (0.95-1.13)	**1.16 (1.05-1.29)**	0.97 (0.62-1.53)	1.25 (0.87-1.80)	**0.75 (0.59-0.95)**	**1.67 (1.48-1.89)**	0.92 (0.83-1.01)	**0.89 (0.81-0.98)**
466-Malfunction, reaction, complication of genitourinary device or procedure	1.11 (0.93-1.32)	1.09 (0.91-1.30)	**1.30 (1.01-1.67)**			**1.92 (1.57-2.34)**	1.01 (0.84-1.21)	1.03 (0.86-1.24)
468-Other kidney & urinary tract diagnoses, signs & symptoms	**1.37 (1.25-1.49)**	**1.43 (1.30-1.57)**	**1.62 (1.42-1.84)**	**0.83 (0.70-0.97)**	0.79 (0.60-1.03)	**1.89 (1.72-2.06)**	1.08 (0.98-1.19)	0.97 (0.88-1.07)
480-Major male pelvic procedures		**1.36 (1.13-1.63)**	**4.09 (2.52-6.63)**	1.48 (0.42-5.24)	2.02 (0.19-21.13)	0.90 (0.38-2.11)	0.86 (0.70-1.06)	**0.79 (0.64-0.97)**

481-Penis procedures		1.59 (0.97-2.59)	**6.89 (2.57-18.45)**	2.95 (0.90-9.69)	1.73 (0.21-14.46)	1.54 (0.82-2.87)	0.60 (0.36-1.00)	0.72 (0.45-1.15)
482-Transurethral prostatectomy		**1.48 (1.33-1.64)**	**2.34 (1.81-3.03)**	**1.63 (1.04-2.54)**	0.75 (0.23-2.51)	**1.72 (1.42-2.10)**	0.96 (0.85-1.08)	0.97 (0.86-1.09)
483-Testes & scrotal procedures		**2.24 (1.55-3.24)**	**3.82 (1.57-9.28)**	0.65 (0.08-5.10)	1.57 (0.47-5.31)	0.98 (0.61-1.56)	0.94 (0.62-1.42)	1.03 (0.69-1.54)
484-Other male reproductive system & related procedures		**1.30 (1.03-1.65)**	**1.95 (1.09-3.48)**	0.53 (0.12-2.32)	0.43 (0.05-3.38)	**2.19 (1.51-3.16)**	1.12 (0.86-1.47)	0.92 (0.70-1.20)
500-Malignancy, male reproductive system		**2.42 (1.63-3.57)**	**2.57 (1.57-4.21)**	0.57 (0.32-1.03)	1.56 (0.66-3.68)	**1.88 (1.44-2.45)**	0.99 (0.73-1.34)	1.05 (0.79-1.42)
501-Male reproductive system diagnoses except malignancy		**1.47 (1.25-1.72)**	**1.70 (1.29-2.23)**	1.19 (0.88-1.60)	1.11 (0.72-1.71)	**1.36 (1.13-1.65)**	0.94 (0.79-1.12)	1.06 (0.89-1.25)
Prolonged length of stay								
440-Kidney transplant	0.97 (0.66-1.42)	1.80 (0.84-3.85)	**4.38 (1.81-10.60)**	1.87 (0.22-16.04)	**7.27 (1.13-46.63)**	0.92 (0.60-1.40)	1.12 (0.72-1.75)	0.97 (0.61-1.52)
441-Major bladder procedures	0.93 (0.73-1.19)	**3.74 (2.70-5.17)**	**12.63 (8.55-18.66)**	1.36 (0.76-2.44)	0.66 (0.20-2.15)	**3.54 (2.67-4.71)**	1.06 (0.82-1.36)	0.88 (0.68-1.15)
442-Kidney & urinary tract procedures for malignancy	0.99 (0.81-1.21)	**3.49 (2.66-4.58)**	**12.54 (8.85-17.77)**	1.38 (0.69-2.76)	2.73 (0.75-9.96)	**9.85 (7.67-12.66)**	**1.35 (1.08-1.70)**	1.17 (0.93-1.48)
443-Kidney & urinary tract procedures for non-malignancy	**0.75 (0.68-0.83)**	**6.30 (5.54-7.17)**	**23.67 (19.63-28.53)**	**2.27 (1.85-2.80)**	1.23 (0.87-1.74)	**4.10 (3.70-4.54)**	**1.27 (1.13-1.43)**	1.04 (0.93-1.17)
444-Renal dialysis access device procedure only	**0.65 (0.46-0.93)**	**2.90 (1.38-6.10)**	**9.33 (4.12-21.11)**	**9.16 (3.32-25.32)**	1.69 (0.36-7.90)	**72.12 (44.16-117.8)**	1.28 (0.83-1.98)	1.26 (0.81-1.95)

445-Other bladder procedures	1.02 (0.75-1.38)	**3.86 (2.84-5.25)**	**18.08 (11.63-28.13)**	**1.89 (1.22-2.93)**	1.03 (0.32-3.29)	**6.63 (5.03-8.74)**	1.15 (0.84-1.57)	1.14 (0.84-1.54)
446-Urethral & transurethral procedures	**1.18 (1.07-1.30)**	**2.81 (2.58-3.07)**	**10.11 (8.49-12.04)**	**3.67 (2.80-4.80)**	**0.62 (0.41-0.92)**	**8.64 (7.88-9.47)**	**1.32 (1.20-1.45)**	**1.11 (1.00-1.22)**
447-Other kidney, urinary tract & related procedures	1.06 (0.75-1.50)	**3.73 (1.89-7.35)**	**11.99 (5.89-24.40)**	**2.27 (1.31-3.95)**	2.31 (0.84-6.35)	**11.05 (7.60-16.08)**	**1.88 (1.22-2.91)**	**1.74 (1.14-2.66)**
460-Renal failure	**0.86 (0.76-0.97)**	**1.51 (1.07-2.13)**	**3.86 (2.74-5.44)**	1.19 (1.00-1.41)	1.02 (0.66-1.55)	**2.09 (1.74-2.50)**	1.11 (0.96-1.29)	0.88 (0.75-1.03)
461-Kidney & urinary tract malignancy	**0.76 (0.62-0.92)**	**5.89 (3.86-8.99)**	**12.31 (7.83-19.36)**	1.32 (0.98-1.77)	0.96 (0.46-2.03)	**2.16 (1.77-2.62)**	0.87 (0.69-1.09)	0.99 (0.79-1.23)
462-Nephritis & nephrosis	**0.72 (0.53-0.98)**	**2.42 (1.51-3.87)**	**11.45 (6.66-19.66)**	**3.63 (2.19-6.02)**	0.33 (0.09-1.24)	**2.51 (1.81-3.48)**	1.17 (0.79-1.73)	1.09 (0.75-1.58)
463-Kidney & urinary tract infections	**0.89 (0.83-0.95)**	**3.03 (2.71-3.38)**	**7.05 (6.26-7.95)**	**0.92 (0.86-0.99)**	1.02 (0.82-1.27)	**1.13 (1.01-1.27)**	**1.15 (1.07-1.24)**	1.02 (0.95-1.10)
465- Urinary stones & acquired upper urinary tract obstruction	**0.60 (0.55-0.65)**	**3.00 (2.74-3.29)**	**11.08 (8.48-14.49)**	**3.34 (2.57-4.33)**	0.94 (0.73-1.20)	**3.15 (2.78-3.57)**	**1.27 (1.15-1.40)**	1.08 (0.97-1.19)
466-Malfunction, reaction, complication of genitourinary device or procedure	**0.75 (0.62-0.90)**	**3.85 (2.87-5.16)**	**12.14 (8.82-16.71)**	**1.52 (1.22-1.90)**	0.57 (0.29-1.11)	**1.88 (1.51-2.33)**	**1.24 (1.02-1.52)**	0.94 (0.76-1.15)
468-Other kidney & urinary tract diagnoses, signs & symptoms	**0.66 (0.61-0.71)**	**5.06 (4.33-5.91)**	**14.94 (12.65-17.63)**	**1.76 (1.56-1.98)**	**1.40 (1.10-1.78)**	**2.47 (2.22-2.74)**	**1.18 (1.07-1.30)**	1.03 (0.93-1.14)
480-Major male pelvic procedures		**2.29 (1.98-2.66)**	**7.05 (4.69-10.60)**	**3.14 (1.11-8.87)**	**0.05 (0.00-0.76)**	**14.21 (8.60-23.48)**	**1.32 (1.11-1.57)**	**1.24 (1.04-1.47)**
481-Penis procedures		**2.70 (1.91-3.83)**	**24.08 (10.49-55.30)**	2.61 (0.99-6.86)	1.94 (0.56-6.72)	**4.05 (2.70-6.07)**	0.91 (0.67-1.25)	**0.70 (0.51-0.98)**

482-Transurethral prostatectomy	**2.33 (2.08-2.61)**	**8.69 (6.87-11.00)**	**3.57 (2.31-5.52)**	0.74 (0.32-1.71)	**30.05 (25.35-35.63)**	**1.22 (1.07-1.39)**	**1.24 (1.09-1.41)**
483-Testes & scrotal procedures	**2.82 (2.24-3.54)**	**11.71 (6.45-21.26)**	**3.28 (1.56-6.90)**	0.96 (0.52-1.78)	**8.63 (6.72-11.09)**	1.00 (0.79-1.26)	0.90 (0.70-1.14)
484-Other male reproductive system & related procedures	**2.58 (2.03-3.29)**	**6.88 (4.20-11.28)**	**3.77 (1.35-10.48)**	**0.27 (0.07-1.00)**	**17.24 (12.88-23.08)**	**1.52 (1.15-2.00)**	**1.37 (1.04-1.80)**
500-Malignancy, male reproductive system	**8.09 (3.93-16.65)**	**15.43 (7.25-32.83)**	**2.57 (1.86-3.54)**	1.54 (0.65-3.63)	**1.34 (1.04-1.72)**	1.06 (0.80-1.40)	0.94 (0.71-1.24)
501-Male reproductive system diagnoses except malignancy	**4.20 (3.58-4.94)**	**15.48 (12.59-19.04)**	**2.40 (1.97-2.93)**	1.01 (0.65-1.57)	**2.16 (1.79-2.59)**	0.95 (0.82-1.11)	1.02 (0.88-1.17)

A.3.11 Overview of the included cardiovascular All Patient Refined-Diagnosis Related Groups (APR-DRG)

APR-DRG	Diagnosis description	Abbreviation or short description	Type
161	Cardiac defibrillator & heart assist implant	Defibrillator	Surgical
162	Cardiac valve procedures with cardiac catheterization	Valve procedures with catheterization	Surgical
163	Cardiac valve procedures without cardiac catheterization	Valve procedures without catheterization	Surgical
165	Coronary bypass with cardiac catheter or percutaneous cardiac procedure	Bypass with catheterization	Surgical
166	Coronary bypass without cardiac catheter or percutaneous cardiac procedure	Bypass without catheterization	Surgical
169	Major thoracic & abdominal vascular procedures	Major procedures	Surgical
170	Permanent cardiac pacemaker implant with acute myocardial infarction, heart failure or shock	Pacemaker with AMI/HF/shock	Surgical
171	Permanent cardiac pacemaker implant without acute myocardial infarction, heart failure or shock	Pacemaker without AMI/HF/shock	Surgical
174	Percutaneous cardiovascular procedures with acute myocardial infarction	PCI with AMI	Surgical
175	Percutaneous cardiovascular procedures without acute myocardial infarction	PCI without AMI	Surgical
176	Cardiac pacemaker & defibrillator device replacement	Pacemaker replacement	Surgical
177	Cardiac pacemaker & defibrillator revision except device replacement	Pacemaker revision	Surgical
190	Acute myocardial infarction	AMI	Medical
191	Cardiac catheterization with circulatory disorders except ischemic heart disease	Catheterization without ischemic heart disease	Medical
192	Cardiac catheterization for ischemic heart disease	Catheterization for ischemic heart disease	Medical
193	Acute & subacute endocarditis	Endocarditis	Medical
194	Heart failure	HF	Medical
196	Cardiac arrest	CA	Medical
197	Peripheral & other vascular disorders	Peripheral disorders	Medical
198	Angina pectoris & coronary atherosclerosis	Angina pectoris	Medical
199	Hypertension	HT	Medical
200	Cardiac structural & valvular disorders	Structural & valvular disorders	Medical
201	Cardiac arrhythmia & conduction disorders	Arrhythmia & conduction disorders	Medical
203	Chest pain	CP	Medical
204	Syncope & collapse	S&C	Medical
205	Cardiomyopathy	CM	Medical
206	Malfunction, reaction, complication of cardiac/vascular device or procedure	Complication of device or procedure	Medical
207*	Pericarditis	Pericarditis	Medical

A.3.12 List of diagnoses and procedures (grouped within ICD-10-CM) that represent over 80% of diagnoses and procedures within cardiovascular APR-DRG codes

ICD-10-CM Code	Description	Percent representation within APR-DRG	Cumulative percent representation within APR-DRG
APR-DRG 161 – Cardiac defibrillator & heart assist implant			
02H	Heart and Great Vessels, Insertion	35,28	35,28
0JH	Subcutaneous Tissue and Fascia, Insertion	18,35	53,63
4A0	Measurement and Monitoring, Physiological Systems, Measurement	7,59	61,23
B21	Imaging, Heart, Fluoroscopy	5,87	67,10
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	4,22	71,32
4B0	Measurement and Monitoring, Physiological Devices, Measurement	3,60	74,93
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	3,22	78,15
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	2,19	80,34
APR-DRG 162 – Cardiac valve procedures with cardiac catheterization			
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	15,19	15,19
4A0	Measurement and Monitoring, Physiological Systems, Measurement	10,85	26,03
302	Administration, Circulatory, Transfusion	10,22	36,26
02R	Heart and Great Vessels, Replacement	10,11	46,37
B21	Imaging, Heart, Fluoroscopy	7,43	53,80
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	6,71	60,51
021	Heart and Great Vessels, Bypass	5,38	65,89
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	5,19	71,08
02H	Heart and Great Vessels, Insertion	4,10	75,17
B24	Imaging, Heart, Ultrasonography	2,87	78,04

06B	Lower Veins, Excision	1,75	79,79
02U	Heart and Great Vessels, Supplement	1,65	81,44
APR-DRG 163 – Cardiac valve procedures without cardiac catheterization			
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	19,63	19,63
02R	Heart and Great Vessels, Replacement	15,07	34,70
302	Administration, Circulatory, Transfusion	12,67	47,37
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	7,76	55,13
021	Heart and Great Vessels, Bypass	5,98	61,11
B24	Imaging, Heart, Ultrasonography	5,39	66,50
02H	Heart and Great Vessels, Insertion	3,95	70,45
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	3,46	73,91
02U	Heart and Great Vessels, Supplement	3,00	76,91
06B	Lower Veins, Excision	2,42	79,33
02Q	Heart and Great Vessels, Repair	2,14	81,47
APR-DRG 165 – Coronary bypass with cardiac catheter or percutaneous cardiac procedure			
021	Heart and Great Vessels, Bypass	21,51	21,51
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	12,69	34,21
B21	Imaging, Heart, Fluoroscopy	12,25	46,46
4A0	Measurement and Monitoring, Physiological Systems, Measurement	12,09	58,55
302	Administration, Circulatory, Transfusion	6,90	65,45
06B	Lower Veins, Excision	5,55	71,00
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	5,48	76,49
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	3,51	80,00
03B	Upper Arteries, Excision	2,80	82,79
APR-DRG 166 – Coronary bypass without cardiac catheter or percutaneous cardiac procedure			
021	Heart and Great Vessels, Bypass	32,34	32,34

5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	16,32	48,66
06B	Lower Veins, Excision	9,87	58,54
302	Administration, Circulatory, Transfusion	7,71	66,25
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	6,27	72,51
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	4,38	76,90
03B	Upper Arteries, Excision	3,82	80,71
APR-DRG 169 – Major thoracic & Abdominal vascular procedures			
025	Heart and Great Vessels, Destruction	11,95	11,95
04C	Lower Arteries, Extirpation	10,35	22,31
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	8,57	30,88
041	Lower Arteries, Bypass	7,66	38,54
302	Administration, Circulatory, Transfusion	7,21	45,75
4A0	Measurement and Monitoring, Physiological Systems, Measurement	5,07	50,83
047	Lower Arteries, Dilation	4,74	55,57
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	4,16	59,73
04R	Lower Arteries, Replacement	3,81	63,54
04U	Lower Arteries, Supplement	2,55	66,08
4A1	Measurement and Monitoring, Physiological Systems, Monitoring	2,42	68,50
02K	Heart and Great Vessels, Map	2,10	70,60
B24	Imaging, Heart, Ultrasonography	1,54	72,14
02H	Heart and Great Vessels, Insertion	1,17	73,31
B41	Imaging, Lower Arteries, Fluoroscopy	1,17	74,48
02R	Heart and Great Vessels, Replacement	1,13	75,60
B21	Imaging, Heart, Fluoroscopy	1,07	76,68
5A2	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Restoration	1,01	77,69

F07	Physical Rehabilitation and Diagnostic Audiology, Rehabilitation, Motor Treatment	0,94	78,63
0W9	Anatomical Regions, General, Drainage	0,86	79,49
5A0	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Assistance	0,80	80,28
APR-DRG 170 – Permanent cardiac pacemaker implant with acute myocardial infarction, heart failure or shock			
02H	Heart and Great Vessels, Insertion	43,57	43,57
0JH	Subcutaneous Tissue and Fascia, Insertion	21,34	64,91
4A0	Measurement and Monitoring, Physiological Systems, Measurement	3,95	68,86
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	3,81	72,67
B21	Imaging, Heart, Fluoroscopy	3,74	76,41
5A1	Extracorporeal or Systemic Assistance and Performance, Physiological Systems, Performance	2,08	78,49
B24	Imaging, Heart, Ultrasonography	2,06	80,55
APR-DRG 171 – Permanent cardiac pacemaker implant without acute myocardial infarction, heart failure or shock			
02H	Heart and Great Vessels, Insertion	49,54	49,54
0JH	Subcutaneous Tissue and Fascia, Insertion	26,84	76,38
4A0	Measurement and Monitoring, Physiological Systems, Measurement	2,99	79,37
4B0	Measurement and Monitoring, Physiological Devices, Measurement	2,95	82,32
APR-DRG 174 – Percutaneous cardiovascular procedures with acute myocardial infarction			
B21	Imaging, Heart, Fluoroscopy	31,39	31,39
027	Heart and Great Vessels, Dilation	26,72	58,11
4A0	Measurement and Monitoring, Physiological Systems, Measurement	20,73	78,85
3E0	3E0 - Administration, Physiological Systems and Anatomical Regions, Introduction	4,16	83,01
APR-DRG 174 – Percutaneous cardiovascular procedures without acute myocardial infarction			
4A0	Measurement and Monitoring, Physiological Systems, Measurement	24,08	24,08
B21	Imaging, Heart, Fluoroscopy	19,84	43,91
027	Heart and Great Vessels, Dilation	18,90	62,82

025	Heart and Great Vessels, Destruction	10,94	73,76
02K	Heart and Great Vessels, Map	6,62	80,37
APR-DRG 176 – Cardiac pacemaker & defibrillator device replacement			
0JH	Subcutaneous Tissue and Fascia, Insertion	40,44	40,44
0JP	Subcutaneous Tissue and Fascia, Removal	32,58	73,02
02H	Heart and Great Vessels, Insertion	9,00	82,02
APR-DRG 177 – Cardiac pacemaker & defibrillator revision except device replacement			
02H	Heart and Great Vessels, Insertion	28,22	28,22
02P	Heart and Great Vessels, Removal	14,94	43,16
02W	Heart and Great Vessels, Revision	11,75	54,91
4B0	Measurement and Monitoring, Physiological Devices, Measurement	5,91	60,81
0JW	Subcutaneous Tissue and Fascia, Revision	5,52	66,33
0JH	Subcutaneous Tissue and Fascia, Insertion	4,13	70,46
3E0	Administration, Physiological Systems and Anatomical Regions, Introduction	4,11	74,57
0JP	Subcutaneous Tissue and Fascia, Removal	4,04	78,61
4A0	Measurement and Monitoring, Physiological Systems, Measurement	2,87	81,48
APR-DRG 190 – Acute myocardial infarction			
I214	Non-ST elevation (NSTEMI) myocardial infarction	68,05	68,05
I2109	ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall	9,04	77,09
I2119	ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall	8,63	85,71
APR-DRG 191 – Cardiac catheterization with circulatory disorder except ischemic heart disease			
I350	Nonrheumatic aortic (valve) stenosis	11,37	11,37
I340	Nonrheumatic mitral (valve) insufficiency	5,01	16,38
I509	Heart failure, unspecified	4,57	20,94
I472	Ventricular tachycardia	4,30	25,24
R55	Syncope and collapse	4,28	29,52
I110	Hypertensive heart disease with heart failure	3,57	33,09

I471	Supraventricular tachycardia	3,44	36,53
I480	Paroxysmal atrial fibrillation	3,29	39,82
I501	Left ventricular failure, unspecified	3,23	43,05
I4891	Unspecified atrial fibrillation	3,16	46,21
I352	Nonrheumatic aortic (valve) stenosis with insufficiency	2,91	49,12
I5181	Takotsubo syndrome	2,77	51,88
I130	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease	2,75	54,64
I493	Ventricular premature depolarization	2,42	57,06
R9439	Abnormal result of other cardiovascular function study	2,28	59,34
I420	Dilated cardiomyopathy	1,87	61,21
I5021	Acute systolic (congestive) heart failure	1,69	62,90
I272	Other secondary pulmonary hypertension	1,52	64,41
R002	Palpitations	1,45	65,87
I351	Nonrheumatic aortic (valve) insufficiency	1,25	67,11
I5020	Unspecified systolic (congestive) heart failure	1,04	68,16
I481	Persistent atrial fibrillation	1,02	69,18
R9431	Abnormal electrocardiogram [ECG] [EKG]	1,01	70,19
I5023	Acute on chronic systolic (congestive) heart failure	0,90	71,09
I4892	Unspecified atrial flutter	0,77	71,86
I495	Sick sinus syndrome	0,76	72,62
I309	Acute pericarditis, unspecified	0,68	73,30
R000	Tachycardia, unspecified	0,63	73,93
I119	Hypertensive heart disease without heart failure	0,63	74,56
I429	Cardiomyopathy, unspecified	0,60	75,16
I4901	Ventricular fibrillation	0,59	75,75
I5022	Chronic systolic (congestive) heart failure	0,59	76,34
I482	Chronic atrial fibrillation	0,55	76,89
I514	Myocarditis, unspecified	0,54	77,43

I5031	Acute diastolic (congestive) heart failure	0,53	77,96
I498	Other specified cardiac arrhythmias	0,52	78,48
I441	Atrioventricular block, second degree	0,51	78,99
T82855A	Stenosis of coronary artery stent, initial encounter	0,51	79,50
Q231	Congenital insufficiency of aortic valve	0,50	80,00
APR-DRG 192 – Cardiac catheterization for ischemic heart disease			
I2510	Atherosclerotic heart disease of native coronary artery without angina pectoris	36,20	36,20
I25118	Atherosclerotic heart disease of native coronary artery with other forms of angina pectoris	13,50	49,70
I25119	Atherosclerotic heart disease of native coronary artery with unspecified angina pectoris	13,13	62,83
I25110	Atherosclerotic heart disease of native coronary artery with unstable angina pectoris	6,38	69,20
R0789	Other chest pain	5,96	75,16
R079	Chest pain, unspecified	4,53	79,70
R072	Precordial pain	4,34	84,03
APR-DRG 193 – Acute & subacute endocarditis			
I330	Acute and subacute infective endocarditis	83,28	83,28
APR-DRG 194 – Heart failure			
I509	Heart failure, unspecified	30,08	30,08
I130	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease	20,38	50,46
I110	Hypertensive heart disease with heart failure	12,21	62,68
I501	Left ventricular failure, unspecified	12,19	74,87
I5023	Acute on chronic systolic (congestive) heart failure	3,82	78,69
I5033	Acute on chronic diastolic (congestive) heart failure	3,70	82,39
APR-DRG 196 – Cardiac arrest			
I469	Cardiac arrest, cause unspecified	61,00	61,00
I4901	Ventricular fibrillation	17,65	78,66

R570	Cardiogenic shock	9,71	88,36
APR-DRG 197 – Peripheral & other vascular disorders			
I872	Venous insufficiency (chronic) (peripheral)	3,52	3,52
I82412	Acute embolism and thrombosis of left femoral vein	3,12	6,64
I743	Embolism and thrombosis of arteries of the lower extremities	2,90	9,55
I70213	Atherosclerosis of native arteries of extremities with intermittent claudication, bilateral legs	2,88	12,42
I714	Abdominal aortic aneurysm, without rupture	2,70	15,12
I82411	Acute embolism and thrombosis of right femoral vein	2,39	17,51
I8012	Phlebitis and thrombophlebitis of left femoral vein	2,01	19,52
I70211	Atherosclerosis of native arteries of extremities with intermittent claudication, right leg	1,88	21,40
I70212	Atherosclerosis of native arteries of extremities with intermittent claudication, left leg	1,88	23,28
I96	Gangrene, not elsewhere classified	1,84	25,12
I82422	Acute embolism and thrombosis of left iliac vein	1,75	26,87
I713	Abdominal aortic aneurysm, ruptured	1,62	28,49
I70245	Atherosclerosis of native arteries of left leg with ulceration of other part of foot	1,49	29,98
I70235	Atherosclerosis of native arteries of right leg with ulceration of other part of foot	1,42	31,41
Q278	Other specified congenital malformations of peripheral vascular system	1,42	32,83
T81718A	Complication of other artery following a procedure, not elsewhere classified, initial encounter	1,42	34,25
I82432	Acute embolism and thrombosis of left popliteal vein	1,35	35,60
I70261	Atherosclerosis of native arteries of extremities with gangrene, right leg	1,29	36,89
I70262	Atherosclerosis of native arteries of extremities with gangrene, left leg	1,27	38,17
I8011	Phlebitis and thrombophlebitis of right femoral vein	1,20	39,37
I871	Compression of vein	1,14	40,51
I70248	Atherosclerosis of native arteries of left leg with ulceration of other part of lower left leg	1,13	41,64
I7101	Dissection of thoracic aorta	1,08	42,72

I82431	Acute embolism and thrombosis of right popliteal vein	1,08	43,80
I808	Phlebitis and thrombophlebitis of other sites	1,04	44,84
I70203	Unspecified atherosclerosis of native arteries of extremities, bilateral legs	0,99	45,83
I70238	Atherosclerosis of native arteries of right leg with ulceration of other part of lower right leg	0,97	46,80
I824Z2	Acute embolism and thrombosis of unspecified deep veins of left distal lower extremity	0,93	47,73
I724	Aneurysm of artery of lower extremity	0,88	48,61
E1151	Type 2 diabetes mellitus with diabetic peripheral angiopathy without gangrene	0,86	49,47
I70222	Atherosclerosis of native arteries of extremities with rest pain, left leg	0,85	50,32
I824Z1	Acute embolism and thrombosis of unspecified deep veins of right distal lower extremity	0,80	51,12
I7103	Dissection of thoracoabdominal aorta	0,77	51,89
I80292	Phlebitis and thrombophlebitis of other deep vessels of left lower extremity	0,77	52,66
I82421	Acute embolism and thrombosis of right iliac vein	0,77	53,42
I739	Peripheral vascular disease, unspecified	0,76	54,18
I80222	Phlebitis and thrombophlebitis of left popliteal vein	0,76	54,94
I70263	Atherosclerosis of native arteries of extremities with gangrene, bilateral legs	0,75	55,69
E1152	Type 2 diabetes mellitus with diabetic peripheral angiopathy with gangrene	0,73	56,42
I80221	Phlebitis and thrombophlebitis of right popliteal vein	0,70	57,12
I708	Atherosclerosis of other arteries	0,69	57,81
I712	Thoracic aortic aneurysm, without rupture	0,69	58,50
I70221	Atherosclerosis of native arteries of extremities with rest pain, right leg	0,67	59,17
I780	Hereditary hemorrhagic telangiectasia	0,67	59,85
I80212	Phlebitis and thrombophlebitis of left iliac vein	0,67	60,51
I70202	Unspecified atherosclerosis of native arteries of extremities, left leg	0,66	61,18
I8002	Phlebitis and thrombophlebitis of superficial vessels of left lower extremity	0,66	61,84
I70223	Atherosclerosis of native arteries of extremities with rest pain, bilateral legs	0,65	62,49
I70201	Unspecified atherosclerosis of native arteries of extremities, right leg	0,64	63,12

I8392	Asymptomatic varicose veins of left lower extremity	0,61	63,74
I745	Embolism and thrombosis of iliac artery	0,58	64,31
I8391	Asymptomatic varicose veins of right lower extremity	0,58	64,89
I748	Embolism and thrombosis of other arteries	0,56	65,45
I82402	Acute embolism and thrombosis of unspecified deep veins of left lower extremity	0,52	65,97
Q2739	Arteriovenous malformation, other site	0,52	66,49
I8001	Phlebitis and thrombophlebitis of superficial vessels of right lower extremity	0,51	67,01
I82492	Acute embolism and thrombosis of other specified deep vein of left lower extremity	0,51	67,52
I771	Stricture of artery	0,50	68,02
I83218	Varicose veins of right lower extremity with both ulcer of other part of lower extremity and inflammation	0,50	68,52
I742	Embolism and thrombosis of arteries of the upper extremities	0,50	69,02
I80291	Phlebitis and thrombophlebitis of other deep vessels of right lower extremity	0,50	69,51
I7409	Other arterial embolism and thrombosis of abdominal aorta	0,49	70,00
I70243	Atherosclerosis of native arteries of left leg with ulceration of ankle	0,48	70,48
I70233	Atherosclerosis of native arteries of right leg with ulceration of ankle	0,47	70,95
I82442	Acute embolism and thrombosis of left tibial vein	0,46	71,41
I7789	Other specified disorders of arteries and arterioles	0,45	71,85
I70244	Atherosclerosis of native arteries of left leg with ulceration of heel and midfoot	0,43	72,29
I700	Atherosclerosis of aorta	0,43	72,72
I82491	Acute embolism and thrombosis of other specified deep vein of right lower extremity	0,41	73,13
I82401	Acute embolism and thrombosis of unspecified deep veins of right lower extremity	0,40	73,53
I82441	Acute embolism and thrombosis of right tibial vein	0,40	73,94
I82890	Acute embolism and thrombosis of other specified veins	0,40	74,34
I83228	Varicose veins of left lower extremity with both ulcer of other part of lower extremity and inflammation	0,40	74,73
I7102	Dissection of abdominal aorta	0,39	75,13

E1159	Type 2 diabetes mellitus with other circulatory complications	0,39	75,51
I80202	Phlebitis and thrombophlebitis of unspecified deep vessels of left lower extremity	0,39	75,90
M318	Other specified necrotizing vasculopathies	0,37	76,27
I728	Aneurysm of other specified arteries	0,37	76,64
I7389	Other specified peripheral vascular diseases	0,36	77,00
I83891	Varicose veins of right lower extremity with other complications	0,36	77,36
I864	Gastric varices	0,36	77,72
I770	Arteriovenous fistula, acquired	0,36	78,08
I70234	Atherosclerosis of native arteries of right leg with ulceration of heel and midfoot	0,35	78,43
I779	Disorder of arteries and arterioles, unspecified	0,35	78,78
I8312	Varicose veins of left lower extremity with inflammation	0,34	79,12
I731	Thromboangiitis obliterans [Buerger's disease]	0,34	79,46
I80232	Phlebitis and thrombophlebitis of left tibial vein	0,34	79,79
I82220	Acute embolism and thrombosis of inferior vena cava	0,34	80,13
APR-DRG 198 – Angina pectoris & coronary atherosclerosis			
R0789	Other chest pain	14,11	14,11
I2510	Atherosclerotic heart disease of native coronary artery without angina pectoris	11,90	26,01
I209	Angina pectoris, unspecified	11,02	37,03
I200	Unstable angina	9,37	46,40
R072	Precordial pain	7,41	53,82
I25110	Atherosclerotic heart disease of native coronary artery with unstable angina pectoris	6,61	60,43
R079	Chest pain, unspecified	6,40	66,82
I255	Ischemic cardiomyopathy	6,33	73,16
I25119	Atherosclerotic heart disease of native coronary artery with unspecified angina pectoris	5,96	79,12
I208	Other forms of angina pectoris	5,58	84,70
APR-DRG 199 – Hypertension			

I10	Essential (primary) hypertension	65,16	65,16
I119	Hypertensive heart disease without heart failure	8,74	73,91
I169	Hypertensive crisis, unspecified	7,98	81,89
APR-DRG 200 – Cardiac structural & valvular disorders			
I350	Nonrheumatic aortic (valve) stenosis	52,47	52,47
I340	Nonrheumatic mitral (valve) insufficiency	15,19	67,66
I352	Nonrheumatic aortic (valve) stenosis with insufficiency	8,67	76,33
I351	Nonrheumatic aortic (valve) insufficiency	3,35	79,68
Q211	Atrial septal defect	2,74	82,42
APR-DRG 201 – Cardiac arrhythmia & conduction disorders			
I4891	Unspecified atrial fibrillation	27,75	27,75
I480	Paroxysmal atrial fibrillation	18,66	46,41
I481	Persistent atrial fibrillation	7,56	53,97
I471	Supraventricular tachycardia	6,73	60,70
I4892	Unspecified atrial flutter	6,11	66,81
R001	Bradycardia, unspecified	5,34	72,15
I482	Chronic atrial fibrillation	4,72	76,88
I472	Ventricular tachycardia	2,90	79,77
R002	Palpitations	2,73	82,50
APR-DRG 203 – Chest pain			
R0789	Other chest pain	51,04	51,04
R072	Precordial pain	23,67	74,71
R079	Chest pain, unspecified	22,67	97,37
APR-DRG 204 – Syncope & collapse			
R55	Syncope and collapse	73,84	73,84
I951	Orthostatic hypotension	25,89	99,73
APR-DRG 205 - Cardiomyopathy			
I420	Dilated cardiomyopathy	44,86	44,86
I422	Other hypertrophic cardiomyopathy	13,93	58,79

I428	Other cardiomyopathies	13,43	72,22
I429	Cardiomyopathy, unspecified	7,88	80,10
APR-DRG 206 – Malfunction, reaction, complication of cardiac/vascular device or procedure			
T82868A	Thrombosis due to vascular prosthetic devices, implants and grafts, initial encounter	16,46	16,46
T827XXA	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts, initial encounter	12,87	29,33
I9789	Other postprocedural complications and disorders of the circulatory system, not elsewhere classified	12,69	42,02
T826XXA	Infection and inflammatory reaction due to cardiac valve prosthesis, initial encounter	4,81	46,82
T8172XA	Complication of vein following a procedure, not elsewhere classified, initial encounter	3,46	50,28
T82838A	Hemorrhage due to vascular prosthetic devices, implants and grafts, initial encounter	3,39	53,67
T82897A	Other specified complication of cardiac prosthetic devices, implants and grafts, initial encounter	3,26	56,93
T82858A	Stenosis of other vascular prosthetic devices, implants and grafts, initial encounter	3,23	60,16
T82190A	Other mechanical complication of cardiac electrode, initial encounter	2,84	63,00
T82898A	Other specified complication of vascular prosthetic devices, implants and grafts, initial encounter	2,35	65,35
T82867A	Thrombosis due to cardiac prosthetic devices, implants and grafts, initial encounter	2,25	67,60
T8621	Heart transplant rejection	1,99	69,59
T82110A	Breakdown (mechanical) of cardiac electrode, initial encounter	1,86	71,45
T82330A	Leakage of aortic (bifurcation) graft (replacement), initial encounter	1,50	72,95
T82538A	Leakage of other cardiac and vascular devices and implants, initial encounter	1,47	74,42
T82594A	Other mechanical complication of infusion catheter, initial encounter	1,29	75,71
I97130	Postprocedural heart failure following cardiac surgery	1,24	76,95
T82857A	Stenosis of other cardiac prosthetic devices, implants and grafts, initial encounter	1,14	78,09
T82120A	Displacement of cardiac electrode, initial encounter	1,11	79,20

T82191A	Other mechanical complication of cardiac pulse generator (battery), initial encounter	1,06	80,26
207* Pericarditis			
I309	Acute pericarditis, unspecified	12,50	25,01
I319	Disease of pericardium, unspecified	6,94	42,56
I301	Infective pericarditis	5,72	48,28
I313	Pericardial effusion (noninflammatory)	2,92	66,92
I5181	Takotsubo syndrome [excluded]	2,45	69,37
I308	Other forms of acute pericarditis	2,20	71,57
I514	Myocarditis, unspecified [excluded]	1,79	75,31
I400	Infective myocarditis [excluded]	1,37	81,06

Dark grey indicates a surgical APR-DRG, while light grey indicates a medical APR-DRG

A.3.13 Estimates of median odds ratio (MOR) with 95% confidence interval from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length of stay for cardiovascular APR-DRGs in 2016-2018.

	Model 1: patient characteristics[a]	Model 2: patient and hospital characteristics[b]
APR-DRG	**Median odds ratio (95% CI)[c]**	**Median odds ratio (95% CI)[c]**
Mortality		
161-Cardiac defibrillator & heart assist implant	NA	NA
162-Cardiac valve procedures with cardiac catheterization	NE	NE
163-Cardiac valve procedures without cardiac catheterization	**1.76 (1.35-2.10)**	1,40 (0.91-1.63)
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	**1.58 (1.06-1.90)**	1.45 (0.87-1.73)
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	**1.85 (1.24-2.32)**	1.54 (0.83-1.89)
169-Major thoracic & abdominal vascular procedures	**1.33 (1.12-1.48)**	1.14 (0.84-1.29)
170-Permanent cardiac pacemaker implant with AMI, heart failure or shock	NA	NA
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	1.63 (0.87-2.02)	1.63 (0.87-2.02)
174-Percutaneous cardiovascular procedures with AMI	**1.43 (1.21-1.59)**	**1.42 (1.20-1.59)**
175-Percutaneous cardiovascular procedures without AMI	**1.54 (1.30-1.74)**	**1.45 (1.22-1.62)**
176-Cardiac pacemaker & defibrillator device replacement	NA	NA
177-Cardiac pacemaker & defibrillator revision except device replacement	NA	NA
190-Acute myocardial infarction (AMI)	**1.51 (1.38-1.63)**	**1.44 (1.32-1.54)**
191-Cardiac catheterization with circulatory disorder except ischemic heart disease	**1.90 (1.52-2.24)**	**1.71 (1.3-1.99)**
192-Cardiac catheterization for ischemic heart disease	1.82 (0.87-2.36)	1.72 (0.77-2.25)
193-Acute & subacute endocarditis	**2.34 (1.24-3.26)**	**2.30 (1.18-3.20)**
194-Heart failure	**1.20 (1.15-1.24)**	**1.16 (1.12-1.20)**
196-Cardiac arrest	**2.22 (1.84-2.58)**	**1.99 (1.69-2.28)**
197-Peripheral & other vascular disorders	**1.30 (1.16-1.40)**	**1.25 (1.10-1.35)**
198-Angina pectoris & coronary atherosclerosis	**2.04 (1.66-2.39)**	**1.76 (1.44-2.05)**
199-Hypertension	**2.51 (1.76-3.22)**	**2.30 (1.59-2.95)**
200-Cardiac structural & valvular disorders	1.43 (0.91-1.67)	1.39 (0.86-1.63)
201-Cardiac arrhythmia & conduction disorders	**1.49 (1.36-1.61)**	**1.41 (1.28-1.52)**
203-Chest pain	NE	NE
204-Syncope & collapse	1.41 (0.92-1.64)	1.33 (0.83-1.55)
205-Cardiomyopathy	1.23 (0.56-1.96)	1.17 (0.56-1.87)
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	1.52 (0.73-1.96)	1.42 (0.70-1.84)
207*-Pericarditis	2.42 (0.65-3.75)	2.24 (0.60-3.49)
Readmissions		
161-Cardiac defibrillator & heart assist implant	NE	NE

162-Cardiac valve procedures with cardiac catheterization	1.34 (0.64-1.84)	1.32 (0.64-1.82)
163-Cardiac valve procedures without cardiac catheterization	1.20 (0.88-1.34)	1.14 (0.85-1.27)
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	1.22 (0.87-1.37)	NE
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	**1.54 (1.21-1.78)**	1.34 (0.95-1.52)
169-Major thoracic & abdominal vascular procedures	1.28 (0.95-1.42)	1.27 (0.93-1.42)
170-Permanent cardiac pacemaker implant with AMI, heart failure or shock	1.27 (0.61-1.83)	1.28 (0.61-1.83)
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	1.08 (0.86-1.20)	NE
174-Percutaneous cardiovascular procedures with AMI	**1.16 (1.04-1.24)**	1.06 (0.90-1.14)
175-Percutaneous cardiovascular procedures without AMI	**1.21 (1.12-1.27)**	**1.13 (1.05-1.18)**
176-Cardiac pacemaker & defibrillator device replacement	1.17 (0.79-1.38)	1.01 (0.77-1.29)
177-Cardiac pacemaker & defibrillator revision except device replacement	NE	NE
190-Acute myocardial infarction (AMI)	1.08 (0.87-1.86)	1.04 (0.87-1.16)
191-Cardiac catheterization with circulatory disorder except ischemic heart disease	**1.20 (1.10-1.29)**	1.16 (0.93-1.25)
192-Cardiac catheterization for ischemic heart disease	**1.30 (1.14-1.41)**	1.18 (0.95-1.28)
193-Acute & subacute endocarditis	NE	NE
194-Heart failure	**1.12 (1.06-1.15)**	**1.09 (1.03-1.13)**
196-Cardiac arrest	1.91 (0.39-3.75)	1.86 (0.38-3.68)
197-Peripheral & other vascular disorders	NE	NE
198-Angina pectoris & coronary atherosclerosis	1.25 (0.95-1.37)	1.23 (0.93-1.36)
199-Hypertension	**1.39 (1.15-1.55)**	**1.33 (1.04-1.50)**
200-Cardiac structural & valvular disorders	1.16 (0.75-1.43)	NE
201-Cardiac arrhythmia & conduction disorders	**1.17 (1.10-1.23)**	**1.13 (1.10-1.18)**
203-Chest pain	1.28 (0.88-1.44)	1.27 (0.88-1.43)
204-Syncope & collapse	1.14 (0.92-1.23)	1.01 (0.88-1.43)
205-Cardiomyopathy	1.39 (0.63-1.92)	1.17 (0.56-1.87)
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	NE	NE
207*-Pericarditis	1.26 (0.84-1.45)	1.20 (0.80-1.40)
Prolonged Length of stay		
161-Cardiac defibrillator & heart assist implant	**1.75 (1.33-2.10)**	**1.40 (1.10-1.60)**
162-Cardiac valve procedures with cardiac catheterization	1.68 (0.90-2.10)	1.54 (0.81-1.90)
163-Cardiac valve procedures without cardiac catheterization	**1.70 (1.39-1.97)**	**1.51 (1.27-1.71)**
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	**1.69 (1.33-1.98)**	**1.49 (1.18-1.72)**
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	**1.96 (1.54-2.34)**	**1.68 (1.78-1.94)**
169-Major thoracic & abdominal vascular procedures	**1.59 (1.41-1.76)**	**1.52 (1.34-1.67)**
170-Permanent cardiac pacemaker implant with AMI, heart failure or shock	1.61 (0.69-2.16)	1.57 (0.67-2.11)
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	**1.69 (1.51-1.86)**	**1.60 (1.43-1.74)**

174-Percutaneous cardiovascular procedures with AMI	**1.48 (1.33-1.61)**	**1.42 (1.28-1.54)**
175-Percutaneous cardiovascular procedures without AMI	**1.51 (1.38-1.63)**	**1.43 (1.31-1.53)**
176-Cardiac pacemaker & defibrillator device replacement	**1.72 (1.40-2.00)**	**1.65 (1.34-1.90)**
177-Cardiac pacemaker & defibrillator revision except device replacement	**1.77 (1.12-2.22)**	0.48 (0.78-1.83)
190-Acute myocardial infarction (AMI)	**1.57 (1.42-1.70)**	**1.49 (1.36-1.61)**
191-Cardiac catheterization with circulatory disorder except ischemic heart disease	**1.62 (1.46-1.76)**	**1.48 (1.35-1.60)**
192-Cardiac catheterization for ischemic heart disease	**1.95 (1.72-2.17)**	**1.73 (1.55-1.89)**
193-Acute & subacute endocarditis	1.49 (0.50-2.45)	1.27 (0.46-2.34)
194-Heart failure	**1.50 (1.40-1.59)**	**1.45 (1.36-1.53)**
196-Cardiac arrest	**1.67 (1.28-1.98)**	**1.64 (1.25-1.94)**
197-Peripheral & other vascular disorders	**1.60 (1.44-1.73)**	**1.47 (1.33-1.59)**
198-Angina pectoris & coronary atherosclerosis	**2.09 (1.81-2.35)**	**1.81 (1.60-2.01)**
199-Hypertension	**1.73 (1.47-1.96)**	**1.57 (1.32-1.77)**
200-Cardiac structural & valvular disorders	**1.98 (1.61-2.31)**	**1.75 (1.42-2.03)**
201-Cardiac arrhythmia & conduction disorders	**1.74 (1.68-1.88)**	**1.55 (1.43-1.65)**
203-Chest pain	**1.87 (1.64-2.10)**	**1.78 (1.57-1.98)**
204-Syncope & collapse	**1.67 (1.51-1.81)**	**1.51 (1.38-1.62)**
205-Cardiomyopathy	1.40 (0.66-1.88)	1.32 (0.64-1.80)
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	**1.53 (1.14-1.80)**	1.42 (0.86-1.68)
207*-Pericarditis	**1.70 (1.37-1.97)**	1.38 (0.90-1.60)

Abbreviations: NA, not applicable; NE, not estimable; CI, confidence interval

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge

[b]Additionally adjusted for region, hospital type, and annual volume per DRG

[c]The odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

Note: Median odds ratios are not presented for models with <30 cases (indicated as NA) and for models in which the random hospital effect was estimated to be zero (indicated as NE).

Dark grey indicates a surgical APR-DRG, while light grey indicates a medical APR-DRG

Median Odds Ratios indicated in bold are statistically significant at an alpha-level of 0.0

A.3.14 Adjusted odds ratios (95% confidence intervals) for patient characteristics from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length-of-stay[a]

	Sex	Comorbidity index		Place before admission		Admission type	Year of discharge	
APR-DRG	Male (vs female)	1-4 (vs 0)	≥5 (vs 0)	Other hospital or nursing home (vs home)	In transit or other (vs home)	Emergency (vs elective)	2016 (vs 2018)	2017 (vs 2018)
Mortality								
162-Cardiac valve procedures with cardiac catheterization	0.72 (0.51-1.03)	1.04 (0.48-2.24)	1.63 (0.75-3.53)	**2.58 (1.58-4.21)**	1.58 (0.67-3.74)	**2.15 (1.45-3.19)**	1.13 (0.74-1.72)	1.06 (0.69-1.65)
163-Cardiac valve procedures without cardiac catheterization	0.80 (0.64-1.01)	1.33 (0.91-1.94)	**2.68 (1.79-4.01)**	**2.62 (1.84-3.73)**	1.34 (0.49-3.69)	**4.38 (3.26-5.89)**	1.25 (0.96-1.65)	1.18 (0.89-1.56)
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	0.89 (0.64-1.24)	1.48 (0.93-2.37)	**4.01 (2.44-6.57)**	1.17 (0.77-1.77)	0.74 (0.31-1.75)	**1.95 (1.41-2.71)**	1.00 (0.69-1.45)	1.14 (0.79-1.64)
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	0.87 (0.59-1.29)	**2.56 (1.47-4.47)**	4.86 (2.59-9.12)	**1.69 (1.05-2.74)**	1.81 (0.58-5.68)	**3.18 (1.97-5.13)**	0.95 (0.62-1.45)	1.03 (0.68-1.56)
169-Major thoracic & abdominal vascular procedures	1.19 (0.98-1.46)	**1.28 (1.01-1.62)**	**2.19 (1.64-2.92)**	**1.85 (1.39-2.46)**	1.14 (0.70-1.85)	**6.45 (5.35-7.78)**	0.91 (0.74-1.14)	1.13 (0.91-1.40)
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	**1.48 (1.06-2.08)**	**2.26 (1.16-4.41)**	**5.64 (2.82-11.26)**	1.25 (0.75-2.07)		**6.03 (3.76-9.65)**	0.95 (0.64-1.42)	0.85 (0.57-1.27)
174-Percutaneous cardiovascular procedures with AMI	**0.80 (0.70-0.91)**	**1.79 (1.53-2.11)**	**2.27 (1.85-2.80)**	1.14 (0.95-1.35)	**1.48 (1.16-1.89)**	**3.45 (2.61-4.56)**	0.97 (0.84-1.13)	0.91 (0.78-1.05)
175-Percutaneous cardiovascular procedures without AMI	1.00 (0.83-1.20)	**2.53 (1.93-3.32)**	**6.00 (4.45-8.11)**	**2.05 (1.54-2.73)**	**2.63 (1.86-3.71)**	**8.42 (6.92-10.25)**	1.02 (0.82-1.26)	1.00 (0.81-1.22)
190-Acute myocardial infarction (AMI)	0.98 (0.89-1.07)	0.94 (0.83-1.06)	1.11 (0.96-1.28)	**1.18 (1.06-1.32)**	**1.55 (1.24-1.93)**	**3.27 (2.71-3.94)**	1.10 (0.98-1.23)	1.07 (0.95-1.19)

191-Cardiac catheterization with circulatory disorder except ischemic heart disease	**1.27 (1.05-1.54)**	**1.85 (1.32-2.61)**	**3.17 (2.22-4.54)**	**2.45 (1.82-3.31)**	**1.89 (1.34-2.65)**	**13.15 (9.73-17.76)**	1.02 (0.82-1.28)	0.95 (0.76-1.20)
192-Cardiac catheterization for ischemic heart disease	**1.80 (1.14-2.84)**	**2.48 (1.40-4.39)**	**3.34 (1.61-6.91)**	**4.13 (2.06-8.26)**	**5.01 (2.77-9.09)**	**10.70 (6.49-17.63)**	1.36 (0.82-2.26)	1.25 (0.75-2.08)
193-Acute & subacute endocarditis	0.70 (0.42-1.15)	**3.11 (1.01-9.65)**	**3.79 (1.18-12.16)**	**2.54 (1.39-4.66)**	1.77 (0.54-5.79)	**3.15 (1.64-6.05)**	1.21 (0.67-2.18)	1.03 (0.58-1.84)
194-Heart failure	**1.36 (1.29-1.42)**	**0.64 (0.55-0.73)**	**0.64 (0.56-0.74)**	**1.80 (1.70-1.91)**	0.89 (0.75-1.06)	**1.39 (1.29-1.51)**	1.01 (0.95-1.07)	1.00 (0.95-1.06)
196-Cardiac arrest	0.96 (0.76-1.21)	**0.24 (0.18-0.32)**	**0.09 (0.07-0.14)**	1.08 (0.74-1.56)	0.94 (0.67-1.31)	**6.64 (3.51-12.56)**	**0.70 (0.53-0.92)**	0.94 (0.71-1.24)
197-Peripheral & other vascular disorders	**1.68 (1.47-1.91)**	**0.78 (0.67-0.92)**	1.00 (0.82-1.21)	**2.11 (1.80-2.47)**	1.14 (0.80-1.62)	**3.61 (3.01-4.32)**	**0.85 (0.73-0.99)**	**0.85 (0.73-0.99)**
198-Angina pectoris & coronary atherosclerosis	**1.49 (1.17-1.89)**	1.20 (0.87-1.63)	**1.45 (1.00-2.09)**	**1.85 (1.34-2.55)**	1.66 (0.97-2.84)	**1.48 (1.04-2.13)**	**1.37 (1.03-1.83)**	1.32 (0.99-1.78)
199-Hypertension	**2.17 (1.41-3.33)**	0.97 (0.59-1.60)	**4.13 (2.26-7.53)**	**4.85 (2.97-7.91)**	0.57 (0.13-2.53)	1.56 (0.75-3.25)	**2.52 (1.53-4.16)**	0.97 (0.55-1.69)
200-Cardiac structural & valvular disorders	1.13 (0.87-1.46)	**1.64 (1.00-2.67)**	**1.79 (1.07-2.99)**	**1.51 (1.10-2.08)**	0.99 (0.50-1.97)	**2.75 (1.93-3.93)**	0.90 (0.66-1.21)	0.90 (0.66-1.22)
201-Cardiac arrhythmia & conduction disorders	**1.55 (1.38-1.74)**	**1.42 (1.21-1.68)**	**2.78 (2.31-3.35)**	**3.05 (2.64-3.53)**	1.05 (0.80-1.39)	**3.83 (2.95-4.98)**	**1.19 (1.04-1.37)**	0.99 (0.86-1.14)
204-Syncope & collapse	**1.79 (1.39-2.32)**	**2.66 (1.71-4.14)**	**5.07 (3.12-8.23)**	**1.48 (1.02-2.17)**	**0.57 (0.36-0.91)**	0.88 (0.51-1.50)	0.94 (0.69-1.27)	0.90 (0.66-1.21)
205-Cardiomyopathy	1.65 (0.99-2.75)	0.82 (0.33-2.06)	1.90 (0.75-4.80)	1.78 (0.91-3.48)	1.10 (0.37-3.26)	**2.97 (1.45-6.07)**	0.69 (0.38-1.26)	0.97 (0.56-1.68)

206-Malfunction, reaction, complication of cardiac/vascular device or procedure	1.23 (0.86-1.76)	1.51 (0.87-2.63)	**2.76 (1.50-5.08)**	**2.22 (1.37-3.61)**	1.87 (0.82-4.27)	**3.05 (1.97-4.72)**	1.22 (0.81-1.85)	0.88 (0.57-1.37)
207*-Pericarditis	0.95 (0.51-1.76)	**26.15 (3.49-195.7)**	**24.63 (2.92-208.1)**	2.68 (0.99-7.25)	**5.21 (1.97-13.80)**	1.37 (0.51-3.67)	1.36 (0.67-2.80)	1.11 (0.52-2.35)
Readmission								
161-Cardiac defibrillator & heart assist implant	0.77 (0.54-1.09)	1.21 (0.74-2.00)	**2.69 (1.55-4.66)**	0.68 (0.38-1.24)	0.62 (0.27-1.40)	**2.61 (1.86-3.67)**	0.86 (0.59-1.25)	0.92 (0.63-1.34)
162-Cardiac valve procedures with cardiac catheterization	0.93 (0.63-1.37)	1.31 (0.61-2.83)	1.39 (0.62-3.13)	0.53 (0.19-1.52)	1.02 (0.34-3.10)	1.48 (0.91-2.39)	0.87 (0.55-1.38)	0.92 (0.58-1.44)
163-Cardiac valve procedures without cardiac catheterization	**0.81 (0.67-0.98)**	1.08 (0.82-1.42)	**1.74 (1.27-2.40)**	**0.29 (0.12-0.71)**	0.35 (0.05-2.69)	**1.86 (1.31-2.65)**	0.81 (0.64-1.02)	0.99 (0.79-1.23)
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	**0.67 (0.50-0.90)**	1.13 (0.81-1.57)	**2.09 (1.41-3.11)**	**0.42 (0.24-0.73)**	0.84 (0.43-1.66)	**1.89 (1.41-2.53)**	1.20 (0.86-1.66)	1.32 (0.96-1.82)
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	**0.65 (0.51-0.82)**	**1.65 (1.26-2.16)**	**3.14 (2.21-4.44)**	0.63 (0.38-1.02)	1.29 (0.47-3.52)	**1.73 (1.17-2.56)**	1.05 (0.81-1.35)	1.00 (0.78-1.29)
169-Major thoracic & abdominal vascular procedures	**0.77 (0.64-0.93)**	**1.36 (1.09-1.69)**	**2.49 (1.84-3.37)**	0.65 (0.38-1.11)	1.16 (0.61-2.21)	**1.67 (1.34-2.09)**	0.91 (0.73-1.12)	0.90 (0.72-1.13)
170-Permanent cardiac pacemaker implant with AMI, heart failure or shock	1.06 (0.66-1.69)	1.34 (0.17-10.80)	1.78 (0.22-14.37)	1.09 (0.47-2.57)	1.62 (0.41-6.37)	**2.66 (1.42-4.97)**	1.04 (0.58-1.87)	1.27 (0.74-2.19)
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	0.90 (0.79-1.03)	1.15 (0.97-1.37)	**1.81 (1.46-2.25)**	1.15 (0.87-1.52)	0.76 (0.51-1.13)	**1.95 (1.69-2.24)**	1.13 (0.96-1.33)	1.15 (0.98-1.35)
174-Percutaneous cardiovascular procedures with AMI	**0.85 (0.75-0.96)**	**1.44 (1.26-1.65)**	**2.59 (2.16-3.11)**	**0.66 (0.52-0.83)**	0.95 (0.74-1.21)	**1.36 (1.11-1.67)**	1.06 (0.93-1.22)	1.00 (0.87-1.15)
175-Percutaneous cardiovascular procedures without AMI	**0.79 (0.73-0.86)**	**1.52 (1.39-1.67)**	**2.88 (2.52-3.29)**	**0.71 (0.53-0.94)**	0.98 (0.72-1.34)	**2.41 (2.19-2.65)**	**1.12 (1.02-1.24)**	1.01 (0.92-1.11)

176-Cardiac pacemaker & defibrillator device replacement	0.89 (0.67-1.18)	**1.98 (1.37-2.86)**	**3.69 (2.33-5.85)**	0.48 (0.17-1.34)	1.88 (0.62-5.73)	**1.78 (1.16-2.73)**	0.93 (0.66-1.30)	0.99 (0.70-1.39)
177-Cardiac pacemaker & defibrillator revision except device replacement	1.10 (0.73-1.67)	1.31 (0.78-2.20)	1.72 (0.88-3.35)	1.55 (0.70-3.39)	**3.19 (1.11-9.16)**	**1.72 (1.09-2.72)**	0.94 (0.57-1.55)	1.15 (0.71-1.87)
190-Acute myocardial infarction (AMI)	1.06 (0.93-1.20)	**1.48 (1.25-1.75)**	**2.13 (1.75-2.60)**	**0.84 (0.73-0.97)**	0.74 (0.51-1.07)	1.06 (0.90-1.23)	**1.19 (1.03-1.38)**	1.04 (0.89-1.20)
191-Cardiac catheterization with circulatory disorder except ischemic heart disease	1.10 (0.98-1.24)	**1.73 (1.45-2.07)**	**2.82 (2.31-3.45)**	1.14 (0.84-1.54)	**0.57 (0.38-0.84)**	**2.65 (2.34-3.00)**	0.99 (0.86-1.14)	1.04 (0.91-1.20)
192-Cardiac catheterization for ischemic heart disease	1.09 (0.95-1.24)	**1.53 (1.31-1.77)**	**2.71 (2.17-3.39)**	0.67 (0.35-1.27)	0.58 (0.33-1.03)	**2.19 (1.90-2.52)**	1.10 (0.94-1.29)	0.96 (0.82-1.14)
193-Acute & subacute endocarditis	0.99 (0.46-2.14)	3.60 (0.45-29.04)	6.37 (0.77-52.38)	**2.39 (1.02-5.59)**		1.86 (0.79-4.37)	1.24 (0.50-3.07)	0.86 (0.36-2.03)
194-Heart failure	**1.07 (1.02-1.13)**	**1.22 (1.01-1.49)**	**1.55 (1.27-1.88)**	**0.80 (0.74-0.87)**	**0.76 (0.64-0.91)**	**1.42 (1.32-1.54)**	1.01 (0.95-1.08)	0.97 (0.91-1.03)
196-Cardiac arrest	0.89 (0.43-1.83)	**4.21 (1.11-15.95)**	**5.58 (1.23-25.34)**	0.84 (0.27-2.68)	0.58 (0.12-2.79)	1.42 (0.30-6.72)	0.95 (0.37-2.47)	1.27 (0.49-3.32)
197-Peripheral & other vascular disorders	1.05 (0.91-1.21)	**1.51 (1.25-1.82)**	**2.24 (1.77-2.82)**	0.98 (0.77-1.25)	0.90 (0.60-1.36)	**1.74 (1.47-2.05)**	1.08 (0.91-1.28)	0.99 (0.83-1.18)
198-Angina pectoris & coronary atherosclerosis	1.14 (0.96-1.34)	**1.47 (1.20-1.82)**	**2.57 (2.00-3.30)**	0.96 (0.73-1.26)	0.97 (0.64-1.45)	**1.71 (1.32-2.21)**	1.03 (0.85-1.24)	0.97 (0.80-1.17)
199-Hypertension	**1.49 (1.19-1.85)**	1.19 (0.94-1.51)	**1.84 (1.27-2.67)**	0.93 (0.59-1.48)	0.80 (0.43-1.49)	1.31 (0.92-1.87)	1.05 (0.81-1.36)	0.98 (0.76-1.27)
200-Cardiac structural & valvular disorders	1.16 (0.87-1.55)	**1.87 (1.07-3.28)**	**3.13 (1.77-5.56)**	0.91 (0.61-1.35)	0.52 (0.19-1.47)	**1.97 (1.39-2.79)**	0.99 (0.70-1.41)	1.29 (0.92-1.81)

201-Cardiac arrhythmia & conduction disorders	0.95 (0.89-1.02)	**1.72 (1.57-1.88)**	**2.59 (2.31-2.91)**	1.03 (0.89-1.20)	**0.68 (0.56-0.82)**	**1.42 (1.28-1.58)**	1.01 (0.93-1.10)	1.05 (0.96-1.14)
203-Chest pain	1.17 (0.98-1.41)	**1.90 (1.54-2.35)**	**4.20 (3.03-5.83)**	0.94 (0.59-1.50)	0.86 (0.56-1.30)	0.83 (0.52-1.34)	1.14 (0.91-1.42)	1.05 (0.84-1.32)
204-Syncope & collapse	**1.12 (1.01-1.25)**	**1.82 (1.56-2.11)**	**3.20 (2.66-3.84)**	**0.79 (0.63-1.00)**	**0.73 (0.62-0.86)**	1.08 (0.85-1.37)	0.90 (0.79-1.03)	0.94 (0.83-1.07)
205-Cardiomyopathy	0.88 (0.55-1.39)	1.97 (0.75-5.21)	2.67 (0.96-7.42)	0.49 (0.19-1.26)	1.42 (0.56-3.65)	**2.01 (1.14-3.55)**	1.33 (0.78-2.27)	0.91 (0.52-1.61)
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	0.88 (0.69-1.13)	0.95 (0.70-1.31)	**1.85 (1.25-2.72)**	0.76 (0.45-1.31)	0.71 (0.32-1.57)	**1.65 (1.28-2.14)**	0.98 (0.73-1.32)	0.92 (0.69-1.24)
207*-Pericarditis	**0.65 (0.52-0.82)**	**1.41 (1.09-1.83)**	**2.08 (1.39-3.12)**	0.67 (0.34-1.33)	0.76 (0.39-1.47)	**1.52 (1.01-2.29)**	0.85 (0.65-1.11)	0.84 (0.64-1.09)
prolonged Length of stay								
161-Cardiac defibrillator & heart assist implant	0.81 (0.63-1.05)	**4.57 (2.60-8.03)**	**16.41 (9.10-29.57)**	**1.82 (1.35-2.45)**	1.19 (0.77-1.84)	**6.58 (5.21-8.31)**	0.91 (0.70-1.17)	0.88 (0.68-1.14)
162-Cardiac valve procedures with cardiac catheterization	1.02 (0.73-1.42)	2.27 (0.88-5.84)	**6.72 (2.62-17.25)**	0.95 (0.56-1.64)	0.70 (0.29-1.68)	**2.79 (1.94-4.01)**	1.29 (0.88-1.88)	0.94 (0.63-1.41)
163-Cardiac valve procedures without cardiac catheterization	1.00 (0.86-1.16)	**1.87 (1.44-2.43)**	**5.53 (4.18-7.32)**	**1.98 (1.55-2.54)**	0.82 (0.39-1.72)	**7.45 (6.10-9.09)**	**1.27 (1.06-1.51)**	1.15 (0.97-1.38)
165-Coronary bypass with cardiac catheter or percutaneous cardiac procedure	**0.77 (0.62-0.97)**	**3.24 (2.23-4.72)**	**10.43 (7.00-15.53)**	0.79 (0.58-1.07)	0.84 (0.49-1.44)	**2.05 (1.64-2.55)**	1.01 (0.78-1.29)	1.10 (0.86-1.41)
166-Coronary bypass without cardiac catheter or percutaneous cardiac procedure	**0.85 (0.72-0.99)**	**2.25 (1.85-2.73)**	**6.17 (4.90-7.79)**	1.23 (0.99-1.53)	1.74 (0.97-3.10)	**3.27 (2.63-4.06)**	1.02 (0.86-1.20)	1.04 (0.89-1.23)
169-Major thoracic & abdominal vascular procedures	1.00 (0.86-1.16)	**2.32 (1.90-2.84)**	**6.75 (5.31-8.57)**	**1.34 (1.03-1.72)**	1.03 (0.68-1.57)	**4.84 (4.19-5.60)**	**0.85 (0.72-1.00)**	0.85 (0.72-1.01)

170-Permanent cardiac pacemaker implant with AMI, heart failure or shock	0.72 (0.45-1.15)			1.13 (0.52-2.45)		**5.09 (2.33-11.13)**	1.20 (0.70-2.07)	0.85 (0.48-1.51)
171-Permanent cardiac pacemaker implant without AMI, heart failure or shock	**0.73 (0.65-0.82)**	**3.33 (2.68-4.15)**	**10.44 (8.26-13.18)**	**1.51 (1.25-1.83)**	1.09 (0.85-1.40)	**8.08 (6.98-9.35)**	**1.29 (1.13-1.48)**	1.10 (0.96-1.26)
174-Percutaneous cardiovascular procedures with AMI	**0.72 (0.65-0.79)**	**5.02 (4.23-5.96)**	**23.89 (19.83-28.78)**	0.91 (0.79-1.05)	**1.38 (1.14-1.67)**	**2.56 (2.13-3.09)**	**1.20 (1.07-1.34)**	**1.12 (1.00-1.25)**
175-Percutaneous cardiovascular procedures without AMI	**0.66 (0.62-0.70)**	**4.60 (4.20-5.03)**	**25.57 (22.93-28.51)**	0.98 (0.85-1.13)	1.12 (0.92-1.35)	**12.66 (11.83-13.55)**	**1.13 (1.05-1.22)**	1.03 (0.96-1.11)
176-Cardiac pacemaker & defibrillator device replacement	0.90 (0.71-1.12)	**4.72 (3.34-6.66)**	**17.23 (11.50-25.81)**	**2.06 (1.27-3.32)**	1.91 (0.89-4.07)	**60.66 (45.64-80.63)**	0.90 (0.69-1.17)	0.91 (0.69-1.19)
177-Cardiac pacemaker & defibrillator revision except device replacement	0.90 (0.66-1.24)	**1.59 (1.01-2.49)**	**5.96 (3.60-9.88)**	**2.82 (1.76-4.54)**	0.22 (0.05-1.04)	**6.25 (4.51-8.65)**	1.03 (0.71-1.51)	0.82 (0.56-1.21)
190-Acute myocardial infarction (AMI)	**0.72 (0.65-0.80)**	**4.56 (3.62-5.75)**	**13.06 (10.28-16.59)**	1.00 (0.89-1.13)	0.76 (0.54-1.06)	0.94 (0.81-1.09)	**1.21 (1.07-1.37)**	1.11 (0.98-1.26)
191-Cardiac catheterization with circulatory disorder except ischemic heart disease	**0.90 (0.82-0.97)**	**5.64 (4.55-6.98)**	**24.75 (19.88-30.82)**	**1.88 (1.58-2.23)**	1.03 (0.84-1.26)	**7.42 (6.70-8.20)**	**1.21 (1.09-1.34)**	**1.11 (1.01-1.23)**
192-Cardiac catheterization for ischemic heart disease	**0.88 (0.81-0.95)**	**2.29 (2.09-2.50)**	**8.89 (7.75-10.20)**	1.01 (0.78-1.30)	0.85 (0.70-1.04)	**26.29 (24.07-28.71)**	**1.29 (1.18-1.42)**	**1.11 (1.01-1.22)**
193-Acute & subacute endocarditis	0.93 (0.52-1.68)	1.27 (0.36-4.44)	3.05 (0.88-10.63)	0.92 (0.43-1.95)	1.45 (0.31-6.72)	0.90 (0.47-1.74)	1.49 (0.73-3.06)	1.33 (0.66-2.68)
194-Heart failure	**0.85 (0.80-0.89)**	**1.85 (1.42-2.40)**	**4.44 (3.42-5.76)**	1.00 (0.93-1.07)	0.95 (0.79-1.13)	1.06 (0.98-1.15)	**1.12 (1.05-1.19)**	1.04 (0.97-1.10)
196-Cardiac arrest	0.86 (0.65-1.14)	**8.23 (4.96-13.63)**	**32.63 (18.96-56.15)**	0.81 (0.53-1.23)	1.08 (0.70-1.68)	**0.50 (0.25-0.98)**	**1.71 (1.21-2.42)**	1.38 (0.98-1.96)

197-Peripheral & other vascular disorders	**0.74 (0.66-0.83)**	**2.13 (1.77-2.56)**	**5.97 (4.90-7.28)**	1.02 (0.86-1.21)	**0.59 (0.39-0.91)**	**1.17 (1.03-1.33)**	1.10 (0.95-1.26)	1.04 (0.90-1.19)
198-Angina pectoris & coronary atherosclerosis	**0.77 (0.68-0.89)**	**3.38 (2.64-4.32)**	**10.85 (8.35-14.11)**	**1.74 (1.44-2.12)**	1.24 (0.87-1.77)	0.85 (0.71-1.02)	1.12 (0.95-1.33)	1.09 (0.92-1.28)
199-Hypertension	**0.80 (0.66-0.98)**	**3.38 (2.62-4.37)**	**11.58 (8.55-15.69)**	**1.64 (1.25-2.15)**	0.98 (0.56-1.72)	0.78 (0.61-1.00)	1.02 (0.83-1.26)	1.01 (0.83-1.24)
200-Cardiac structural & valvular disorders	0.82 (0.64-1.06)	**2.42 (1.39-4.21)**	**4.93 (2.81-8.67)**	1.03 (0.74-1.42)	0.81 (0.39-1.69)	**1.60 (1.18-2.16)**	0.92 (0.69-1.23)	1.00 (0.75-1.33)
201-Cardiac arrhythmia & conduction disorders	**0.82 (0.77-0.88)**	**3.93 (3.47-4.44)**	**14.63 (12.84-16.68)**	**1.51 (1.36-1.67)**	**0.79 (0.66-0.94)**	**2.19 (1.97-2.45)**	**1.12 (1.04-1.21)**	1.06 (0.98-1.15)
203-Chest pain	**0.64 (0.56-0.73)**	**3.19 (2.71-3.76)**	**9.16 (7.23-11.61)**	**1.62 (1.25-2.11)**	1.03 (0.76-1.40)	**0.57 (0.42-0.77)**	**1.30 (1.11-1.53)**	1.09 (0.92-1.28)
204-Syncope & collapse	**0.69 (0.64-0.75)**	**2.61 (2.28-2.99)**	**6.59 (5.66-7.68)**	1.01 (0.88-1.16)	**0.35 (0.30-0.41)**	**0.72 (0.61-0.86)**	1.06 (0.96-1.18)	0.92 (0.83-1.01)
205-Cardiomyopathy	1.13 (0.74-1.73)	2.63 (0.79-8.75)	**8.59 (2.57-28.68)**	1.28 (0.69-2.40)	1.99 (0.82-4.83)	0.78 (0.49-1.25)	1.14 (0.69-1.88)	1.00 (0.61-1.64)
206-Malfunction, reaction, complication of cardiac/vascular device or procedure	1.17 (0.93-1.47)	**1.91 (1.32-2.75)**	**4.95 (3.30-7.42)**	**3.02 (2.18-4.17)**	0.89 (0.43-1.82)	**1.60 (1.26-2.04)**	1.19 (0.90-1.58)	1.14 (0.86-1.50)
207*-Pericarditis	**0.50 (0.37-0.66)**	**3.78 (2.40-5.98)**	**9.10 (5.31-15.60)**	1.10 (0.62-1.98)	1.22 (0.57-2.65)	0.92 (0.61-1.37)	**1.51 (1.08-2.11)**	1.01 (0.70-1.46)

Abbreviation: AMI, acute myocardial infarction
Light grey indicates a surgical APR-DRG

A.3.15 List of All Patient Refined Diagnosis Related Groups (APR-DRGs) that represent over 80% of APR-DRGs within the Major Diagnostic Categories (MDCs)

APR-DRG	Description	Percent representation within MDC	Cumulative percent representation within MDC
MDC 1 – Diseases & disorders of the nervous system			
58	Other disorders of the nervous system	14.84	14.84
53	Seizure	12.50	27.33
45	CVA & precerebral occlusion with infarct	11.90	39.23
42	Degenerative nervous system disorders except multiple sclerosis	9.53	48.76
57	Concussion, closed skull Fx nos, uncomplicated intracranial injury, coma < 1 hr or no coma	6.47	55.23
47	Transient ischemia	5.94	61.17
54	Migraine & other headaches	5.05	66.23
24	Extracranial vascular procedures	4.05	70.28
21	Craniotomy except for trauma	3.80	74.08
48	Peripheral, cranial & autonomic nerve disorders	3.37	77.45
23	Spinal procedures	3.03	80.48
MDC 2 – Diseases & disorders of the eye			
73	Eye procedures except orbit	72.38	72.38
82	Eye disorders except major infections	19.58	91.96
MDC 3 – Diseases & disorders of the ear, nose, mouth & throat			
115	Other ear, nose, mouth, throat & cranial/facial diagnoses	49.25	49.25
113	Infections of upper respiratory tract	13.04	62.30
98	Other ear, nose, mouth & throat procedures	11.11	73.40
97	Tonsil & adenoid procedures	6.09	79.50
111	Vertigo & other labyrinth disorders	4.88	84.38
MDC 4 – Diseases & disorders of the respiratory system			
139	Other pneumonia	22.67	22.67
140	Chronic obstructive pulmonary disease	22.47	45.14
144	Respiratory signs, symptoms & minor diagnoses	16.26	61.41
137	Major respiratory infections & inflammations	6.24	67.64
136	Respiratory malignancy	5.91	73.56
141	Asthma	4.05	77.60
134	Pulmonary embolism	4.04	81.65
MDC 5 – Diseases & disorders of the circulatory system			
175	Percutaneous cardiovascular procedures w/o AMI	13.13	13.13

173	Other vascular procedures	11.41	24.54
194	Heart Failure	11.25	35.79
201	Cardiac arrhythmia & conduction disorders	9.55	45.34
192	Cardiac catheterization for ischemic heart disease	7.86	53.20
191	Cardiac catheterization w circ disord exc ischemic heart disease	5.75	58.95
204	Syncope & collapse	5.25	64.20
174	Percutaneous cardiovascular procedures w AMI	4.34	68.54
190	Acute myocardial infarction	3.46	72.00
171	Perm cardiac pacemaker implant w/o AMI, heart failure or shock	3.18	75.18
197	Peripheral & other vascular disorders	2.64	77.81
207	Other circulatory system diagnoses	2.61	80.42
MDC 6 – Diseases & disorders of the digestive system			
249	Non-bacterial gastroenteritis, nausea & vomiting	13.85	13.85
254	Other digestive system diagnoses	11.73	25.58
221	Major small & large bowel procedures	8.72	34.31
228	Inguinal, femoral & umbilical hernia procedures	7.93	42.23
225	Appendectomy	7.19	49.42
244	Diverticulitis & diverticulosis	5.43	54.85
247	Intestinal obstruction	4.55	59.40
227	Hernia procedures except inguinal, femoral & umbilical	4.52	63.92
241	Peptic ulcer & gastritis	4.28	68.20
240	Digestive malignancy	3.76	71.96
226	Anal procedures	3.61	75.57
251	Abdominal pain	3.38	78.95
243	Other esophageal disorders	2.97	81.92
MDC 7 – Diseases & disorders of the hepatobiliary system & pancreas			
263	Laparoscopic cholecystectomy	35.01	35.01
284	Disorders of gallbladder & biliary tract	18.18	53.18
282	Disorders of pancreas except malignancy	11.84	65.03
281	Malignancy of hepatobiliary system & pancreas	8.36	73.38
280	Alcoholic liver disease	6.26	79.65
264	Other hepatobiliary, pancreas & abdominal procedures	4.83	84.47
MDC 8 – Diseases & disorders of the musculoskeletal system & connective tissue			
315	Shoulder, upper arm & forearm procedures	13.74	13.74
301	Hip joint replacement	11.69	25.43
302	Knee joint replacement	10.01	35.44
347	Other back & neck disorders, fractures & injuries	7.52	42.96

313	Knee & lower leg procedures except foot	7.09	50.05
310	Intervertebral disc excision & decompression	6.81	56.86
314	Foot & toe procedures	6.39	63.25
351	Other musculoskeletal system & connective tissue diagnoses	5.23	68.48
317	Tendon, muscle & other soft tissue procedures	4.55	73.04
320	Other musculoskeletal system & connective tissue procedures	4.21	77.24
308	Hip & femur procedures for trauma except joint replacement	4.14	81.39
MDC 9 – Diseases & disorders of the skin, subcutaneous tissue & breast			
363	Breast procedures except mastectomy	25.21	25.21
383	Cellulitis & other bacterial skin infections	19.79	45.01
364	Other skin, subcutaneous tissue & related procedures	12.45	57.46
384	Contusion, open wound & other trauma to skin & subcutaneous tissue	11.81	69.27
361	Skin graft for skin & subcutaneous tissue diagnoses	8.27	77.54
362	Mastectomy procedures	7.96	85.49
MDC 10 – Endocrine, nutritional & metabolic diseases & disorders			
403	Procedures for obesity	30.73	30.73
420	Diabetes	21.09	51.82
404	Thyroid, parathyroid & thyroglossal procedures	13.34	65.16
421	Malnutrition, failure to thrive & other nutritional disorders	9.69	74.86
422	Hypovolemia & related electrolyte disorders	8.73	83.59
MDC 11 – Diseases & disorders of the kidney & urinary tract			
463	Kidney & urinary tract infections	25.03	25.03
446	Urethral & transurethral procedures	16.51	41.54
465	Urinary stones & acquired upper urinary tract obstruction	14.13	55.67
468	Other kidney & urinary tract diagnoses, signs & symptoms	13.74	69.41
443	Kidney & urinary tract procedures for nonmalignancy	10.22	79.63
460	Renal failure	5.12	84.75
MDC 12 – Diseases & disorders of the male reproductive system			
482	Transurethral prostatectomy	34.16	34.16
501	Male reproductive system diagnoses except malignancy	21.43	55.59
480	Major male pelvic procedures	17.06	72.65
483	Testes & scrotal procedures	9.10	81.75
MDC 13 – Diseases & disorders of the female reproductive system			

513	Uterine & adnexa procedures for non-malignancy except leiomyoma	42.66	42.66
519	Uterine & adnexa procedures for leiomyoma	14.88	57.54
514	Female reproductive system reconstructive procedures	13.42	70.96
518	Other female reproductive system & related procedures	6.01	76.97
532	Menstrual & other female reproductive system disorders	5.92	82.89
MDC 16 – Diseases & disorders of blood, blood forming organs, immunological disorders			
663	Other anemia & disorders of blood & blood-forming organs	60.20	60.20
660	Major hematologic/immunologic diag exc sickle cell crisis & coagul	22.14	82.33
MDC 17 – Myeloproliferative diseases & disorders, poorly differentiated neoplasm			
693	Chemotherapy	63.65	63.65
681	Other O.R. procedures for lymphatic/hematopoietic/other neoplasms	10.70	74.35
691	Lymphoma, myeloma & non-acute leukemia	8.91	83.25
MDC 18 – Infectious & parasitic diseases, systemic or unspecified sites			
720	Septicemia & disseminated infections	36.08	36.08
723	Viral illness	21.55	57.63
721	Post-operative, post-traumatic, other device infections	11.38	69.01
724	Other infectious & parasitic diseases	8.46	77.48
710	Infectious & parasitic diseases including HIV w O.R. procedure	8.30	85.78
MDC 19 – Mental diseases & disorders			
760	Other mental health disorders	55.69	55.69
757	Organic mental health disturbances	21.96	77.65
756	Acute anxiety & delirium states	20.53	98.18
MDC 21 – Injuries, poisonings & toxic effects of drugs			
812	Poisoning of medicinal agents	40.80	40.80
813	Other complications of treatment	20.80	61.59
791	O.R. procedure for other complications of treatment	17.62	79.21
815	Other injury, poisoning & toxic effect diagnoses	7.98	87.20
MDC 23 – Factors influencing health status & other contacts with health services			
861	Signs, symptoms & other factors influencing health status	50.48	50.48
862	Other aftercare & convalescence	24.41	74.88
850	Procedure w diag of rehab, aftercare or oth contact w health service	14.91	89.80
MDC 25 – Multiple significant trauma			
930	Multiple significant trauma w/o O.R. procedure	43.77	43.77

912	Musculoskeletal & other procedures for multiple significant trauma	42.72	86.49

A.3.16 Estimates of median odds ratio (MOR) with 95% confidence interval from hierarchical logistic regression analyses of in-hospital mortality, 30-day readmission, and prolonged length-of-stay in 2016-2018

	Model 1: patient characteristics[a]	**Model 2: patient and hospital characteristics[b]**
Major Diagnostic Category	**Median odds ratio (95% CI)[c]**	**Median odds ratio (95% CI)[c]**
Mortality		
MDC 1 – Diseases & disorders of the nervous system	**1.31 (1.25-1.37)**	**1.28 (1.22-1.33)**
MDC 2 – Diseases & disorders of the eye	**2.11 (1.44-2.70)**	**1.94 (1.28-2.48)**
MDC 3 – Diseases & disorders of the ear, nose, mouth & throat	**1.61 (1.44—1.77)**	**1.58 (1.41-1.73)**
MDC 4 – Diseases & disorders of the respiratory system	**1.20 (1.17-1.24)**	**1.19 (1.16-1.22)**
MDC 5 – Diseases & disorders of the circulatory system	**1.30 (1.24-1.35)**	**1.21 (1.17-1.24)**
MDC 6 – Diseases & disorders of the digestive system	**1.26 (1.21-1.31)**	**1.25 (1.20-1.30)**
MDC 7 – Diseases & disorders of the hepatobiliary system & pancreas	**1.34 (1.27-1.41)**	**1.32 (1.25-1.38)**
MDC 8 – Diseases & disorders of the musculoskeletal system & connective tissue	**1.30 (1.23-1.36)**	**1.29 (1.23-1.35)**
MDC 9 – Diseases & disorders of the skin, subcutaneous tissue & breast	**1.38 (1.29-1.46)**	**1.36 (1.27-1.44)**
MDC 10 – Endocrine, nutritional & metabolic diseases & disorders	**1.28 (1.20-1.35)**	**1.24 (1.15-1.30)**
MDC 11 – Diseases & disorders of the kidney & urinary tract	**1.28 (1.22-1.34)**	**1.24 (1.18-1.30)**
MDC 12 – Diseases & disorders of the male reproductive system	**1.54 (1.38-1.68)**	**1.46 (1.31-1.59)**
MDC 13 – Diseases & disorders of the female reproductive system	**1.66 (1.46-1.84)**	**1.60 (1.41-1.77)**
MDC 16 – Diseases & disorders of blood, blood forming organs, immunological disorders	**1.27 (1.16-1.35)**	**1.19 (1.03-1.27)**
MDC 17 – Myeloproliferative diseases & disorders, poorly differentiated neoplasm	**1.51 (1.39-1.62)**	**1.48 (1.36-1.58)**
MDC 18 – Infectious & parasitic diseases, systemic or unspecified sites	**1.31 (1.25-1.37)**	**1.22 (1.17-1.27)**
MDC 19 – Mental diseases & disorders	1.43 (0.79-1.74)	1.29 (0.76-1.57
MDC 21 – Injuries, poisonings & toxic effects of drugs	**1.38 (1.25-1.49)**	**1.29 (1.16-1.38)**
MDC 23 – Factors influencing health status & other contacts with health services	**1.68 (1.53-1.81)**	**1.64 (1.50-1.77)**
MDC 25 – Multiple significant trauma	**1.48 (1.29-1.63)**	**1.26 (1.06-1.37)**
Readmissions		
MDC 1 – Diseases & disorders of the nervous system	**1.19 (1.14-1.22)**	**1.16 (1.12-1.20)**
MDC 2 – Diseases & disorders of the eye	**1.40 (1.20-1.54)**	**1.34 (1.16 (1.47)**
MDC 3 – Diseases & disorders of the ear, nose, mouth & throat	**1.40 (1.31-1.48)**	**1.32 (1.24-1.38)**

MDC 4 – Diseases & disorders of the respiratory system	**1.13 (1.10-1.16)**	**1.12 (1.09-1.14)**
MDC 5 – Diseases & disorders of the circulatory system	**1.15 (1.12-1.18)**	**1.13 (1.10-1.16)**
MDC 6 – Diseases & disorders of the digestive system	**1.18 (1.14-1.21)**	**1.14 (1.11-1.16)**
MDC 7 – Diseases & disorders of the hepatobiliary system & pancreas	**1.17 (1.13-1.20)**	**1.13 (1.10-1.17)**
MDC 8 – Diseases & disorders of the musculoskeletal system & connective tissue	**1.19 (1.15-1.23)**	**1.16 (1.13-1.19**
MDC 9 – Diseases & disorders of the skin, subcutaneous tissue & breast	**1.16 (1.11-1.20)**	**1.14 (1.09-1.18)**
MDC 10 – Endocrine, nutritional & metabolic diseases & disorders	**1.19 (1.14-1.23)**	**1.18 (1.14-1.22)**
MDC 11 – Diseases & disorders of the kidney & urinary tract	**1.14 (1.11-1.17)**	**1.12 (1.09-1.15)**
MDC 12 – Diseases & disorders of the male reproductive system	**1.21 (1.14-1.26)**	**1.19 (1.11-1.25)**
MDC 13 – Diseases & disorders of the female reproductive system	**1.23 (1.15-1.29)**	**1.19 (1.11-1.25)**
MDC 16 – Diseases & disorders of blood, blood forming organs, immunological disorders	**1.20 (1.13-1.26)**	**1.15 (1.07-1.21)**
MDC 17 – Myeloproliferative diseases & disorders, poorly differentiated neoplasm	**1.19 (1.13-1.24)**	**1.18 (1.12-1.22)**
MDC 18 – Infectious & parasitic diseases, systemic or unspecified sites	**1.16 (1.11-1.20)**	**1.13 (1.07-1.17)**
MDC 19 – Mental diseases & disorders	1.18 (0.82-1.36)	NE
MDC 21 – Injuries, poisonings & toxic effects of drugs	**1.16 (1.08-1.21)**	**1.12 (1.01-1.18)**
MDC 23 – Factors influencing health status & other contacts with health services	**1.40 (1.31-1.47)**	**1.29 (1.23-1.36)**
MDC 25 – Multiple significant trauma	1.28 (0.80-1.52)	1.23 (0.79-1.47)
Prolonged Length of stay		
MDC 1 – Diseases & disorders of the nervous system	**1.50 (1.41-1.58)**	**1.47 (1.38-1.55)**
MDC 2 – Diseases & disorders of the eye	**1.68 (1.50-1.84)**	**1.55 (1.40-1.69)**
MDC 3 – Diseases & disorders of the ear, nose, mouth & throat	**1.77 (1.62-1.92)**	**1.66 (1.53-1.77)**
MDC 4 – Diseases & disorders of the respiratory system	**1.44 (1.36-1.52)**	**1.41 (1.34-1.48)**
MDC 5 – Diseases & disorders of the circulatory system	**1.39 (1.32-1.45)**	**1.35 (1.28-1.40)**
MDC 6 – Diseases & disorders of the digestive system	**1.31 (1.25-1.36)**	**1.28 (1.23-1.33)**
MDC 7 – Diseases & disorders of the hepatobiliary system & pancreas	**1.33 (1.27-1.38)**	**1.32 (1.26-1.38)**
MDC 8 – Diseases & disorders of the musculoskeletal system & connective tissue	**1.52 (1.42-1.60)**	**1.48 (1.39-1.55)**
MDC 9 – Diseases & disorders of the skin, subcutaneous tissue & breast	**1.31 (1.25-1.36)**	**1.30 (1.24-1.36)**
MDC 10 – Endocrine, nutritional & metabolic diseases & disorders	**1.57 (1.46-1.67)**	**1.52 (1.42-1.62)**
MDC 11 – Diseases & disorders of the kidney & urinary tract	**1.32 (1.26-1.37)**	**1.29 (1.23-1.33)**
MDC 12 – Diseases & disorders of the male reproductive system	**1.59 (1.47-1.70)**	**1.48 (1.38-1.57)**
MDC 13 – Diseases & disorders of the female reproductive system	**1.59 (1.47-1.69)**	**1.53 (1.42-1.63)**
MDC 16 – Diseases & disorders of blood, blood forming organs, immunological disorders	**1.37 (1.29-1.44)**	**1.30 (1.23-1.37)**

MDC 17 – Myeloproliferative diseases & disorders, poorly differentiated neoplasm	**1.61 (1.47-1.73)**	**1.46 (1.36-1.56)**
MDC 18 – Infectious & parasitic diseases, systemic or unspecified sites	**1.26 (1.20-1.31)**	**1.25 (1.19-1.30)**
MDC 19 – Mental diseases & disorders	**1.98 (1.69-2.26)**	**1.83 (1.57-2.07)**
MDC 21 – Injuries, poisonings & toxic effects of drugs	**1.37 (1.29-1.43)**	**1.33 (1.25-1.39)**
MDC 23 – Factors influencing health status & other contacts with health services	**1.61 (1.49-1.71)**	**1.51 (1.42-1.60)**
MDC 25 – Multiple significant trauma	**1.81 (1.54-2.06)**	**1.72 (1.46-1.94)**

Abbreviations: NE, not estimable; CI, confidence interval

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge

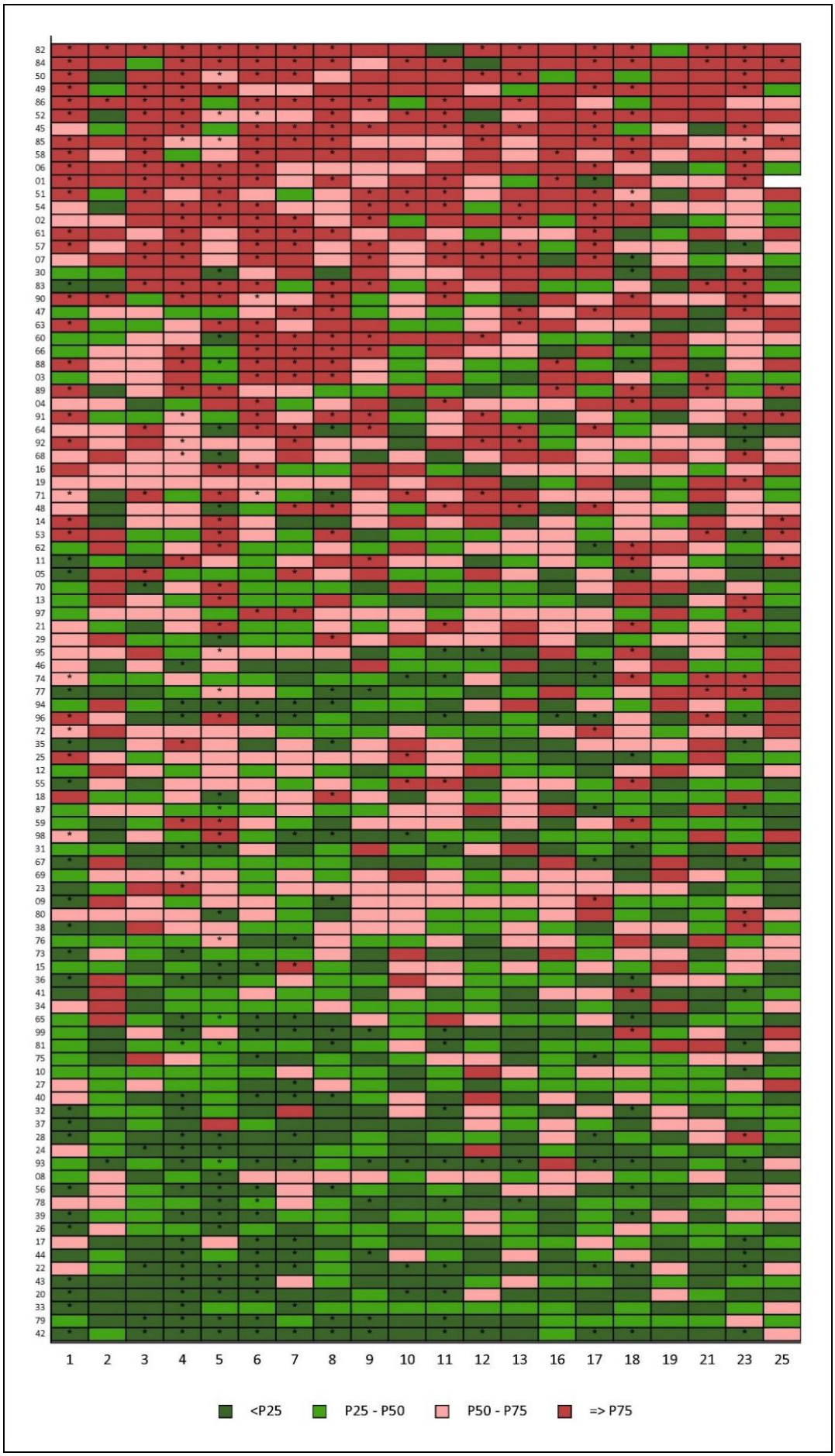
[b]Additionally adjusted for region, hospital type, and annual volume per DRG

[c]The odds for a randomly chosen patient in a high-risk hospital compared to a similar patient (i.e., with the same fixed effects) in a low-risk hospital.

Note: Median odds ratios are not presented for models in which the random hospital effect was estimated to be zero (indicated as NE). Median Odds Ratios indicated in bold are statistically significant at an alpha-level of 0.05.

A.3.17 Standardised mortality rates between 2016-2018 for individual hospitals in Belgium, categorised into quartiles and sorted according to descending upper quartile (indicated in red) category.

The x-axis depicts Major Diagnostic Categories, while the y-axis depicts individual Belgian hospitals. Hospital identification numbers correspond to the hospital numbers assigned within Figure 4.17 of the main text.


1 2 3 4 5 6 7 8 9 10 11 12 13 16 17 18 19 21 23 25
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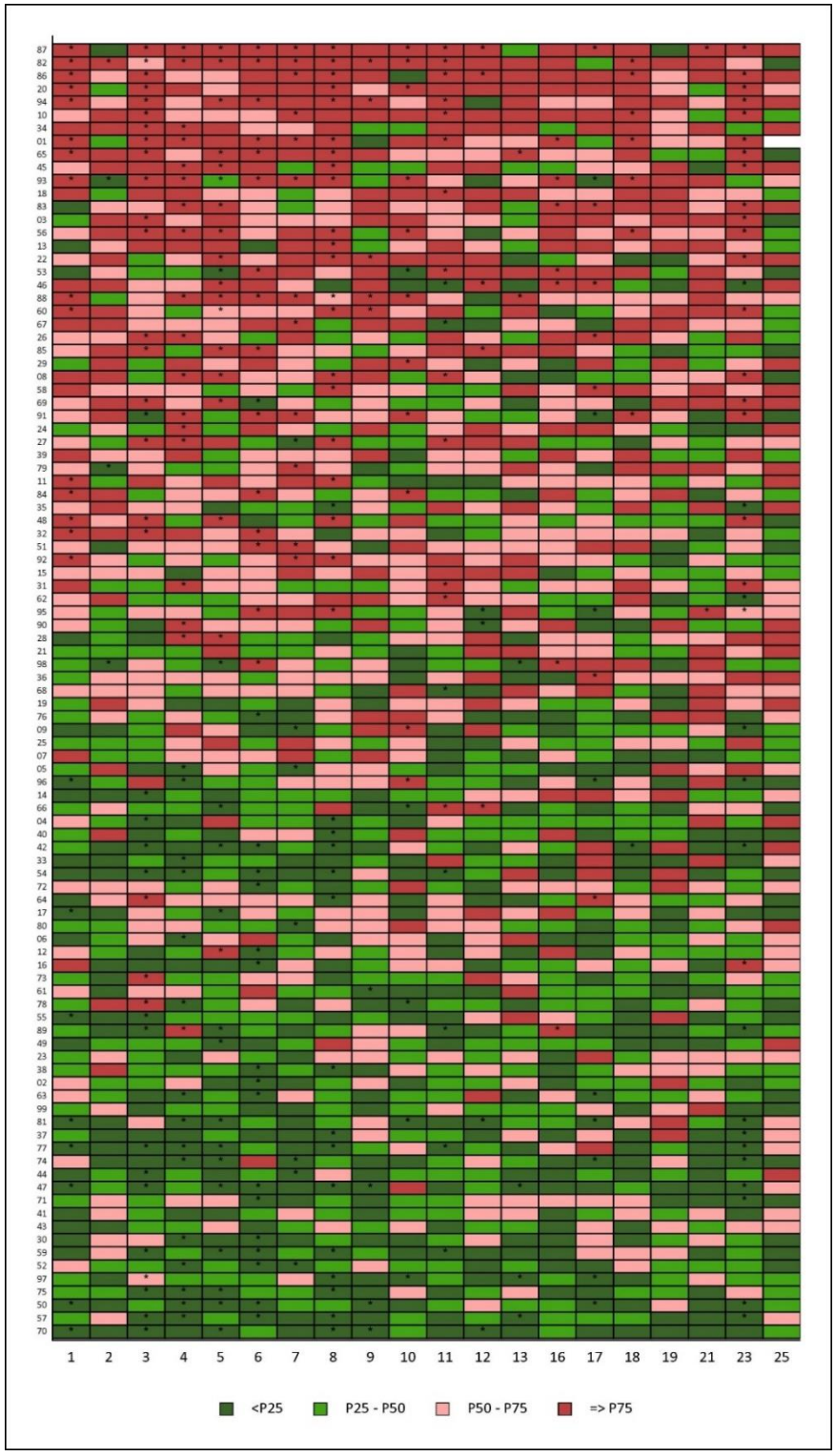
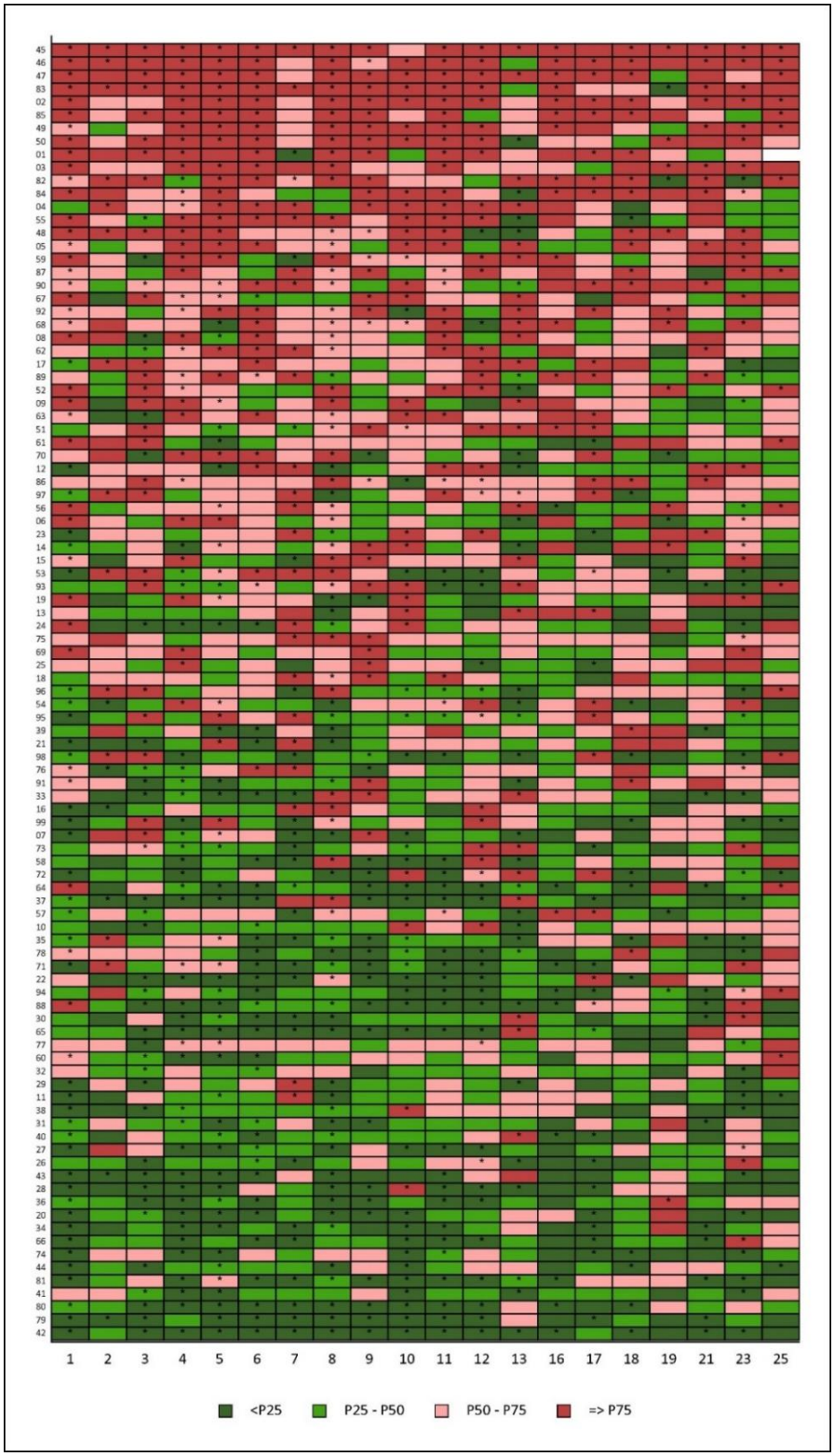
A.3.18 Standardised readmission rates between 2016-2018 for individual hospitals in Belgium, categorised into quartiles and sorted according to descending upper quartile (indicated in red) category.

The x-axis depicts Major Diagnostic Categories, while the y-axis depicts individual Belgian hospitals. Hospital identification numbers correspond to the hospital numbers assigned within Figure 4.17 of the main text.



A.3.19 Standardised prolonged length of stay rates between 2016-2018 for individual hospitals in Belgium, categorised into quartiles and sorted according to descending upper quartile (indicated in red) category.

The x-axis depicts Major Diagnostic Categories, while the y-axis depicts individual Belgian hospitals. Hospital identification numbers correspond to the hospital numbers assigned within Figure 4.17 of the main text.



A.3.20 Combined number of MDCs categorised within the lower quartile category for standardised mortality, readmissions and prolonged length of stay between 2016-2018 for individual hospitals in Belgium, in descending order.

Hospital identification numbers correspond to the hospital numbers assigned within Figure 4.17 of the main body of text.

<400 beds	Mortality	Readm.	pLOS	TOTAL
42	13	6	16	35
22	10	0	10	20
20	6	0	9	15
28	5	0	10	15
37	1	2	11	14
43	4	0	9	13
44	5	2	6	13
35	3	2	7	12
33	3	1	6	10
36	4	0	6	10
39	5	0	4	9
27	1	1	7	9
30	1	2	5	8
40	4	1	3	8
34	0	0	8	8
24	3	0	5	8
31	4	0	4	8
14	0	5	2	7
17	4	2	1	7
29	2	0	5	7
7	1	0	5	6
41	1	0	5	6
38	1	2	3	6
26	2	0	4	6
32	4	0	1	5
12	0	1	4	5
11	1	0	4	5
21	0	0	4	4
9	2	2	0	4
5	2	2	0	4
16	0	1	2	3
25	1	0	2	3
6	0	1	2	3
15	2	0	1	3
10	1	0	2	3
4	0	2	0	2
1	1	0	1	2
19	0	0	2	2
8	1	0	1	2
23	0	0	2	2
2	0	1	0	1
13	0	0	1	1
18	1	0	0	1
3	0	0	0	0

400-800 beds	Mortality	Readm.	pLOS	TOTAL
79	7	1	13	21
81	3	7	11	21
74	3	5	7	15
80	1	1	12	14
65	4	0	10	14
64	3	1	9	13
78	4	2	6	12
71	1	2	8	11
66	0	2	9	11
70	1	6	4	11
77	3	7	1	11
57	1	6	3	10
54	0	5	4	9
53	1	2	6	9
72	0	1	7	8
50	0	7	1	8
47	0	8	0	8
56	6	0	1	7
58	0	0	7	7
59	0	5	2	7
75	2	4	0	6
60	2	0	3	5
55	1	2	2	5
76	1	1	2	4
68	1	1	2	4
46	2	2	0	4
73	2	0	2	4
67	3	1	0	4
63	0	3	1	4
52	0	3	1	4
61	0	1	2	3
48	1	0	2	3
62	1	1	0	2
69	0	1	0	1
49	0	1	0	1
51	0	0	0	0
45	0	0	0	0

>800 beds	Mortality	Readm.	pLOS	TOTAL
93	12	2	4	18
96	7	4	3	14
98	3	3	7	13
94	5	0	7	12
99	6	0	6	12
88	1	0	10	11
97	0	4	2	6
91	0	2	3	5
95	2	2	1	5
89	0	4	0	4
83	1	0	1	2
87	2	0	0	2
92	1	0	1	2
82	0	0	2	2
84	0	0	1	1
86	0	0	1	1
90	0	1	0	1
85	0	0	0	0

A.3.21 The 64 APR-DRGs explaining 80% of mortality in the Flemish Hospital Network sample.

APR-DRG	Description
4	Tracheostomy w MV 96+ hours w extensive procedure or ECMO
5	Tracheostomy w MV 96+ hours w/o extensive procedure
9	Extracorporeal membrane oxygenation (ECMO)
20	Craniotomy for trauma
21	Craniotomy except for trauma
41	Nervous system malignancy
42	Degenerative nervous system disorders exc mult sclerosis
44	Intracranial hemorrhage
45	CVA & precerebral occlusion w infarct
53	Seizure
55	Head trauma w coma >1 hr or hemorrhage
58	Other disorders of nervous system
110	Ear, nose, mouth, throat, cranial/facial malignancies
121	Other respiratory & chest procedures
130	Respiratory system diagnosis w ventilator support 96+ hours
133	Respiratory failure
134	Pulmonary embolism
136	Respiratory malignancy
137	Major respiratory infections & inflammations
139	Other pneumonia
140	Chronic obstructive pulmonary disease
143	Other respiratory diagnoses except signs, symptoms & minor diagnoses
144	Respiratory signs, symptoms & minor diagnoses
145	Acute bronchitis and related symptoms
174	Percutaneous coronary intervention w AMI
190	Acute myocardial infarction
192	Cardiac catheterization for other non-coronary conditions

194	Heart failure
196	Cardiac arrest & shock
197	Peripheral & other vascular disorders
201	Cardiac arrhythmia & conduction disorders
230	Major small bowel procedures
231	Major large bowel procedures
240	Digestive malignancy
246	Gastrointestinal vascular insufficiency
247	Intestinal obstruction
249	Other gastroenteritis, nausea & vomiting
254	Other digestive system diagnoses
279	Hepatic coma & other major acute liver disorders
280	Alcoholic liver disease
281	Malignancy of hepatobiliary system & pancreas
284	Disorders of gallbladder & biliary tract
308	Hip & femur fracture repair
323	Non-elective or complex hip joint replacement
343	Musculoskeletal malignancy & pathol fracture d/t muscskel malig
347	Other back & neck disorders, fractures & injuries
351	Other musculoskeletal system & connective tissue diagnoses
382	Malignant breast disorders
383	Cellulitis & other skin infections
384	Contusion, open wound & other trauma to skin & subcutaneous tissue
422	Hypovolemia & related electrolyte disorders
461	Kidney & urinary tract malignancy
463	Kidney & urinary tract infections
468	Other kidney & urinary tract diagnoses, signs & symptoms
469	Acute kidny injury
500	Malignancy, male reproductive system
530	Female reproductive system malignancy
660	Major hematologic/immunologic diag exc sickle cell crisis & coagul

690	Acute leukemia
691	Lymphoma, myeloma & non-acute leukemia
694	Lymphatic & other malignancies & neoplasms of uncertain behavior
710	Infectious & parasitic diseases including HIV w O.R. procedure
720	Septicemia & disseminated infections
861	Signs, symptoms & other factors influencing health status

A.3.22 Internal validation of the FHN and 3M models.

APR-DRG	C-statistic[a]						Area Under the Precision-Recall Curve (AUC-PR)[a]						Adjusted Brier score[a]					
	FHN	3M, ROM dis-charge	3M, ROM admis-sion	*p*1[b]	*p*2[b]	*p*3[b]	FHN	3M, ROM dis-charge	3M, ROM admis-sion	*p*1[b]	*p*2[b]	*p*3[b]	FHN	3M, ROM dis-charge	3M, ROM admis-sion	*p*1[b]	*p*2[b]	*p*3[b]
All	0.87	0.96	0.94	***	***	**	0.34	0.42	0.36	*	**		0.17	0.26	0.21	**	***	
4	0.69	0.64	0.60				0.51	0.50	0.48				0.10	0.06	0.03			
5	0.66	0.59	0.61				0.58	0.61	0.63				0.08	0.05	0.04			
9	0.63	0.65	0.64				0.70	0.76	0.79				0.05	0.07	0.05			
20	0.67	0.84	0.83	*	*		0.31	0.63	0.68	*	*		0.06	0.33	0.35	*	*	
21	0.84	0.89	0.83				0.29	0.36	0.31				0.13	0.25	0.17			
41	0.64	0.62	0.58				0.35	0.36	0.31				0.05	0.06	0.03			
42	0.68	0.77	0.70	*			0.11	0.21	0.12	*			0.03	0.12	0.05	*		*
44	0.71	0.78	0.73				0.53	0.71	0.67	*	*		0.12	0.29	0.23	*	*	
45	0.80	0.84	0.78			*	0.25	0.37	0.28	*			0.09	0.22	0.14	*		
53	0.90	0.91	0.87				0.13	0.16	0.13				0.06	0.11	0.08			
55	0.75	0.87	0.85	*	*		0.27	0.55	0.58	*	*		0.09	0.35	0.36	*	*	
58	0.88	0.90	0.85				0.10	0.18	0.09				0.05	0.12	0.06			

110	0.78	0.74	0.72			0.39	0.34	0.31			0.13	0.12	0.10				
121	0.88	0.90	0.87			0.27	0.27	0.21			0.13	0.17	0.13				
130	0.71	0.60	0.57			0.68	0.60	0.59			0.13	0.04	0.02				
133	0.72	0.76	0.75			0.41	0.44	0.44			0.11	0.16	0.15				
134	0.78	0.87	0.83			0.18	0.25	0.22			0.07	0.15	0.12				
136	0.69	0.70	0.67			0.43	0.42	0.38			0.09	0.11	0.08				
137	0.71	0.72	0.70			0.29	0.31	0.28			0.07	0.10	0.08				
139	0.79	0.81	0.78		*	0.22	0.26	0.22			0.08	0.13	0.10	*			
140	0.73	0.77	0.73			0.14	0.14	0.11			0.04	0.06	0.04				
143	0.84	0.85	0.82			0.26	0.28	0.24			0.12	0.17	0.13				
144	0.89	0.88	0.86			0.14	0.17	0.13			0.06	0.11	0.08				
145	0.84	0.88	0.83			0.09	0.16	0.10			0.04	0.11	0.06				
174	0.81	0.92	0.87	*		0.15	0.36	0.29	*		0.06	0.27	0.19	*	*		
190	0.77	0.81	0.78			0.26	0.38	0.33			0.09	0.20	0.15	*			
192	0.88	0.95	0.88			0.08	0.25	0.15	*		0.03	0.22	0.12	*			
194	0.68	0.75	0.71	*	*	0.18	0.27	0.21	*	*	0.03	0.12	0.07	**	*	*	
196	0.74	0.63	0.66			0.90	0.86	0.87			0.12	0.03	0.05				
197	0.77	0.85	0.82			0.21	0.40	0.37			0.07	0.27	0.24	*	*		
201	0.83	0.92	0.88	*		0.10	0.25	0.17			0.04	0.19	0.11	*			
230	0.88	0.91	0.80		*	0.24	0.27	0.20			0.12	0.20	0.11				

231	0.93	0.95	0.86		*	0.18	0.28	0.17		0.09	0.23	0.12		
240	0.73	0.75	0.73			0.38	0.37	0.32		0.10	0.15	0.11		
246	0.80	0.77	0.75			0.32	0.35	0.31		0.12	0.19	0.15		
247	0.83	0.88	0.85			0.14	0.28	0.21		0.05	0.19	0.13	*	
249	0.91	0.92	0.88			0.08	0.17	0.10		0.04	0.14	0.07	*	
254	0.90	0.94	0.91			0.10	0.29	0.22	*	0.04	0.22	0.17	*	
279	0.77	0.82	0.82			0.34	0.35	0.33		0.12	0.17	0.16		
280	0.69	0.84	0.74	*		0.23	0.40	0.30		0.05	0.24	0.13	*	
281	0.68	0.71	0.68			0.42	0.45	0.40		0.08	0.13	0.10		
284	0.86	0.91	0.86			0.14	0.20	0.15		0.07	0.15	0.09		
308	0.81	0.88	0.77		*	0.18	0.32	0.17		0.07	0.22	0.08	*	
323	0.84	0.90	0.78		*	0.16	0.28	0.14		0.07	0.19	0.07	*	
343	0.66	0.70	0.67			0.28	0.31	0.26		0.05	0.10	0.06		
347	0.88	0.93	0.85			0.11	0.27	0.14		0.05	0.20	0.09	*	
351	0.85	0.90	0.84			0.08	0.21	0.14		0.03	0.15	0.10		
382	0.68	0.71	0.70			0.51	0.49	0.47		0.10	0.14	0.13		
383	0.91	0.93	0.90			0.13	0.25	0.15		0.06	0.19	0.10		
384	0.80	0.87	0.81			0.10	0.22	0.13		0.04	0.15	0.08		
422	0.81	0.83	0.79			0.19	0.25	0.21		0.07	0.14	0.10		
461	0.80	0.80	0.78			0.46	0.46	0.42		0.17	0.21	0.18		

463	0.85	0.88	0.84			0.10	0.17	0.11			0.04	0.11	0.07		
468	0.88	0.90	0.85			0.14	0.19	0.13			0.06	0.13	0.08		
469	0.75	0.75	0.71			0.26	0.32	0.25			0.08	0.14	0.08		
500	0.78	0.78	0.77			0.42	0.38	0.37			0.14	0.16	0.15		
530	0.76	0.73	0.71			0.48	0.33	0.30			0.16	0.11	0.09		
660	0.71	0.82	0.74			0.15	0.32	0.20			0.04	0.21	0.10	*	
690	0.76	0.69	0.67			0.43	0.37	0.33			0.14	0.10	0.08		
691	0.74	0.75	0.69			0.33	0.38	0.30			0.09	0.15	0.08		
694	0.70	0.74	0.70			0.31	0.36	0.31			0.07	0.14	0.09		
710	0.76	0.84	0.81			0.34	0.33	0.32			0.11	0.20	0.16		
720	0.70	0.81	0.78	**	*	0.30	0.39	0.36	*		0.07	0.19	0.16	**	*
861	0.88	0.88	0.86			0.13	0.22	0.16			0.06	0.15	0.11	*	

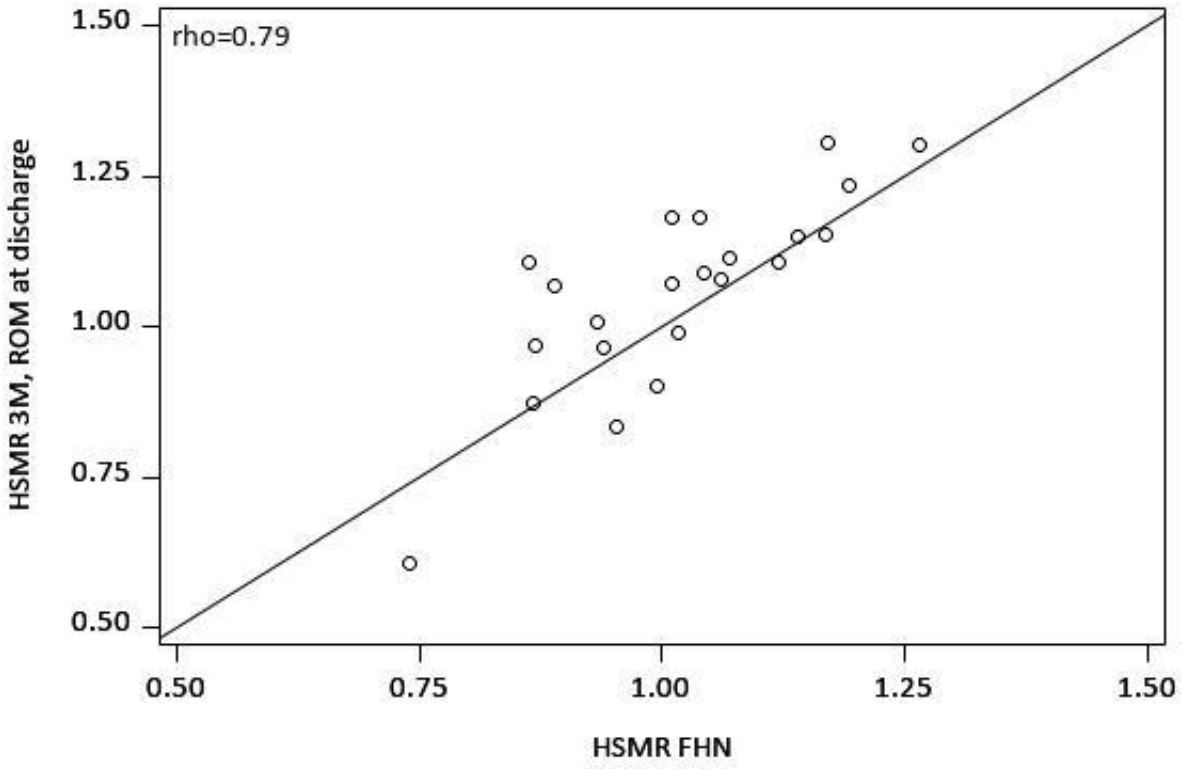
[a] Mean values of 100 bootstrap samples

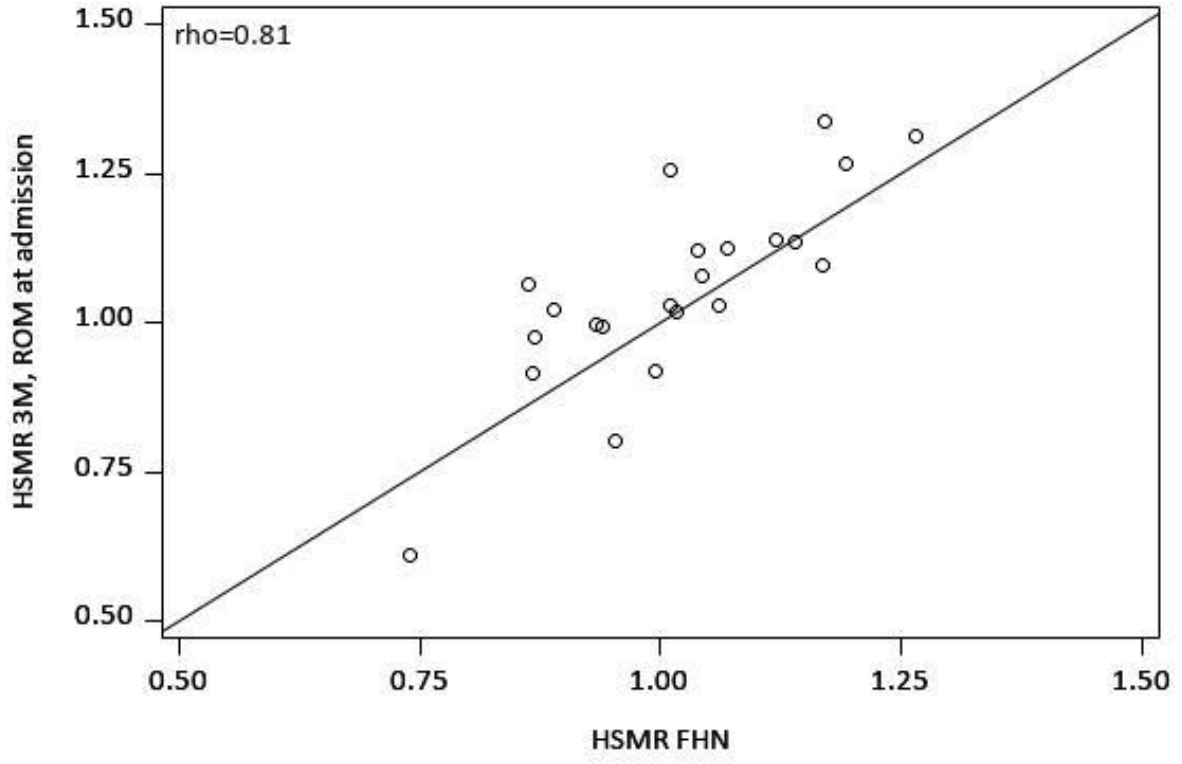
[b] P-value of t-test for the difference in C-statistic, AUC-PR or adjusted Brier score: $p1$ = comparison FHN model and standard 3M model (ROM at discharge), $p2$ = comparison FHN model and 3M model using ROM at admission instead of discharge, $p3$ = comparison 3M models with ROM at discharge and ROM ad admission. All 3M models presented were ran on the 3M sample.

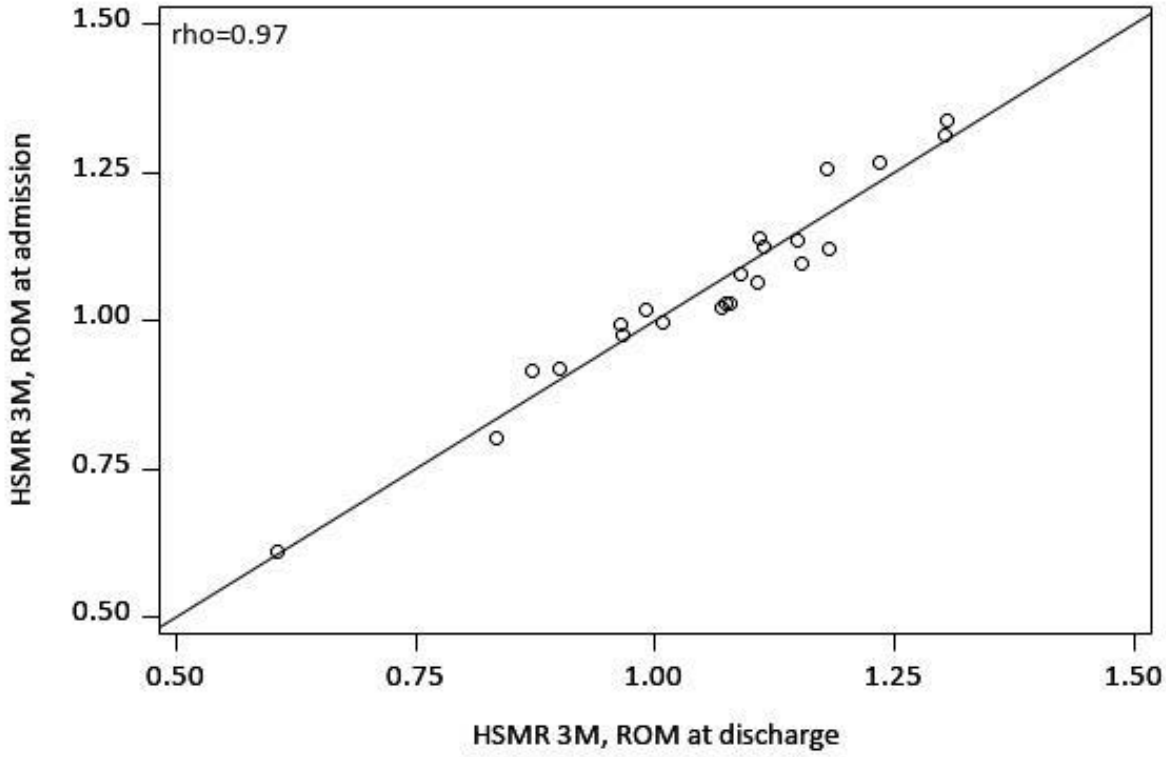
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Yellow cells indicate the model with the highest measure (best performance)

A.3.23 Comparison of HSMRs estimated by the FHN model, the standard 3M model (using ROM at discharge), and the 3M model using ROM at admission. Rho = Spearman correlation.

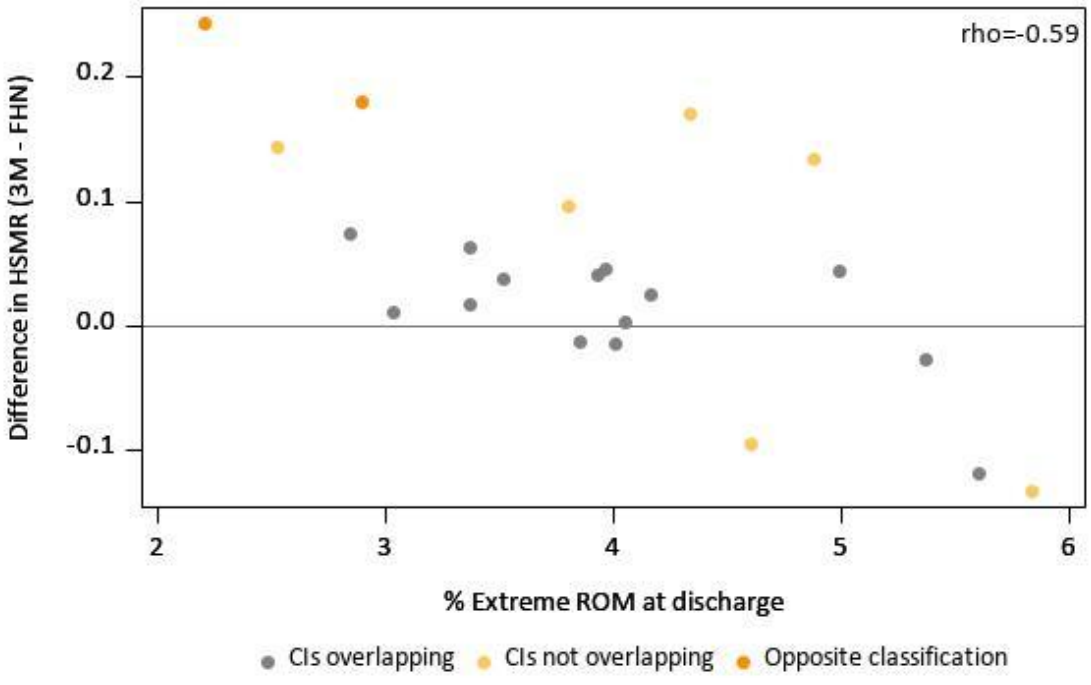




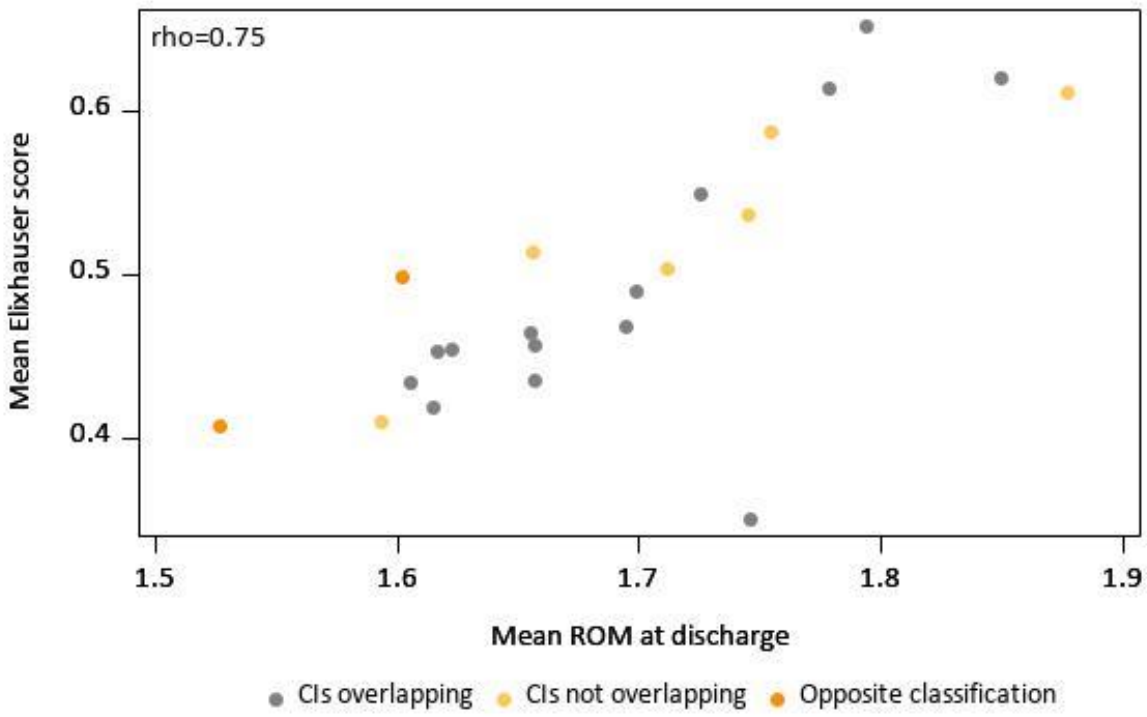


A.3.24 Difference in HSMR estimated by the standard 3M model and the FHN model (HSMR 3M minus HSMR FHN) versus the percentage of patients with extreme ROM at discharge for the 22 hospitals.

Rho = Spearman correlation. Opposite classification = HSMR < 1.00 according to FHN, HSMR > 1.00 according to 3M.



A.3.25 Mean Elixhauser score versus mean ROM at discharge. Rho = Spearman correlation.



A.4 Additional material to Chapter 5

A.4.1 Overview of included adverse event indicators derived from AHRQ Patient Safety Indicators[a]

	NUMERATOR	DENOMINATOR
PSI 02 - Death Rate in Low-Mortality DRGs	Number of in-hospital deaths per 1,000 discharges for hospitalizations with low expected mortality (less than 0.5%)	Discharges among patients ages 18 years and older with a low-mortality (less than 0.5% mortality) APR-DRG code[b]. The following discharges are excluded: - with any listed ICD-10-CM diagnosis code for trauma. - with any listed ICD-10-CM diagnosis code for cancer. - with any listed ICD-10-CM diagnosis code for immunocompromised state - with any listed ICD-10-PCS procedure code for immunocompromised state - transferred to an acute care facility - within MDC 15 (newborns and neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing discharge disposition, gender, age, quarter, year or principal diagnosis - with missing MDC when the user indicates that MDC is provided
PSI 03 - Pressure Ulcer Rate	Discharges with any secondary ICD-10-CM diagnosis code not present on admission for stage 3 or 4 (or unstageable) pressure ulcer in the absence of a secondary ICD-10-CM diagnosis code present on admission for deep tissue injury or unstageable pressure injury at the same anatomic site.	Surgical or medical discharges for patients ages 18 years and older. Exclude discharges: - with length of stay of less than 3 days - with a principal ICD-10-CM diagnosis code for site-specific pressure ulcer stage 3 or 4 (or unstageable) or deep tissue injury at the same anatomic site - with any ICD-10-CM diagnosis code for severe burns (≥20% body surface area) - with any ICD-10-CM diagnosis code for exfoliative disorders of the skin (≥20% body surface area) - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 04 - Death Rate among Surgical	In-hospital deaths per 1,000 surgical discharges, among	Surgical discharges for patients ages 18 through 89 years or patients of any age with MDC 14 (pregnancy, childbirth, and puerperium), with any listed ICD-10-

Inpatients with Serious Treatable Complications (=Failure-to-rescue)	patients ages 18 through 89 years or obstetric patients of any age, with serious treatable complications (shock/cardiac arrest, sepsis, pneumonia, gastrointestinal hemorrhage/acute ulcer, or deep vein thrombosis/pulmonary embolism).	PCS procedure code for an operating room procedure and all of the following: - Admission type of elective (ATYPE = 3) or any admission type in which the earliest ICD-10-PCS code for an operating room procedure - occurs within two days of admission. - Meet the inclusion and exclusion criteria[a] for shock or cardiac arrest, sepsis, pneumonia, gastrointestinal hemorrhage or acute ulcer, or deep vein thrombosis or pulmonary embolism. Exclude discharges: - transferred to an acute care facility - admitted from a hospice facility - MDC 15 (Newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing discharge disposition (DISP=missing), gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	Surgical or medical discharges for patients ages 18 years and older or MDC 14 (pregnancy, childbirth, and puerperium), with any secondary ICD-10-CM diagnosis code for retained surgical item or unretrieved device fragment.	Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for retained surgical item or unretrieved device fragment - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 06 - Iatrogenic Pneumothorax Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with a secondary ICD-10-CM diagnosis code for iatrogenic pneumothorax.	Surgical or medical discharges for patients ages 18 years and older. Exclude discharges: - with a principal ICD-10-CM diagnosis (or secondary diagnosis present on admission) of iatrogenic pneumothorax - with any listed ICD-10-CM diagnosis code for specified chest trauma (rib fractures, traumatic pneumothorax and related chest wall injuries) - with any listed ICD-10-CM diagnosis code for pleural effusion - with any listed ICD-10-PCS procedure code for thoracic surgery, including lung or pleural biopsy and diaphragmatic repair - with any listed ICD-10-PCS procedure code for potentially trans-pleural cardiac procedure

		- MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with a secondary ICD-10-CM diagnosis code for central venous catheter-related bloodstream infections	Surgical or medical discharges for patients ages 18 years and older or discharges with MDC 14 (pregnancy, childbirth, and puerperium) for patients of any age. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for central venous catheter-related bloodstream infection - with length of stay less than two (2) days - with any listed ICD-10-CM diagnosis code for cancer - with any listed ICD-10-CM diagnosis code for immunocompromised state - with any listed ICD-10-PCS procedure code for immunocompromised state - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 08 - In Hospital Fall with Hip Fracture Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any secondary ICD-10-CM diagnosis code for hip fracture.	Surgical or medical discharges for patients ages 18 years and older. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for hip fracture - with any listed ICD-10-CM diagnosis code for joint prosthesis-associated fracture - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing)

		- with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any secondary ICD-10-CM diagnosis code for postoperative hemorrhage or hematoma and any listed ICD-10-PCS procedure code for treatment of postoperative hemorrhage or hematoma.	Surgical discharges for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for an operating room procedure. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for postoperative hemorrhage or postoperative hematoma - where the only operating room procedure is for treatment of postoperative hemorrhage or hematoma - where the treatment of postoperative hemorrhage or hematoma occurs before the first operating room procedure, if the dates of both procedures are available - with any listed ICD-10-CM diagnosis code for coagulation disorder - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any secondary ICD-10-CM diagnosis code for acute kidney failure and any listed ICD-10-PCS procedure code for dialysis.	Elective surgical discharges, for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for an operating room procedure. Elective surgical discharges are defined by specific MS-DRG codes with admission type recorded as elective. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for acute kidney failure - with any dialysis procedure that occurs before or on the same day as the first operating room procedure - with any dialysis access procedure that occurs before or on the same day as the first operating room procedure with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for cardiac arrest - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for severe cardiac dysrhythmia - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for shock

		- with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for chronic kidney disease stage 5 or end stage renal disease - with a principal ICD-10-CM diagnosis code for urinary tract obstruction - any ICD-10-CM diagnosis present on admission of solitary kidney and any ICD-10-PCS procedure code for partial nephrectomy - MDC 14 (pregnancy, childbirth and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 11 - Postoperative Respiratory Failure Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with either: - any secondary ICD-10-CM diagnosis code of acute postprocedural respiratory failure - the last date of an ICD-10-PCS procedure code for a mechanical ventilation for greater than 96 consecutive hours is zero or more days after the first major operating room procedure, if the dates of both procedures are available - the last date of an ICD-10-PCS procedure code for a mechanical ventilation for	Elective surgical discharges, for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for an operating room procedure. Elective surgical discharges are defined by specific MS-DRG codes with admission type recorded as elective. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) of acute respiratory failure - with any listed ICD-10-CM diagnosis code present on admission for tracheostomy - where the only operating room procedure is tracheostomy - where a procedure for tracheostomy occurs before the first operating room procedure, if the dates of both procedures are available - with any listed ICD-10-CM diagnosis code for malignant hyperthermia - with any listed ICD-10-CM diagnosis code present on admission for neuromuscular disorder - with any listed ICD-10-CM diagnosis code present on admission for degenerative neurological disorder - with any listed ICD-10-PCS procedure code for laryngeal, pharyngeal, nose, mouth, or facial surgery involving significant risk of airway compromise - with any listed ICD-10-PCS procedure code for esophageal surgery - with any listed ICD-10-PCS procedure code for lung cancer - with any listed ICD-10-PCS procedure code for lung or heart transplant

	24 - 96 consecutive hours is two or more days after the first major operating room procedure, if the dates of both procedures are available - the last date of any ICD-10-PCS procedure code for an intubation is one or more days after the first major operating room procedure, if the dates of both procedures are available	- MDC 4 (diseases/disorders of respiratory system) - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 12 – Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with a secondary ICD10-CM diagnosis code for proximal deep vein thrombosis or a secondary ICD-10-CM diagnosis code for pulmonary embolism	Surgical discharges for patients ages 18 years and older, with any listed ICD-10- PCS procedure code for an operating room procedure. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for proximal deep vein thrombosis - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for pulmonary embolism - where a procedure for interruption of vena cava occurs before or on the same day as the first operating room procedure - where a procedure for pulmonary arterial or dialysis access thrombectomy occurs before or on the same day as the first operating room procedure - where the only operating room procedure(s) is/are for interruption of vena cava and/or pulmonary arterial or dialysis access thrombectomy - with any listed ICD-10-CM diagnosis code present on admission for acute brain or spinal injury - with any listed ICD-10-PCS procedure code for extracorporeal membrane oxygenation (ECMO) - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956)

		- with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 13 - Postoperative Sepsis Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any secondary ICD-10-CM diagnosis code for sepsis.	Elective surgical discharges, for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for an operating room procedure. Elective surgical discharges are defined by specific MS-DRG codes with admission type recorded as elective. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for sepsis - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for infection - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 14 - Postoperative Wound Dehiscence Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any listed ICD-10-PCS procedure code for repair of abdominal wall and with an ICD-10-CM diagnosis code for disruption of internal surgical wound.	Discharges, for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for abdominopelvic surgery, open approach, or with any listed ICD-10-PCS procedure code for abdominopelvic surgery, other than open approach. Exclude discharges: - the last date of a procedure for abdominal wall reclosure occurs on or before the date of the first open abdominopelvic surgery procedure, if any, and on or before the date of the first abdominopelvic surgery, other than open approach, if any - with an ICD-10-CM principal or secondary diagnosis code present on admission for disruption of internal operation (surgical) wound - with length of stay less than two days - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing),

		year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with: - any secondary ICD-10-CM diagnosis code for accidental puncture or laceration during an abdominopelvic procedure - a second abdominopelvic procedure follows one or more days after an index abdominopelvic procedure.	Surgical or medical discharges for patients ages 18 years and older, with any ICD-10-PCS procedure code for an abdominopelvic procedure. Exclude discharges: - with a principal ICD-10-CM diagnosis code (or secondary diagnosis present on admission) for accidental puncture or laceration during an abdominopelvic procedure - with a missing index abdominopelvic procedure date and/or missing all subsequent abdominopelvic procedure dates - MDC 14 (pregnancy, childbirth, and puerperium) - MDC 15 (newborns and other neonates with conditions originating in perinatal period) - with an ungroupable DRG (APR-DRG 956) - with missing gender (SEX=missing), age (AGE=missing), quarter (DQTR=missing), year (YEAR=missing), or principal diagnosis (DX1=missing) - with missing MDC (MDC=missing) when the user indicates that MDC is provided

Note: Grey indicates a Patient Safety Indicator exclusively measured within the surgical inpatient population.

[a]ICD-10-CM codes are available on https://qualityindicators.ahrq.gov/measures/PSI_TechSpec

[b]APR-DRG codes have been adapted to reflect discharges with mortality below 0.5% within the Belgian Hospital Discharge Dataset, rather than US-based DRGs. Abbreviations: APR-DRG, All Patient Refined-Diagnosis Related Group; DRG, Diagnosis Related Group; ICD-10-CM, International Classification of Diseases 10 Clinical Modification; MDC, Major Diagnostic Category

A.4.2 Odds ratios and confidence intervals for predictors selected by the backward selection procedure

PSI	C-statistic	Age group*	APR-DRG*	Gender	Type of admission
				Female vs Male	Emergy vs elective
PSI 02 - Death Rate in Low-Mortality DRGs	0.96	x	x	**0.74 (0.63; 0.86)**	**6.25 (5.19; 7.51)**
PSI 03 - Pressure Ulcer Rate	0.88	x	x		**1.74 (1.59; 1.89)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable Complications	0.76	x	x		**1.68 (1.57; 1.80)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	0.67			0.97 (0.71; 1.32)	
PSI 06 - Iatrogenic Pneumothorax Rate	0.90	x	x	**1.63 (1.47; 1.82)**	**0.85 (0.75; 0.97)**
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	0.94		x	**0.82 (0.71; 0.95)**	**1.67 (1.39; 2.01)**
PSI 08 - In Hospital Fall with Hip Fracture Rate	0.97	x	x	**1.39 (1.19; 1.62)**	**2.40 (1.96; 2.93)**
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	0.82	x	x	**0.80 (0.75; 0.85)**	**1.15 (1.06; 1.24)**
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	0.97	x	x	0.86 (0.74; 1.00)	
PSI 11 - Postoperative Respiratory Failure Rate	0.93	x	x	**0.71 (0.63; 0.80)**	
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	0.86	x	x	1.10 (1.00; 1.21)	**2.45 (2.19; 2.75)**
PSI 13 - Postoperative Sepsis Rate	0.92	x	x	**0.71 (0.65; 0.77)**	
PSI 14 - Postoperative Wound Dehiscence Rate	0.81	x		**0.70 (0.55; 0.90)**	**1.58 (1.22; 2.04)**
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	0.88	x	x		**1.38 (1.26; 1.52)**

* Because of the high number of categories for age and APR-DRG, odds ratios for individual categories are not presented, but only the selection of these variables (indicated by an 'x') is shown.
Note: Odds Ratios that are statistically significant are indicated in bold.

APPENDIX A.4.2 (continued)

PSI	Admission source			Year	
	Other hospital vs Home	Nursing home vs Home	Other vs Home	2017 vs 2016	2018 vs 2016
PSI 02 - Death Rate in Low-Mortality DRGs	**5.14 (3.46; 7.62)**	**2.52 (1.97; 3.23)**	**3.36 (2.39; 4.72)**	0.98 (0.83; 1.17)	**0.81 (0.67; 0.97)**
PSI 03 - Pressure Ulcer Rate	**1.97 (1.76; 2.20)**	**1.23 (1.11; 1.37)**	**1.28 (1.10; 1.50)**		
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable	**1.64 (1.48; 1.82)**	**1.16 (1.01; 1.33)**	0.90 (0.78; 1.05)		
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count					
PSI 06 - Iatrogenic Pneumothorax Rate					
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	**2.16 (1.76; 2.66)**	**1.12 (0.82; 1.52)**	**1.52 (1.14; 2.04)**		
PSI 08 - In Hospital Fall with Hip Fracture Rate	**1.90 (1.38; 2.62)**	**1.39 (1.10; 1.75)**	1.06 (0.62; 1.82)		
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.50 (1.31; 1.71)**	1.09 (0.83; 1.42)	0.85 (0.67; 1.07)		
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	**1.98 (1.52; 2.58)**	1.13 (0.27; 4.73)	1.14 (0.27; 4.87)	0.85 (0.72; 1.00)	**0.84 (0.71; 0.99)**
PSI 11 - Postoperative Respiratory Failure Rate	**3.70 (2.93; 4.68)**	**2.35 (1.13; 4.88)**	1.57 (0.57; 4.28)	**0.83 (0.73; 0.95)**	**0.74 (0.65; 0.85)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.65 (1.34; 2.02)**	0.88 (0.71; 1.10)	1.20 (0.96; 1.51)		
PSI 13 - Postoperative Sepsis Rate	**2.22 (1.86; 2.64)**	**2.17 (1.32; 3.56)**	0.97 (0.40; 2.37)		
PSI 14 - Postoperative Wound Dehiscence Rate					
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.42 (1.16; 1.74)**	0.90 (0.69; 1.16)	0.99 (0.73; 1.36)		

APPENDIX A.4.2 (continued)

PSI	Mean N secondary diagnoses	% not POA	Elixhauser comorbidities		
			Aids	Alcohol abuse	Blood loss anaemia
PSI 02 - Death Rate in Low-Mortality DRGs	**0.93 (0.86; 0.99)**			**2.63 (2.00; 3.46)**	
PSI 03 - Pressure Ulcer Rate	**1.15 (1.13; 1.17)**	**1.14 (1.13; 1.15)**		**1.51 (1.37; 1.67)**	**1.59 (1.28; 1.98)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable		1.00 (0.99; 1.00)		**1.11 (1.01; 1.22)**	**0.64 (0.50; 0.81)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	**1.21 (1.11; 1.33)**				
PSI 06 - Iatrogenic Pneumothorax Rate	**1.13 (1.09; 1.16)**	**1.12 (1.09; 1.15)**		**1.38 (1.15; 1.65)**	
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	**1.21 (1.16; 1.26)**	**1.22 (1.20; 1.25)**			
PSI 08 - In Hospital Fall with Hip Fracture Rate	**0.94 (0.89; 0.98)**	**1.06 (1.03; 1.09)**		**1.85 (1.42; 2.41)**	0.61 (0.35; 1.08)
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.03 (1.02; 1.05)**	**1.07 (1.07; 1.08)**		**1.38 (1.23; 1.53)**	
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	**0.95 (0.91; 0.99)**	**1.02 (1.01; 1.04)**			
PSI 11 - Postoperative Respiratory Failure Rate	**0.93 (0.89; 0.96)**	**1.03 (1.02; 1.04)**		**1.58 (1.31; 1.91)**	
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.04 (1.01; 1.07)**	**1.05 (1.04; 1.06)**			
PSI 13 - Postoperative Sepsis Rate	**0.95 (0.93; 0.97)**	**1.05 (1.04; 1.05)**	**6.59 (4.01;10.84)**	**1.42 (1.25; 1.61)**	
PSI 14 - Postoperative Wound Dehiscence Rate		**1.08 (1.06; 1.10)**		**2.16 (1.49; 3.13)**	
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.10 (1.08; 1.13)**	**1.08 (1.07; 1.09)**			

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities				
	Cardiac arrhythmias	Congestive heart failure	Coagulopathy	Chronic pulmonary disease	Deficiency anaemia
PSI 02 - Death Rate in Low-Mortality DRGs	**1.87 (1.57; 2.22)**	**1.92 (1.56; 2.36)**	**1.62 (1.10; 2.39)**	**1.43 (1.16; 1.75)**	
PSI 03 - Pressure Ulcer Rate	**1.37 (1.28; 1.47)**	**1.38 (1.27; 1.49)**	**1.19 (1.05; 1.36)**	**1.11 (1.03; 1.20)**	
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable	**1.27 (1.18; 1.35)**	**1.28 (1.19; 1.39)**	**1.48 (1.32; 1.66)**	**1.15 (1.07; 1.24)**	**0.60 (0.51; 0.70)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	0.98 (0.61; 1.56)		1.59 (0.69; 3.65)	**1.84 (1.24; 2.73)**	
PSI 06 - Iatrogenic Pneumothorax Rate				**1.43 (1.24; 1.64)**	
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate		**1.24 (1.01; 1.51)**		**1.33 (1.12; 1.59)**	
PSI 08 - In Hospital Fall with Hip Fracture Rate		**1.63 (1.35; 1.97)**		**1.53 (1.27; 1.83)**	
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.39 (1.28; 1.51)**		**1.33 (1.00; 1.78)**		
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	**1.37 (1.16; 1.62)**	**2.06 (1.73; 2.47)**	**1.64 (1.15; 2.36)**	**1.46 (1.23; 1.72)**	
PSI 11 - Postoperative Respiratory Failure Rate	**1.61 (1.37; 1.89)**	**1.56 (1.28; 1.91)**	**2.74 (2.13; 3.52)**	**1.76 (1.52; 2.02)**	
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate		**1.29 (1.11; 1.50)**	**1.54 (1.22; 1.94)**	**1.16 (1.03; 1.32)**	**1.32 (1.05; 1.66)**
PSI 13 - Postoperative Sepsis Rate	**1.40 (1.27; 1.55)**	**1.43 (1.27; 1.61)**	**1.88 (1.53; 2.30)**	**1.38 (1.25; 1.52)**	**1.45 (1.17; 1.80)**
PSI 14 - Postoperative Wound Dehiscence Rate	**1.42 (1.03; 1.95)**			**1.76 (1.31; 2.36)**	
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.18 (1.05; 1.33)**			**1.22 (1.09; 1.37)**	

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities				
	Depression	Diabetes, complicated	Diabetes, uncomplicated	Drug abuse	Fluid and electrolyte disorders
PSI 02 - Death Rate in Low-Mortality DRGs		**1.70 (1.28; 2.26)**	**1.39 (1.15; 1.69)**	**2.56 (1.25; 5.21)**	**3.35 (2.74; 4.10)**
PSI 03 - Pressure Ulcer Rate		**1.66 (1.51; 1.83)**	**1.30 (1.20; 1.41)**	**1.40 (1.10; 1.79)**	**1.43 (1.34; 1.54)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable	**0.80 (0.70; 0.93)**		**1.10 (1.01; 1.19)**		**1.15 (1.07; 1.24)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	1.64 (0.86; 3.13)				
PSI 06 - Iatrogenic Pneumothorax Rate			**0.83 (0.70; 0.98)**	**2.33 (1.70; 3.19)**	**1.58 (1.36; 1.83)**
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate		**1.33 (1.04; 1.69)**		**1.92 (1.36; 2.71)**	**1.90 (1.61; 2.24)**
PSI 08 - In Hospital Fall with Hip Fracture Rate	1.32 (0.99; 1.76)			1.75 (0.91; 3.36)	**1.41 (1.18; 1.68)**
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.27 (1.08; 1.49)**	**0.83 (0.72; 0.96)**		**1.34 (1.02; 1.75)**	
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate		**1.75 (1.37; 2.24)**	**1.25 (1.06; 1.49)**	**0.13 (0.02; 0.99)**	
PSI 11 - Postoperative Respiratory Failure Rate	**2.01 (1.59; 2.54)**	**1.36 (1.07; 1.72)**	**1.20 (1.03; 1.39)**	**2.30 (1.44; 3.66)**	**2.22 (1.86; 2.66)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.44 (1.18; 1.75)**			1.50 (1.00; 2.24)	1.14 (0.99; 1.32)
PSI 13 - Postoperative Sepsis Rate	**1.97 (1.65; 2.36)**	**1.33 (1.14; 1.56)**		**1.72 (1.19; 2.49)**	**1.74 (1.52; 2.00)**
PSI 14 - Postoperative Wound Dehiscence Rate			0.68 (0.46; 1.00)		**1.65 (1.18; 2.30)**
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate		**0.80 (0.65; 0.98)**	**0.80 (0.71; 0.92)**		**1.24 (1.10; 1.40)**

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities				
	Hypertension, complicated	Hypothyroidism	Hypertension, uncomplicated	Liver disease	Lymphoma
PSI 02 - Death Rate in Low-Mortality DRGs				**2.51 (1.81; 3.47)**	
PSI 03 - Pressure Ulcer Rate	**1.13 (1.02; 1.25)**			**1.29 (1.14; 1.45)**	**1.32 (1.03; 1.70)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable			**0.88 (0.82; 0.94)**	**1.86 (1.67; 2.07)**	**1.64 (1.29; 2.09)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	**3.21 (1.61; 6.37)**		1.34 (0.95; 1.89)	1.58 (0.82; 3.04)	
PSI 06 - Iatrogenic Pneumothorax Rate					1.45 (0.94; 2.25)
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate	**1.49 (1.21; 1.84)**		**1.18 (1.01; 1.38)**	**1.55 (1.23; 1.94)**	
PSI 08 - In Hospital Fall with Hip Fracture Rate	**0.76 (0.60; 0.96)**	**1.25 (1.00; 1.58)**		**0.51 (0.36; 0.73)**	
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.19 (1.04; 1.36)**	**1.25 (1.12; 1.39)**	**1.21 (1.13; 1.29)**	1.16 (1.00; 1.35)	1.39 (0.98; 1.97)
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate		**1.46 (1.15; 1.83)**	**1.26 (1.07; 1.49)**	**1.89 (1.45; 2.46)**	**2.08 (1.12; 3.86)**
PSI 11 - Postoperative Respiratory Failure Rate	**1.36 (1.05; 1.76)**	**1.34 (1.10; 1.62)**	**1.49 (1.31; 1.69)**	**1.69 (1.38; 2.07)**	**1.69 (1.01; 2.84)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.36 (1.18; 1.57)**		**1.21 (1.10; 1.34)**		**2.20 (1.53; 3.17)**
PSI 13 - Postoperative Sepsis Rate	**1.30 (1.12; 1.52)**	**1.24 (1.08; 1.42)**	**1.21 (1.12; 1.31)**	**1.42 (1.22; 1.66)**	**2.33 (1.72; 3.14)**
PSI 14 - Postoperative Wound Dehiscence Rate				**0.40 (0.23; 0.69)**	
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.28 (1.11; 1.47)**		**1.11 (1.01; 1.22)**		

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities				
	Metastatic cancer	Obesity	Other neurological disorders	Paralysis	Pulmonary circulation disorders
PSI 02 - Death Rate in Low-Mortality DRGs		**0.70 (0.56; 0.88)**	**3.37 (2.71; 4.18)**	**3.83 (2.48; 5.92)**	**2.11 (1.46; 3.04)**
PSI 03 - Pressure Ulcer Rate	**1.22 (1.07; 1.39)**	**1.08 (0.99; 1.18)**	**1.58 (1.45; 1.72)**	**2.68 (2.35; 3.05)**	
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable	**1.57 (1.42; 1.73)**	**0.68 (0.62; 0.74)**	**1.29 (1.18; 1.41)**	0.87 (0.76; 1.00)	**0.77 (0.68; 0.87)**
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	1.31 (0.69; 2.51)				
PSI 06 - Iatrogenic Pneumothorax Rate	**0.80 (0.65; 0.99)**	**0.54 (0.45; 0.65)**	**1.41 (1.17; 1.70)**	1.34 (0.96; 1.89)	
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate		**1.33 (1.12; 1.58)**	**1.45 (1.18; 1.77)**	**1.43 (1.07; 1.93)**	
PSI 08 - In Hospital Fall with Hip Fracture Rate		**0.51 (0.38; 0.67)**	**1.79 (1.45; 2.22)**		
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.13 (1.01; 1.27)**			**1.19 (0.97; 1.44)**	
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate		**1.23 (1.04; 1.44)**			
PSI 11 - Postoperative Respiratory Failure Rate	**1.22 (1.03; 1.44)**	**1.38 (1.20; 1.58)**	**1.87 (1.52; 2.31)**	**2.11 (1.53; 2.90)**	**2.20 (1.59; 3.05)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.75 (1.50; 2.05)**	**1.40 (1.25; 1.57)**	**1.31 (1.11; 1.55)**	**2.23 (1.74; 2.85)**	**2.12 (1.69; 2.64)**
PSI 13 - Postoperative Sepsis Rate	**1.37 (1.23; 1.52)**	**1.14 (1.04; 1.25)**	**1.74 (1.49; 2.04)**	**2.48 (1.87; 3.30)**	
PSI 14 - Postoperative Wound Dehiscence Rate		**1.86 (1.40; 2.47)**	**1.69 (1.10; 2.60)**		**1.74 (0.94; 3.24)**
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.19 (1.05; 1.34)**	1.10 (0.98; 1.23)		0.69 (0.47; 1.01)	

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities				
	Psychoses	Peptic ulcer disease	Peripheral vascular disorders	Renal failure	Rheumatoid arthritis/collaged vascular disease
PSI 02 - Death Rate in Low-Mortality DRGs	**3.45 (1.44; 8.28)**		**1.59 (1.20; 2.12)**		
PSI 03 - Pressure Ulcer Rate	**1.64 (1.17; 2.28)**	**1.57 (1.29; 1.92)**	**1.76 (1.60; 1.94)**	**1.21 (1.10; 1.33)**	**1.45 (1.26; 1.67)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable			**1.27 (1.15; 1.40)**	**1.17 (1.08; 1.26)**	
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count				**0.32 (0.15; 0.68)**	
PSI 06 - Iatrogenic Pneumothorax Rate		**1.56 (1.02; 2.39)**			
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate					**2.01 (1.49; 2.70)**
PSI 08 - In Hospital Fall with Hip Fracture Rate	**3.72 (1.98; 6.99)**	**1.57 (1.02; 2.42)**	**0.65 (0.49; 0.85)**	**1.47 (1.19; 1.82)**	
PSI 09 - Perioperative Hemorrhage or Hematoma Rate		**1.51 (1.14; 1.99)**	**1.50 (1.35; 1.65)**	**1.30 (1.14; 1.48)**	1.19 (0.99; 1.42)
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate			**1.57 (1.28; 1.92)**	**3.85 (3.20; 4.64)**	
PSI 11 - Postoperative Respiratory Failure Rate		**1.73 (1.14; 2.64)**	**1.65 (1.30; 2.10)**	**1.68 (1.32; 2.14)**	**1.55 (1.13; 2.12)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	1.67 (0.91; 3.07)	**1.55 (1.10; 2.19)**			**1.44 (1.14; 1.81)**
PSI 13 - Postoperative Sepsis Rate	**2.21 (1.26; 3.86)**	**1.75 (1.31; 2.36)**	**1.51 (1.32; 1.73)**	**1.69 (1.46; 1.96)**	**1.55 (1.26; 1.90)**
PSI 14 - Postoperative Wound Dehiscence Rate		**2.30 (1.12; 4.70)**			
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate			**1.46 (1.24; 1.72)**		

APPENDIX A.4.2 (continued)

PSI	Elixhauser comorbidities		
	Solid tumour	Valvular disease	Weight loss
PSI 02 - Death Rate in Low-Mortality DRGs		**1.73 (1.39; 2.16)**	**1.51 (1.14; 1.99)**
PSI 03 - Pressure Ulcer Rate	**1.27 (1.14; 1.42)**	1.09 (1.00; 1.19)	**2.18 (2.03; 2.35)**
PSI 04 - Death Rate among Surgical Inpatients with Serious Treatable Complications	**1.26 (1.15; 1.37)**		
PSI 05 - Retained Surgical Item or Unretrieved Device Fragment Count	1.48 (0.80; 2.73)		
PSI 06 - Iatrogenic Pneumothorax Rate	**1.63 (1.35; 1.96)**	**1.25 (1.04; 1.50)**	**1.74 (1.48; 2.03)**
PSI 07 - Central Venous Catheter-Related Blood Stream Infection Rate		**1.42 (1.15; 1.74)**	**1.75 (1.42; 2.16)**
PSI 08 - In Hospital Fall with Hip Fracture Rate	**0.55 (0.40; 0.77)**		**2.33 (1.97; 2.77)**
PSI 09 - Perioperative Hemorrhage or Hematoma Rate	**1.28 (1.15; 1.42)**	**1.48 (1.33; 1.63)**	**1.56 (1.38; 1.76)**
PSI 10 - Postoperative Acute Kidney Injury Requiring Dialysis Rate	**1.88 (1.53; 2.31)**	**1.52 (1.26; 1.83)**	**1.37 (1.06; 1.79)**
PSI 11 - Postoperative Respiratory Failure Rate	**1.92 (1.65; 2.23)**	**1.42 (1.14; 1.77)**	**2.41 (2.03; 2.88)**
PSI 12 - Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate	**1.75 (1.51; 2.03)**	**1.39 (1.20; 1.62)**	**1.81 (1.59; 2.08)**
PSI 13 - Postoperative Sepsis Rate	**1.93 (1.75; 2.13)**	**1.31 (1.16; 1.49)**	**2.68 (2.38; 3.02)**
PSI 14 - Postoperative Wound Dehiscence Rate	**2.46 (1.87; 3.23)**		**1.50 (1.02; 2.22)**
PSI 15 - Abdominopelvic Accidental Puncture or Laceration Rate	**1.30 (1.15; 1.46)**	**1.22 (1.05; 1.43)**	**1.47 (1.30; 1.66)**

CURRICULUM

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"*Retrospective analysis of quality improvement initiatives and patient outcomes in Belgium."*

Master of Science: Healthcare Management and Policy

KU Leuven | 2016-2017

Summa cum laude

Specialisation: Management

Master of Science: Pharmaceutical Sciences

KU Leuven | 2014-2016

University College London School of Pharmacy (Erasmus exchange) | 2015

Magna cum laude

Specialisation: Pharmaceutical care

Bachelor of Science: Pharmaceutical Sciences

KU Leuven | 2011-2014

Secondary education: Greek-Mathematics

Sint-Jozefscollege Aalst | 2005-2011

HONORS/AWARDS

3 Minute Thesis Competition | December 2022

"Observational study of trends and variation in patient outcomes across Belgian hospitals"

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European Health management Association International Conference

DOCsDAY Videocast winner | September 2019

Doctoral School of Biomedical Sciences KU Leuven

Erasmus Award | June 2016

Prize for best thesis on an exchange program

'**Prima Perpetua' Award | June 2011**

Sint-Jozefscollege Aalst (secondary education)

BBC Public Speaking Awards | 2010

Quarter Finalist

PROFESSIONAL EXPERIENCE

Community pharmacist

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KAVA & Domus Medica | 2019-today

Science tutor

De Limiet | 2018-2022

English teacher

Roeland vzw | 2010-2022

CONFERENCES

International Conference on Integrated Care, Antwerp, 2023

"*Lessons to enhance integrated care by assessing between-hospital variation in mortality, readmissions and prolonged length-of-stay for cardiovascular diagnoses: results of a*

cardiovascular population analysis. Presented at the International Conference on Integrated Care" – oral presentation

"Population analysis of temporal trends and between-hospital variation in mortality, readmission and prolonged length-of-stay between 2008 and 2018: improving integrated care by knowledge sharing of hospitals' care progress." – poster presentation

BMJ International Forum on Quality & Safety in Healthcare, Gothenburg, 2022

"Unwarranted between-hospital variation in the vital few as trigger for quality priorities" – poster presentation

EHMA 2022 Annual Conference, Brussels, 2022

"Unwarranted between-hospital variation in the vital few as trigger for quality priorities" – oral presentation

CERNER Collaboration Forum, London, 2016

"*How Electronic Prescribing and Medication Administration affects nurses' workflow on a UK Hospital Ward."* – poster presentation

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Language skills

Dutch (native), English (C2), French (C1)

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Loyal and professional, empathic, motivated and enthusiastic, large sense of responsibility, flexible, team player

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Music (piano, classical and choral singing), Sports (running, swimming, biking), literature

LIST OF PUBLICATIONS

Incorporated within this PhD dissertation

PUBLISHED (In order of appearance)

Van Wilder, A., Bruyneel, L., De Ridder, D., Seys, D., Brouwers, J., Claessens, F., Cox, B., Vanhaecht, K. (2021). Is a hospital quality policy based on a triad of accreditation, public reporting and inspection evidence-based? A narrative review. *INTERNATIONAL JOURNAL FOR QUALITY IN HEALTH CARE*, *33* (2), 1-7. doi: 10.1093/intqhc/mzab085

Van Wilder, A.,* Brouwers, J.,* Cox, B., Bruyneel, L., De Ridder, D., Claessens, F., Eeckloo, K., Vanhaecht, K. with Van Wilder, A. (joint first author), Brouwers, J. (joint first author), Van Wilder, A. (corresp. author) (2021). A decade of commitment to hospital quality of care: overview of and perceptions on multicomponent quality improvement policies involving accreditation, public reporting, inspection and pay-for-performance. *BMC Health Services Research*, *21*, Art.No. 990. doi: 10.1186/s12913-021-07007-w

Van Wilder, A., Vanhaecht, K., De Ridder, D., Cox, B., Brouwers, J., Claessens, F., De Wachter, D., Deneckere, S., Ramaekers, D., Tambuyzer, E., Weeghmans, I., Bruyneel, L. with Van Wilder, A. (corresp. author) (2020). Six years of measuring patient experiences in Belgium: Limited improvement and lack of association with improvement strategies. *PLOS One*, *15* (11), Art.No. e0241408. doi: 10.1371/journal.pone.0241408

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Chapter 2: Astrid Van Wilder (AVW) performed the search strategy for the narrative review and content analysis, which was validated by Jonas Brouwers (JB) and Deborah Seys (DS).

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