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Hospital readmissions
Just a number or a stepping stone
to quality improvement?
Karin Hekkert
Hospital readmissions

Just a number or a stepping stone to quality improvement?
The studies presented in this thesis have been performed at the Scientific Center for Quality of Healthcare (IQ healthcare). IQ healthcare is part of the Radboud Institute for Health Sciences (RIHS), one of the approved research institutes of the Radboud University Medical Center.

Financial support by IQ healthcare and the Dutch Health and Youth Care Inspectorate (IGJ) for the publication of this thesis is gratefully acknowledged.

ISBN: 978-94-6332-539-4

Cover design: Karin Hekkert, Ineke Jansen
Cover photo: Shutterstock
Lay-out: Karin Hekkert, Jolanda van Haren
Print: GVO drukkers en vormgevers, Ede

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Hospital readmissions

Just a number or a stepping stone to quality improvement?

Proefschrift

ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.H.J.M. van Krieken,
volgens besluit van het college van decanen
in het openbaar te verdedigen op donderdag 31 oktober 2019
om 12.30 uur precies

door
Karin Dorieke Hekkert

geboren op 5 september 1983
te Wierden
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Chapter 1

General introduction
Hospital readmissions are the subject of much discussion in health care policy. Unintended readmissions are presumed to be related to problems with the quality of care,\(^1,2\) are a burden to patients, and are costly for the health care system.\(^5\) Therefore, many countries have introduced quality indicators based on readmissions during the last decades in order to assess the quality of care.\(^6-9\) The hypothesis is that hospitals can gain insight into complications and substandard quality of care using an indicator based on readmissions. They might improve further their quality of care for patient groups who experience more unintended readmissions than expected. Until recently, no such indicator existed yet in the Netherlands. The Dutch Health and Youth Care Inspectorate (IGJ) commissioned this research project in order to add hospital readmissions to their indicator framework for supervision (Text box 1). This thesis describes this research, and aims to examine how a quality indicator based on readmissions should be defined in order to be of use to hospitals in identifying problems with the quality of care. It could then be used by the Inspectorate for its supervision.

**Text box 1. The Dutch Health and Youth Care Inspectorate’s indicator framework**

The Dutch Inspectorate uses an indicator framework for the supervision of hospitals. In this framework, the Hospital Standardised Mortality Ratio (HSMR)\(^3\) and Unexpectedly Long Length of Stay (ULLOS)\(^4\) are important indicators that can reveal substandard quality of care. They are, however, not representative of the complete quality of care. As most complications do not lead to death, the indicator HSMR reveals only a small part of all the opportunities for improvement. The indicator ULLOS is concerned with all complications which lead to a substantial increase in length of stay. However it is necessary to consider readmissions too, as undesirable outcomes can also be revealed after discharge from the hospital. Furthermore, the indicators are partly substitutable. For example, patients who are discharged too early from the hospital might be readmitted. Therefore, it is assumed that the three indicators should be considered in coherence.\(^4\) The main importance for the Inspectorate is that hospitals are organisations geared towards learning which use these indicators in their management of the quality of care.

**WHY READMISSIONS?**

The relationship between readmissions and the quality of care is discussed in the literature\(^10,11\) with several studies showing, in particular, that unintended readmissions are related to problems with quality.\(^1,2,12-15\) Ashton *et al* assessed the quality of care during the initial admission by chart review using disease-specific criteria for the process of inpatient care.\(^1\) They found that the process of care during the initial admission was associated with an increased chance of an unplanned readmission within 14 days in patients with diabetes, heart failure and obstructive lung disease. Balla *et al* found problems with the quality of care in 33% of the readmissions studied, all of which were considered preventable.\(^2\) The main drawbacks during the initial admission, identified in this study, included inappropriate medication, incomplete preparation for the patient, and too short hospital stay.\(^2\) Furthermore,
Rosen et al showed that safety-related events during the initial admission increased the risk of readmission. For example, these might include postoperative haemorrhage, postoperative wound dehiscence, and problems with the continuity of care. A meta-analysis of Ashton et al showed that the risk of early readmission increased by 55% when the process of inpatient care is of relatively low quality. Preventable readmissions can, for example, be a result of insufficient nurse staffing or the result of a substandard work environment. A recent study performed an in-depth analysis of the causes leading to readmission related to human, organisational, technical, disease and patient factors. They considered half of the readmissions studied to be potentially preventable. Of these readmissions, nearly half again had involved human-related factors as their root causes. This was mostly due to the lack of coordination within the health care system resulting, for example, in an inadequate assessment of a patient's situation at home and the handing over of insufficient information to the general practitioner, the patient, and their home carers.

Another reason for paying attention to hospital readmissions is that they are costly for the health care system. A study in the USA estimated the annual cost of unplanned hospital readmissions at $17 billion.

From a methodological point of view, one of the advantages of using readmissions as an indicator is that it is an event which can be relatively easily identified. Furthermore, most of the data needed to calculate readmission rates, adjusted for their case mix, are already collected routinely. As readmissions include a wide range of clinical diagnoses, they reflect most parts of hospital care. Readmissions occur frequently with readmission rates reported in the literature of between 4% and 29%, depending on the definition of a readmission. This concerns mainly studies from the USA. It is known that readmissions vary considerably between diagnosis, hospitals, and countries. This variation in readmission rates is a rationale to investigate which part of the readmissions is preventable. A review of Van Walraven et al found that the percentage of preventable readmissions varied from 5% to 79%. A quality indicator that identifies preventable readmissions can offer hospitals insight into potential areas of improvement.

**READMISSIONS IN A BROADER CONTEXT**

When investigating readmissions, it is relevant to know how they have developed over the last years and how they relate to the length of stay and the number of deaths in the hospital. In Figure 1 the readmission percentage for all Dutch hospitals is shown for the period 1992 until 2018. All clinical readmissions within 30 days were taken into account. Patients who died during admission were not counted in the total number of initial admissions, as they could not be readmitted. The number of readmissions increased until 2011, reaching almost 18%, and stabilised around 15% from 2013 onwards. In the meantime, the length of stay decreased until recently and has now stabilised at around four days. The number of deaths in hospital has been relatively stable for some decades at between 2% and 3%.
There are several factors that might influence the percentage of readmissions. A tendency which runs in parallel with the increase in the readmission percentage is the increase in the number of day care admissions over a period of years (Figure 2). This is because basic planned care is increasingly treated in day care instead of in a clinical admission. This might influence the percentage of readmissions as an increasing part is no longer included when looking solely at clinical readmissions. There has also been an increased attention given to readmissions in recent years. Since 2014, hospitals receive an annual report which includes their number of readmissions, so that they can compare it with the national average. In the light of the increasing costs of hospital care, this might have stimulated hospitals to reduce unintended readmissions because of their associated high costs.

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1. 2013 was a transitional year in the registration.
DEFINING READMISSIONS AND IDENTIFYING THE RELEVANT ONES

It is crucial to use a transparent and appropriate definition when investigating readmissions. In particular the initial admissions involved are of importance. It is presumed that substandard care during the initial admission could result in a readmission. The admission preceding the readmission is called the index admission. Regarding the readmission, many different terms are used to capture the relevant types of readmissions: related, planned, emergency, acute, intended, avoidable, preventable, and so on. Therefore, it is necessary to clarify the different terms used before investigating readmissions.

**Related readmissions**

In the first place, it is of interest if the readmission is related to its index admission. Readmissions that are a direct result of the care provided during the initial admission can indicate a potential for quality improvement. However, in many cases, the related readmission is a result of the underlying disease and does not reflect the quality of care. Whether related readmissions are a result of the quality of care or the underlying disease, is difficult to assess, especially if based only on administrative data. An example is a patient with acute myocardial infarction who is admitted for coronary bypass surgery and develops a pneumonia after discharge for which a readmission is

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2 From 2014 onwards long-term observations were also registered, which were previously registered as clinical admissions lasting one day. For comparability over the years these are included in the number of clinical admissions in Figure 2.

3 In 2012 the definition of the Dutch Health care Authority (NZa) for clinical admissions and day care admissions became leading for the registration, which caused a decrease in the number of clinical admissions and day care admissions.
needed. This readmission is likely to be related to the index admission, however, there is no direct relationship in the administrative data between the diagnosis for the index admission and for the readmission. In addition, the degree of the relationship is still not evident in the administrative data alone as the pneumonia could also be acquired from the patient’s child.

Unplanned and acute readmissions
Almost all readmission measures aim to exclude the planned readmissions. Defining a planned readmission is, however, not as easy as it seems. A clear example is a patient admitted with an acute myocardial infarction who has a scheduled coronary artery bypass graft one week later. At the time of discharge, it is known that a subsequent admission is needed. The fact that this second admission is planned can be revealed from administrative data, as it will be registered as an elective admission. Different terms are used for this characteristic of an admission. We consider elective the same as non-acute and non-urgent, and, correspondingly, emergency the same as acute and urgent. Though the exact definition of emergency and elective depends on the registration guidelines. This approach is however complicated because not all elective admissions, within a certain time frame from the initial admission, can be seen as planned readmissions. In addition, it is the admission itself which is registered as acute or non-acute, and not the readmission. Whether the particular admission is also a readmission, is derived from the characteristics of this admission, in regard to its eventual previous admission. In the Dutch administrative database an admission is registered acute if care is needed within 24 hours. However, when a non-acute admission is flagged as a readmission, because the patient was admitted two weeks earlier, it does not necessarily mean that it concerns a planned readmission. The patient might have developed a complication for which it is not necessary to be treated directly, and an admission is scheduled two days later.

Unintended readmissions
Another difficulty with the term ‘planned’ is that many patients with chronic conditions are admitted to hospital frequently. These do not necessarily have to be planned readmissions, neither do they have to be related to the quality of care. It is, for example, unknown if and when a patient with heart failure needs to be admitted again when problems with the heart recur. Therefore, an unintended readmission seems to reflect better the relationship with the quality of care. Unintended means that, at the moment of discharge, the purpose is that no subsequent admission is needed. Complications that develop after discharge are clearly unintended. However, a recurrence of a chronic illness is also unintended. In addition, the difficulty with the term unintended, is that this is not registered in administrative databases.

Preventable readmissions
It is the preventable or avoidable readmissions which are of interest. Preventable readmissions are those that could have been prevented by members of the health care system through actions
taken during or after hospitalisation, such as patient counselling, communication among health care providers, and following the medical care guidelines.\textsuperscript{23} This type of readmission is however even more difficult to define accurately. For example, many physicians will discuss if postoperative infections are a calculated risk or could have been prevented. An even greater challenge is to extract preventable readmissions from an administrative database. Postoperative infections are registered in the database identically whether they are caused by inadequate hygiene in the operating room or by inaccurate wound care by the patient at home.

**Identifying the relevant readmissions**

Reviewing medical records is seen as the gold standard when determining the cause of readmissions.\textsuperscript{18} However, this is not feasible because the physicians, who are most likely to be the reviewers because of their medical expertise, have limited time. Algorithms based on administrative data have the potential to identify potentially preventable readmissions efficiently. In England, a classification has been developed using administrative data that can differentiate between potentially preventable readmissions and other reasons for readmissions within 30 days.\textsuperscript{24} This classification distinguishes six categories:

- potentially preventable readmissions. This means that the readmission might be the result of substandard care during the index admission;
- anticipated but unpredictable readmissions. Examples are patients with a chronic disease or those likely to need long-term care;
- readmissions related to patient and staff preferences;
- coding errors in data collection;
- readmissions as a result of an accident, coincidence, or related to a different body system;
- broadly related readmissions. This means that the initial admission and readmission concern the same body system.

The first category of readmissions is most valuable for an indicator that aims to reflect the quality of care.

**Readmissions as an indicator of the quality of care**

Different factors should be addressed when using readmissions as an indicator of the quality of care. These include: the time frame, that is the time between initial admission and readmission; inclusion and exclusion criteria; and case mix correction. In this thesis, we mean quality as defined in the framework of the Institute of Medicine (IOM). This consists of six aims for the health care system. It must be: safe, effective, patient-centred, timely, efficient, and equitable.\textsuperscript{25} In the case of readmission measures, it is mainly the safety, effectiveness and efficiency of care which are addressed.
Time frame

Different time frames between index admission and readmission are used in the literature.\textsuperscript{6} When using a short time frame, many unintended readmissions could be missed. However, when using a long time frame, many unrelated readmissions could be taken into account. Moreover, it is likely that the optimal time frame depends on the diagnosis of the initial admission.\textsuperscript{26} However, we chose for every diagnosis the same time frame of 30 days because this was feasible within the research project. This time frame is most common in international literature.\textsuperscript{27,28} Readmissions occurring within this time frame are likely to reveal weaknesses in the quality of care during the index admission.\textsuperscript{1,15,29}

Inclusion and exclusion criteria

Admissions in which the principal diagnosis is related to cancer, obstetrics, or psychiatric care, are commonly excluded from readmission measures.\textsuperscript{20} For these patients, a major part of the readmissions is considered as necessary follow-up care, such as chemotherapy. Therefore, it is difficult to assess whether a readmission for these diagnoses is preventable. Obstetric admissions have unique attributes and only rarely lead to readmissions.\textsuperscript{30} Furthermore, admissions in which the patient died are usually not counted as an index admission, as they cannot be followed by a readmission.\textsuperscript{31}

Many readmission measures aim to include only the unplanned readmissions.\textsuperscript{7,31} In most cases, this means that only emergency readmissions are included.\textsuperscript{20} However, elective readmissions could also be a result of substandard quality of care, as is clarified in the paragraph ‘Defining readmissions and identifying the relevant ones’. Therefore, it seems more feasible to identify planned readmissions, based on characteristics such as the diagnosis and procedure, in order to exclude these from the indicator. For example Horwitz \textit{et al} developed an algorithm to identify planned readmissions.\textsuperscript{32}

Another inconsistency is whether readmissions to other hospitals are taken into account in the indicator. It is plausible that patients are also readmitted to other hospitals. This might occur after a complication in the first hospital or when patients are not satisfied with the care provided in the original hospital. It is important to be aware of the impact of readmissions that take place in other hospitals in order to benchmark readmissions fairly. However, whether it is possible to track patients across hospitals is dependent on the administrative database.

Case mix correction

The chance of being readmitted to hospital is affected by a variety of variables not related to the quality of care, for example the patient’s age. Therefore, it is important to adjust for the relevant variables. However, not all relevant variables are registered in the database and there is no consensus on which case mix variables should be accounted for.\textsuperscript{31} The commonly used variables in readmission prediction models are: age, gender, main diagnosis, and comorbidity score.\textsuperscript{33} Some studies also use length of stay and number of previous hospitalisations as case mix
variables. However, these characteristics could also be related to the quality of care within the hospital. Furthermore, studies based on primary data collection often use additional correction variables such as marital status and ethnicity.

**Relationship with other quality indicators**

When introducing a new indicator of the quality of care, it is important to know how it relates to the existing comparable indicators. It is presumed that a partly substitutable, and partly complementary, relationship exists between readmissions, length of stay, and morality. All three are used as indicators of the quality of care, however they generally reveal different kinds of problems with the quality of care. The indicator Hospital Standardised Mortality Ratio (HSMR) misses a considerable number of opportunities for improvement as most complications do not lead to death. The indicator Unexpectedly Long Length of Stay (ULLOS) is concerned with all complications which lead to a substantial increase in the length of stay. All patients who died in the hospital are excluded from this indicator, so it is, therefore, complementary to the hospital mortality. Readmissions are complementary to both indicators as they reveal undesirable outcomes after discharge from the hospital - excluding death. Furthermore, the indicators are partly substitutable. For example, patients who are discharged too early from the hospital, might be readmitted. On the other hand, patients who die in hospital, cannot be readmitted.

Different studies have tried to disentangle the relationship between these indicators. Marang et al found no correlation between standardised mortality and readmission rates, and between readmission and long length of stay rates. Other studies indicate that the relationship is dependent upon the level of analysis (patient or hospital level) and the diagnosis group. Westert et al showed that on the patient level, initial hospital stays were generally longer for patients who were readmitted than for those who were not. This result suggests that both outcomes, longer length of stay and readmission, are the result of substandard quality of care, and are therefore complementary. On a national level, however, short initial stays were related to higher readmission rates, and vice versa. This result suggests that length of stay and readmission are substitutable. Furthermore, Hofstede et al showed that the relationship between readmission, length of stay, and mortality differs on the patient level compared with the hospital level. These relationships are even more complex as they also differed per diagnosis group. For example, patients with heart failure, who experienced a long length of stay during the initial admission, had an increased chance of being readmitted. However, hospitals with longer lengths of stay had lower readmission rates for heart failure. On the contrary, for colorectal carcinoma, a positive association between the length of stay and readmission was found on both the patient and hospital levels. In the figure below, these different relationships are illustrated. Because the relationship between these three indicators is both substitutable and complementary, it is crucial to analyse the indicators in coherence.
Chapter 1

Figure 3. The relationship between readmission, length of stay and mortality on the patient level and hospital level

READMISSIONS IN THIS THESIS

The choices of the definitions of a readmission depend partly on the aim for which they are measured and the data available. In this thesis, the aims of the indicator are: 1) For the Dutch Health and Youth Care Inspectorate to add this indicator to their indicator framework for the supervision of hospitals, and; 2) For hospitals to gain insight into complications and substandard quality of care in order to make further improvements. Both aims have a common ground, as the ability of hospitals to use these indicators in a continuous learning process is of key importance for the Inspectorate.

In this thesis, the definition of a readmission is a clinical admission to the same hospital, within 30 days of discharge, following the clinical index admission. We used the index admission as the unit of analysis, which means that each readmission of the same patient is again an index admission for a subsequent readmission. We analysed ‘all-cause readmissions’, which means that they do not need to be related to the cause of the initial hospitalisation. We examined acute admissions, as well as admissions which are not acute. We excluded admissions in which the principal diagnosis was either cancer care, obstetrics, or psychiatric care. Finally, admissions in which the patient died were not counted as an index admission.

We used data from the National Database of Hospital Care (LBZ)\textsuperscript{38} for the analysis of readmissions. This provides data from all general and university hospitals in the Netherlands and contains all hospital admissions.
RESEARCH QUESTIONS
The aim of this thesis is to examine how a quality indicator based on readmissions should be defined in order to be of use to hospitals in identifying problems with the quality of care and consequently can be used by the Inspectorate for its supervision. Therefore, it is necessary to address the variety of factors that influence the chance of a readmission. These factors can be categorised into four levels as illustrated in the figure below. This thesis answers four research questions on those four different levels. The research questions of this thesis are summarised in Text box 2.

Figure 4. The different levels that influence the number of readmissions

On the **first level**, the chance of being readmitted is influenced by the **patient**. Some examples are the diagnosis, the severity of the illness, and patient characteristics such as age and gender. While it is generally agreed that case mix adjustment is needed when calculating the readmission ratio, there is no agreement on the relevant variables (see paragraph ‘Readmissions as an indicator of the quality of care’). We explored in this research project which variables should be taken into account when calculating the readmission ratio (Chapter 2).

On the **second level**, the chance of being readmitted is influenced by the **hospital**. For example, the quality of care provided during the initial admission and the discharge process. This level is of interest for quality improvement and supervision of health care. Hospitals in the UK, USA and Germany are even held accountable for high rates of readmissions for some diagnoses. It is, however, not known to what extent hospitals themselves can influence the risk of readmission.
Hospitals differ in readmission rates, but it is not clear yet to what degree these differences are determined by the hospital itself. A couple of studies examined this by applying multilevel analyses in which they added a hospital level. Most of these studies focused on specific groups of diagnoses, or on a specific population of elderly patients. More extensive research is needed to investigate if this also applies to the diagnosis groups that account for most readmissions. Therefore, this research project aims to quantify the contribution of the hospital to the variation in readmissions. By using multilevel logistic regression analyses, we estimated the variance on the hospital level after adjustment for case mix variables by using a random intercept for the factor ‘hospital’ (Chapter 2).

The way health care is arranged after discharge also determines the chances of being readmitted. This concerns follow-up care on the third level. When health care provided by, among others, the general practitioner, home carers, and nursing home staff, is easily accessible and of good quality, a patient is probably less likely to be readmitted. Transfers between hospitals, and readmissions to hospitals other than the original hospital, concern both the second and third level. Substandard care provided in the initial hospital might result in a readmission to another hospital. Several studies have shown a substantial impact when these readmissions are included. This varies from 17% to 32% of the total number of readmissions. However, most of these studies are performed in the USA, so it is not known if these results are also applicable to European countries with different health care systems, such as the Netherlands. Therefore, one of the aims of this thesis is to determine the impact of the inclusion of readmissions to other hospitals on the indicator. We examined the differences between case mix adjusted readmission ratios for each hospital, including readmissions to other hospitals, and those based solely on readmissions which occur in the same hospital (Chapter 3).

Another way to address the accountability of hospitals for their readmissions is to quantify that part of the readmissions which is potentially preventable. A classification developed in the UK using administrative data which distinguishes between different reasons for readmissions within 30 days offers a hopeful sign. It is, however, not known how applicable this classification of readmissions is for identifying potentially preventable readmissions. Therefore, one of the goals of this research project is to verify the results of this classification by reviewing and categorising the patient records of the same readmissions. Such a classification based on administrative data could be of great value in creating an indicator based on readmissions that can be used as a screening tool for improvements in the quality of care (Chapter 4).

Finally, on the fourth level, readmissions are influenced by the health care system, for example patient logistics and the financing of health care. Comparing readmissions internationally can help to provide insight into the impact of this relationship. If health care systems are comparable, countries can learn from each other. For example, how readmissions should be defined in order to be of use as a quality indicator and how the number of readmissions can be reduced. An
international comparison of indicators based on readmissions in the UK, USA, Australia and the Netherlands demonstrated different ways of calculating and using these indicators.\textsuperscript{20} Readmission rates vary depending on the diagnosis group. However, they did not conduct analysis based on diagnosis groups in this study. Another international study of hospital readmissions in Europe and the USA found a general level of agreement between readmission rates in different countries.\textsuperscript{8} This study was performed in 2002, however, and the Dutch health care system was reformed in 2006,\textsuperscript{22} which could affect the comparison between countries. One of the aims of this research project was to compare readmission rates and reasons for readmissions between England and the Netherlands, in order to facilitate shared learning (Chapter 5).

\underline{Text box 2. Research questions}

\textbf{The main research question}
How should a quality indicator based on readmissions be defined in order to be of use to hospitals in identifying problems with the quality of care, and which consequently can be used by the Inspectorate for its supervision?

\textbf{Sub questions}
- To what degree are hospitals accountable for the variation in readmission rates? (Chapter 2)
- What is the impact on the readmission ratio of taking into account readmissions to other hospitals? (Chapter 3)
- How applicable is a classification of readmissions based on administrative data in identifying potentially preventable readmissions? (Chapter 4)
- Are there differences in readmission rates, and reasons for readmissions, between England and the Netherlands which can indicate opportunities for reducing unnecessary readmissions? (Chapter 5)
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Chapter 2

To what degree can variations in readmission rates be explained on the level of the hospital?

A multilevel study using a large Dutch database

Karin Hekkert
Rudolf B Kool
Ester Rake
Sezgin Cihangir
Ine Borghans
Femke Atsma
Gert P Westert
ABSTRACT

Background: It is not clear which part of the variation in hospital readmissions can be attributed to the standard of care hospitals provide. This is in spite of their widespread use as an indicator of a lower quality of care. The aim of this study is to assess the variation in readmissions on the hospital level after adjusting for case mix factors.

Methods: We performed multilevel logistic regression analyses with a random intercept for the factor ‘hospital’ to estimate the variance on the hospital level after adjustment for case mix variables. We used administrative data from 53 Dutch hospitals from 2010 to 2012 (58% of all Dutch hospitals; 2,577,053 admissions). We calculated models for the top ten diagnosis groups with the highest number of readmissions after an index admission for a surgical procedure. We calculated intraclass correlation coefficients (ICC) per diagnosis group in order to explore the variation in readmissions between hospitals. Furthermore, we determined C-statistics for the models with and without a random effect on the hospital level to determine the discriminative ability.

Results: The ICCs on the hospital level ranged from 0.48 to 2.70% per diagnosis group. The C-statistics of the models with a random effect on the hospital level ranged from 0.58 to 0.65 for the different diagnosis groups. The C-statistics of the models that included the hospital level were higher compared to the models without this level.

Conclusions: For some diagnosis groups, a small part of the explained variation in readmissions was found on the hospital level, after adjusting for case mix variables. However, the C-statistics of the prediction models are moderate, so the discriminative ability is limited. Readmission indicators might be useful for identifying areas for improving quality within hospitals on the level of diagnosis or specialty.
BACKGROUND

Hospital readmissions are increasingly used as an indicator of the quality of care.¹⁻⁵ This is because premature discharge or substandard care during the initial hospitalisation has shown to increase the risk of readmission.⁶⁻⁹ Furthermore, hospital readmissions are a burden to patients and are costly for the healthcare system.¹⁰ The advantages of readmissions as an indicator are that they occur frequently, include a wide range of clinical diagnoses and most of the data needed to calculate readmission rates adjusted for their case mix are already collected routinely.¹¹ Given the presumed negative relationship between readmissions and the quality of care, insight into the readmission rate might help hospitals to identify areas where the quality of their care can be improved.¹²

Even though readmission indicators are already used worldwide, it is still not clear how much the indicator actually reveals about how far the hospital should be held accountable for readmissions. It is estimated that only around 30% of all readmissions are avoidable.¹⁰,¹³⁻¹⁵ The many different definitions used for readmissions also complicate their use as an indicator.² Also, the data collection methodology chosen (clinical reviewer method, administrative billing data method versus physician review of medical record) influences the differences in the rates of readmissions reported.¹⁶ Despite these ambiguities, hospitals in the UK, USA and Germany are already held accountable for high rates of readmissions for some diagnoses.¹⁷,¹⁸ In the UK penalties are imposed for high emergency readmission rates, while in the USA this applies to the diagnosis groups: acute myocardial infarction, COPD, heart failure and pneumonia. In Germany hospitals only receive payments based on one diagnosis-related group (DRG) - that is to say only for the initial admission and not an eventual readmission. Readmissions are, therefore, paid for by the hospital.¹⁸

It has now become necessary to understand the factors associated with readmissions because the readmission indicator is getting more and more popular and its consequences are increasingly far-reaching. A fundamental step is to understand to what extent hospitals themselves can influence the risk of readmission. Hospitals differ in readmission rates, but it is not clear yet which part of these differences is determined by the hospital itself. One technique to quantify the variation in readmissions on the hospital level is through multilevel analysis. This analysis takes into account the hierarchical structure of the admission data. Admissions are clustered within hospitals. Therefore, each observation is not independent. To take this into account, a couple of studies applied multilevel analysis in which they added a hospital level. Most of these studies focused on specific groups of diagnoses,¹⁹⁻二十四 or on a specific population of elderly patients.²⁵,²⁶ These studies found an ICC on the hospital level of around 1 to 5%. More extensive research is needed to investigate if this also applies with regard to the diagnosis groups that account for most readmissions.
The aim of this study is to assess the variation in readmissions on the hospital level after adjusting for the relevant case mix in the Netherlands.

**METHODS**

**DATA**

We used data from the National Medical Registration (Landelijke Medische Registratie, LMR), one of the major Dutch administrative databases. This database provides data from 87 out of the 91 general and university hospitals in the Netherlands and contains all hospital admissions. We looked only at clinical admissions and excluded day care, which concerns, for example, patients undergoing outpatient surgery. This is because day care contains mainly planned admissions which are expected to have little effect upon the quality of care. We then extracted patients from the LMR database who were resident in the Netherlands for the period of 2010 to 2012. Patients not living in the Netherlands were excluded as either their index admission or their readmission could have taken place in their country of residence, and therefore readmissions could be underestimated. Dutch Hospital Data, the national organisation that administers the data from all the hospitals, gave permission to use the data anonymously.

**DEFINITION, TIMEFRAME AND INCLUSION/EXCLUSION CRITERIA**

We defined a readmission as a clinical admission to the same hospital, within 30 days of discharge, following the clinical index admission, which is the original hospital stay. Patient identifiers are specific to an individual hospital and therefore it is only possible to look at readmissions within the same hospital. We chose this time frame in accordance with the international literature. Readmissions occurring within this time frame are likely to reveal weaknesses in the quality of care during the index admission. We used the index admission as the unit of analysis, because this reflects better the clinical course of care. This means that each readmission of the same patient is again an index admission for a subsequent readmission.

We did not take into account whether the readmission was related to the previous hospitalisation, because no reliable method exists yet to select readmissions related to the previous principal diagnosis. Therefore, using our definition, the readmissions were ‘all-cause readmissions’. Acute admissions, as well as admissions which are not acute, were taken into account.

Admissions were included with a discharge date from 1 January 2010 until 31 December 2012. Furthermore, readmissions in January 2013 were included if they followed within 30 days of an index admission which had a discharge date in 2012.

Hospitals offering just one particular specialised form of care, such as ophthalmic surgery, were excluded from the dataset because they are not comparable with the general and university hospitals. Subsequently, we excluded hospitals with inadequate data quality. We investigated the
Variations in readmission rates on the level of the hospital

following criteria, which are the same as those used for the calculation of the Hospital Standardised Mortality Ratio (HSMR) in the Netherlands,\textsuperscript{32} in order to assess data quality. There should be: at least six consecutive months of data registration, not more than 2% vague diagnoses, at least 30% acute admissions and, at least 0.5 comorbidities, on average, per admission. We assessed these variables - diagnosis, urgency and comorbidities - because they are subject to variations in coding between different hospitals as is known from the calculation of the HSMR. These variables are also important in the calculation of readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of readmission.\textsuperscript{1,11} Hospitals that did not meet one or more criteria were excluded from the analyses. Additionally, hospitals that registered a new patient ID at every admission were excluded because no readmissions could be identified. We focused on index admissions with surgical procedures with the highest number of readmissions in our analysis. Therefore, we only included hospitals which had a surgical procedure registered in at least 10% of the admissions. This was because not all hospitals register procedures in the LMR. We compared the characteristics of the dataset used for analysis, with the dataset of hospitals that were excluded because they do not register procedures, in order to assess the comparability of both datasets.

Based on previous literature, we excluded admissions in which the principal diagnosis was either cancer care, obstetrics or psychiatric care.\textsuperscript{33} For these patients, a major part of the readmissions is considered as necessary care. Cancer care and psychiatric care require follow-up care that is intrinsically clinically complex and extensive and therefore the degree to which it can be said to be preventable is difficult to assess. Obstetric readmissions are difficult to identify because most hospital deliveries in the Netherlands take place in the outpatient clinic and are therefore not registered in the LMR.

Furthermore, patients who died during their index admission were excluded from the population at risk. Additionally, we excluded hospital admissions where their values were missing for one of the variables which were used in the logistic regression models. The number of hospitals and admissions excluded is shown in Figure 1.

**CASE MIX VARIABLES**

We included the following predicting variables of the index admission in the model: age, gender, socioeconomic status (SES), urgency, year of discharge and comorbidities.\textsuperscript{34,35} The SES was derived from a table of postal codes from the Netherlands Institute for Social Research (SCP). These SES data were added to the database and provided five SES groups (lowest, below average, average, above average, highest). The variable urgency (acute versus non-acute) indicated whether care within 24 hours was needed.

Comorbidities were assessed by the Charlson index,\textsuperscript{36} based on the secondary diagnoses for each admission. This index consists of 17 groups of comorbidities (Appendix 1), each being a separate case mix variable. We assigned a 0 or 1 to each comorbidity group per admission to indicate the
absence, or presence, of the comorbidity respectively. Secondary diagnoses, registered as a complication - coded with a ‘C’ added to the relevant secondary diagnosis - were not taken into account because they could be related to the quality of care in the hospital.

We included the year of discharge as a variable in order to take into account changes in the health care system every year due to new regulations and innovations. For example, when new coding rules apply and new financial incentives are created.\(^{37}\) The date of discharge of the index admission determined to which year a record was assigned. We used the Clinical Classifications Software (CCS) to stratify for diagnosis.\(^{38}\) This system consists of 259 diagnosis groups based on the International Classification of Diseases (ICD).

We did not take into account the length of stay, because it could be related to the quality of care within the hospital. Variation in the quality of the care, or its level of service, as with different waiting times for diagnostic tests or interventions, can affect the length of stay\(^ {39}\) and we did not want to correct for these differences.

**ANALYSIS**

**Top ten diagnosis groups with large numbers of readmissions**

We focused on index admissions with surgical procedures for the top ten diagnosis groups with the highest number of readmissions. This was because the literature indicates that unintended readmissions after surgical procedures are mainly the result of complications.\(^ {40,41}\) The analysis was performed based on the diagnosis of the index admission. The readmissions, however, were all-cause readmissions. Procedures were registered in the LMR with CvV codes - a Dutch classification of procedures, used at the time of the research - and were classified as ‘surgical procedure’ or ‘no surgical procedure’. In order to compare hospitals that did register procedures and those that did not, we calculated the mean percentage of readmissions after an index admission with a ‘surgical procedure’ and the range of readmission rates across hospitals. We analysed Cohen’s \(d\) to calculate the effect size in order to analyse the relevance of the difference between the two datasets.

**Variation on the hospital level**

To assess the variation in readmission rates between hospitals, we performed multilevel logistic regression analyses, with a random effect on the hospital level. We did this for each of the top ten diagnosis groups. We also calculated these models without a random effect on the hospital level in order to assess the difference. In total, twenty models were calculated for each of the ten diagnosis groups, with and without a random effect for the hospital. We included in the models the case mix factors: age, gender, SES, urgency, year of discharge and Charlson index (17 groups of comorbidities). This was in order to adjust for differences between hospitals in these factors. We scaled the variable, age, by calculating a z-score.\(^ {42}\) This appeared to be necessary to make the models fit, because this scale differed from the scales of the other case mix variables. This
standardisation puts the explanatory variables on an equal footing because it makes the scale of the variables irrelevant.

Case mix variables with fewer than 50 admissions in a category were excluded from the models to prevent the standard errors of the regression coefficients becoming too large (a category is a combination of readmission yes/no and case mix variable category). Comorbidities 9 and 17 (liver disease and severe liver disease) and 10 and 11 (diabetes and diabetes complications) were merged into one when there were fewer than 50 admissions where the comorbidity was present.

We then calculated the intraclass correlation coefficient (ICC) for each of the top ten diagnosis groups in order to assess the variation in readmissions between hospitals. This was achieved by using the method for calculating an ICC in the logistic multilevel models of Snijders and Bosker. We calculated a C-statistic for the models including a random effect on the hospital level and for the models not including this hospital effect. The difference between the two C-statistics was used as a measure for the contribution of the hospital to the variation in readmission rates.

We adjusted for case mix in order to take into account the differences between hospitals regarding their patient population. We added only the significant predictors (p<0.05) from the univariate analyses in the final models, because models which included all case mix factors could not converge.

The data were analysed using R 3.2.1. The package lme4 was used for the multilevel logistic regression and the package pROC was used to calculate the C-statistic.

RESULTS

A total of 6,077,310 admissions in 87 hospitals were present in the cohort from January 2010 until January 2013. In total three university and 31 general hospitals were excluded because of incomplete or incomparable data (The criteria are described in Figure 1). The dataset used for further analyses consisted of 53 hospitals with, in total, 2,577,053 admissions of 1,784,709 patients. An overview of all the steps leading to exclusion, including the amount of admissions excluded in each step, is given in Figure 1.
6,077,310 admissions in 87 hospitals cohort January 2010 until January 2013

1 excluded

Specialist hospital: two hospitals, 9665 admissions

In total: eight hospitals1, 347,288 admissions

Hospitals with inadequate data quality
- < 6 months data registration: three hospitals
- > 2% vague diagnoses: three hospitals
- < 30% acute admissions: two hospitals
- < 0.5 comorbidities (average) per admission: one hospital

1 one hospital was excluded for two reasons

New patient ID assigned at admission: two hospitals, 102,239 admissions
Hospitals that did not register procedures: 22 hospitals, 1,040,778 admissions

Year 2013: 5864 admissions
Died in hospital: 80,792 admissions

Obstetric care: 610,760 admissions
Cancer care: 1,212,187 admissions
Psychiatric care: 58,195 admissions

Time until readmission < 0 days: 254 admissions
Missing CCS unable to recode/exclusion group: 4230 admissions (0.04% of all admissions)
Missing SES: 28,005 admissions (0.27% of all admissions)

2,577,053 admissions in 53 hospitals remaining

Figure 1. Flowchart admissions in dataset
Variations in readmission rates on the level of the hospital

BASELINE CHARACTERISTICS

Table 1 gives the median, 5th and 95th percentile of the mean age, percentage women, percentage acute admissions, percentage acute readmissions and mean number of comorbidities per hospital. To calculate the comorbidities per hospital, we added up the comorbidities 1 to 17. It appears that there was some variation in age, gender, urgency of the admission, urgency of the readmission and comorbidities between the hospitals. The latter varied the most. The dataset of 22 hospitals that did not register procedures had comparable baseline characteristics, but the mean number of comorbidities was lower compared to the dataset of 53 hospitals. These differences were, however, not relevant. For all variables the Cohen’s $d$ was around 0.

Table 1. Baseline characteristics (N = 53 hospitals)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median</th>
<th>5th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions (N)</td>
<td>41,770</td>
<td>23,168</td>
<td>86,151</td>
</tr>
<tr>
<td>Readmissions (N)</td>
<td>4262</td>
<td>2236</td>
<td>9182</td>
</tr>
<tr>
<td>% Readmissions</td>
<td>10.16</td>
<td>8.68</td>
<td>11.89</td>
</tr>
<tr>
<td>Mean age</td>
<td>51.28</td>
<td>45.33</td>
<td>54.84</td>
</tr>
<tr>
<td>% Women</td>
<td>50.61</td>
<td>45.85</td>
<td>53.43</td>
</tr>
<tr>
<td>% Acute$^1$ admissions</td>
<td>55.61</td>
<td>41.73</td>
<td>67.58</td>
</tr>
<tr>
<td>% Acute$^1$ readmissions</td>
<td>68.87</td>
<td>49.20</td>
<td>78.12</td>
</tr>
<tr>
<td>Mean number of comorbidities</td>
<td>0.22</td>
<td>0.06</td>
<td>0.44</td>
</tr>
</tbody>
</table>

$^1$ In the LMR an admission is registered ‘acute’ if care is needed within 24 hours

VARIATION ON THE HOSPITAL LEVEL

The top ten diagnosis groups was calculated using the index admissions with a surgical procedure that accounted for most readmissions. It appeared that the absolute number of readmissions after an index admission with a surgical procedure was highest in the diagnosis group ‘biliary tract disease’. The percentage of readmissions after an index admission with a surgical procedure was highest in the group ‘complications of surgical procedures or medical care’ (Table 2). See for the contribution of the case mix variables of the models with hospital level Appendix 2.
Table 2. Admissions and readmissions per diagnosis group of the index admission (N = 53 hospitals)

<table>
<thead>
<tr>
<th>Diagnosis group (CCS code)</th>
<th>Admissions total (N)</th>
<th>Admissions with surgical procedure (N)</th>
<th>Readmissions after surgical procedure (N)</th>
<th>Readmissions and range (% of admissions with surgical procedure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary tract disease (149)</td>
<td>60,238</td>
<td>47,379</td>
<td>4435</td>
<td>9.4 (4.7-13.3)</td>
</tr>
<tr>
<td>Osteoarthritis (203)</td>
<td>86,268</td>
<td>83,302</td>
<td>3177</td>
<td>3.8 (2.4-7.4)</td>
</tr>
<tr>
<td>Complication of device; implant or graft (237)</td>
<td>40,625</td>
<td>25,374</td>
<td>2929</td>
<td>11.5 (4.3-18.7)</td>
</tr>
<tr>
<td>Fracture of neck of femur (hip) (226)</td>
<td>31,672</td>
<td>29,136</td>
<td>2242</td>
<td>7.7 (2.2-11.0)</td>
</tr>
<tr>
<td>Complications of surgical procedures or medical care (238)</td>
<td>36,835</td>
<td>13,265</td>
<td>1972</td>
<td>14.9 (5.3-23.0)</td>
</tr>
<tr>
<td>Appendicitis and other appendiceal conditions (142)</td>
<td>27,247</td>
<td>24,546</td>
<td>1751</td>
<td>7.1 (3.4-12.4)</td>
</tr>
<tr>
<td>Calculus of urinary tract (160)</td>
<td>20,344</td>
<td>11,300</td>
<td>1412</td>
<td>12.5 (0.0-26.4)</td>
</tr>
<tr>
<td>Abdominal hernia (143)</td>
<td>26,286</td>
<td>23,647</td>
<td>1421</td>
<td>6.0 (3.3-12.1)</td>
</tr>
<tr>
<td>Cardiac dysrhythmias (106)</td>
<td>92,360</td>
<td>15,129</td>
<td>1239</td>
<td>8.2 (2.8-66.7)</td>
</tr>
<tr>
<td>Hyperplasia of prostate (164)</td>
<td>16,631</td>
<td>15,591</td>
<td>1181</td>
<td>7.6 (3.2-17.5)</td>
</tr>
</tbody>
</table>

1. CCS = Clinical Classifications Software
2. Diagnosis groups are sorted by number of readmissions after surgical procedure

Each of the index admissions can be also a readmission of a previous index admission. This is especially the case for the diagnosis groups ‘Complications of surgical procedures or medical care’ and ‘Complication of device; implant or graft’. Of these index admissions, 45% respectively 30% is also a readmission of a previous index admission. Therefore, a large number of the index admissions is also a readmission in these diagnosis groups. After adjusting for case mix factors, the ICCs on the hospital level per diagnosis group ranged from 0.48 to 2.70% (Table 3). The C-statistics in the models with a random effect on the hospital level per diagnosis group varied between 0.58 and 0.65. The C-statistics in the models without a random effect on the hospital level varied between 0.52 and 0.64.
Variations in readmission rates on the level of the hospital

Table 3. ICCs hospital level and C-statistics of the models per diagnosis group of the index admission (N = 53 hospitals)

<table>
<thead>
<tr>
<th>Diagnosis group (CCS¹ code)</th>
<th>ICC hospital (% and 95% CI)</th>
<th>C-statistic model with random effect hospital (95% CI)</th>
<th>C-statistic model without random effect hospital (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary tract disease (149)</td>
<td>0.48 (0.23-0.68)</td>
<td>0.651 (0.644-0.657)*</td>
<td>0.641 (0.635-0.648)</td>
</tr>
<tr>
<td>Osteoarthritis (203)</td>
<td>1.81 (1.26-2.41)</td>
<td>0.620 (0.611-0.630)*</td>
<td>0.597 (0.587-0.607)</td>
</tr>
<tr>
<td>Complication of device; implant or graft (237)</td>
<td>1.73 (1.22-2.15)</td>
<td>0.641 (0.634-0.649)*</td>
<td>0.625 (0.618-0.632)</td>
</tr>
<tr>
<td>Fracture of neck of femur (hip) (226)</td>
<td>2.33 (1.74-2.83)</td>
<td>0.617 (0.606-0.628)*</td>
<td>0.575 (0.564-0.586)</td>
</tr>
<tr>
<td>Complications of surgical procedures or medical care (238)</td>
<td>0.70 (0.45-1.15)</td>
<td>0.576 (0.568-0.584)*</td>
<td>0.556 (0.548-0.564)</td>
</tr>
<tr>
<td>Appendicitis and other appendiceal conditions (142)</td>
<td>1.45 (0.67-1.79)</td>
<td>0.583 (0.571-0.596)*</td>
<td>0.520 (0.506-0.533)</td>
</tr>
<tr>
<td>Calculus of urinary tract (160)</td>
<td>2.31 (1.57-2.64)</td>
<td>0.615 (0.604-0.625)*</td>
<td>0.574 (0.563-0.585)</td>
</tr>
<tr>
<td>Abdominal hernia (143)</td>
<td>1.36 (0.63-1.76)</td>
<td>0.648 (0.636-0.661)*</td>
<td>0.628 (0.615-0.641)</td>
</tr>
<tr>
<td>Cardiac dysrhythmias (106)</td>
<td>1.11 (0.65-1.18)</td>
<td>0.590 (0.585-0.595)*</td>
<td>0.568 (0.562-0.573)</td>
</tr>
<tr>
<td>Hyperplasia of prostate (164)</td>
<td>2.70 (1.37-3.86)</td>
<td>0.636 (0.620-0.651)*</td>
<td>0.592 (0.576-0.608)</td>
</tr>
</tbody>
</table>

¹ CCS = Clinical Classifications Software
* significantly (p<0.05) higher compared to the C-statistics of the models without a random effect on the hospital level

**DISCUSSION**

**VARIATION ON THE HOSPITAL LEVEL**

The ‘biliary tract disease’ was the diagnosis group of the index admissions with a surgical procedure which was followed most often by a readmission in absolute terms. The percentage of readmissions varied between hospitals. The range of crude readmission rates was greatest for cardiac dysrhythmias. This means that there is quite some degree of variation between the hospitals in the crude number of readmissions for these cardiology diagnoses.

The ICCs we found in this study (ranging from 0.48 to 2.70% for the diagnosis groups) are comparable with the study of Singh et al who found an ICC on the hospital level of 0.84% in a Medicare population, which are mainly older patients, and a study of Jorgensen et al who found an ICC of 1 to 2% in a cohort of colorectal cancer patients. Burke et al found a slightly higher ICC of 4.6% in a patient group hospitalised for ischaemic stroke. ICCs on the hospital level for outcome measures are usually 1% or even 0.1%.
The C-statistics differed significantly for all diagnosis groups between the models with and without a random effect on the hospital level. The C-statistics of the models which included the hospital level were higher compared to the models which did not. The size of the difference varied between the different diagnosis groups. The higher C-statistics of the models which included the hospital level might indicate that part of the variation is explained by the hospital. This is especially the case in the diagnosis groups where the difference between the C-statistic of the model with hospital level and without hospital level is the largest: ‘appendicitis and other appendiceal conditions’, ‘hyperplasia of prostate’, ‘fracture of neck of femur (hip)’ and ‘calculus of urinary tract’.

The effect of the different patient characteristics varied between the models per diagnosis group (See Appendix 1).

We took the SES as a case mix variable into account in our analysis as this is a relevant patient characteristic that influences the risk of a readmission. However, some studies showed that patients with a lower SES receive a lower quality of care. Therefore, it can be argued that SES should not be taken into account when calculating the indicator for use in practice as it is better not to adjust for this difference.

The C-statistics of the models with a random effect on the hospital level were modest ranging from 0.58 to 0.65, which is in accordance with the international literature. The C-statistic was lower than in a comparable Belgian study which found a C-statistic of 0.73. These moderate C-statistics suggest that, given the predictors, the risk of readmission cannot be predicted accurately. Readmissions are probably influenced by other patient factors not available in administrative databases. This idea is supported by Barnett et al who linked national survey data to that from Medicare claims. Of the 29 patient characteristics studied, 22 significantly predicted readmissions. Among these patient characteristics were social aspects, including marital status, employment status and having friends who are living nearby. These variables were not available in our database.

**Implications for Practice**

Our study showed that, after adjusting for the relevant case mix variables, a small part of the explained variation in readmission rates for some diagnosis groups exists on the hospital level. As the models for predicting readmissions show only moderate C-statistics, the discriminative ability is limited.

It is important to mention that the care provided in the immediate period after receiving hospital care can influence the number of readmissions. More specifically, this number depends on the destination of patients after discharge and the way the hospital arranges this care after discharge. Even if readmissions seem largely dependent on the patient’s health status or the quality of care after the patient’s discharge, hospitals can take responsibility for factors outside of their walls. For example, the hospital could improve the communication between the hospital and the community care physicians or by improving the discharge planning process.
Variations in readmission rates on the level of the hospital

Studies show that hospital strategies to reduce readmissions can be successful. For example, hospitals experienced significant reductions in unplanned readmission rates when they adopted the strategy of routinely discharging patients with a follow-up appointment already scheduled. Therefore, the indicator could be used as a screening tool in the internal process of improving the quality of care and also improving the aftercare and coordination in the health care chain. By identifying diagnosis groups and patient groups with a high risk of readmission, hospitals can take this into account in the planning of care for these patients and around their discharge.

STRENGTHS AND LIMITATIONS
Several studies calculated readmission rates without applying multilevel analysis. However, it is necessary to use this technique, because of the hierarchical structure of the dataset. We also used the multilevel analysis to quantify the hospital contribution to the risk of readmission. Furthermore, several multilevel studies focused only on a specific diagnosis or patient group, while our study concerns ten different diagnosis groups in which readmissions are common after an index admission with a surgical procedure. The number of hospitals included in the database is another strength of this study. It contains admission data for more than half of the Dutch hospitals. Furthermore, data from 3 consecutive years were included for analysis. As the effect of the factor ‘year’ in the models is very small, we do not expect other results for more recent years.

Our study did not include the hospitals that did not register procedures. The characteristics of the 53 hospitals used for analysis were comparable to the characteristics of the 22 excluded hospitals which did not register procedures. However, the mean number of comorbidities was lower in these 22 hospitals. Therefore, the database used in this study might include relatively more severe patients. On the other hand, it could also indicate that these excluded hospitals did not register comorbidities completely.

Our study was limited to Dutch hospitals. It could be plausible that because of financial incentives in other countries, such as the UK and USA, their readmission rates differ from those in our study. In addition, the number of admissions could be influenced by the way the immediate care after discharge from the hospital is arranged. In the Netherlands, general practice performs a strong gate keeping role and so many patients receive health care at home after discharge. Some systems, such as that in Belgium, which borders the Netherlands, are comparable. A Belgian study with similar methodology found a slightly lower acute readmission percentage compared to the Netherlands. This might be because the registration of the urgency of admissions is not exactly the same. Furthermore, our results concerning the crude readmission rate and the ICCs are in line with the international literature. Therefore, we do not expect a different outcome when studying hospitals from other countries.

As this study is based on administrative data, it is important to minimise bias caused by differences in registration between the hospitals. Therefore, we excluded hospitals with inadequate data quality, so we expect that this did not affect our results.
However, our study was limited in its ability to track patients across hospitals because the database has no reliable information about transfers between different hospitals or readmissions to other hospitals. Nasir et al reported that 19% of the readmissions occurred in a different hospital and Halfon et al reported 17%.

Another limitation concerned the lack of mortality data after discharge. A better estimate of the population at risk for readmissions could have been made with these data. Therefore, this can be included in further research by combining the medical database with the Dutch Municipal Personal Records Database (Gemeentelijke basisadministratie persoonsgegevens).

We could not exclude the intended readmissions from the indicator in this study. This is because it is difficult to identify intended readmissions - based on the available variables in the LMR - through the use of just one variable such as urgency. In the LMR an admission is registered ‘acute’ if care is needed within 24 hours and therefore does not seem to reflect the difference between unintended and intended readmissions.

**Future research**

It is necessary to exclude intended readmissions from the indicator in order to develop a readmission measure which reflects the quality of care. This is because they do not reflect poor quality of care. Investigating patient records retrospectively can be seen as the gold standard for selecting unintended readmissions. However, this is a time-consuming procedure. Blunt et al (2015) were able to classify preventable readmissions based on administrative data and to select readmissions for immediate reduction. Furthermore, Goldfield et al (2008) made an attempt to select potentially preventable readmissions (PPR) based on administrative data. A recent study of Borzecki et al examined whether the PPR algorithm distinguishes between good and bad quality of care on the individual case level in readmissions for pneumonia. Based on administrative data, the PPR software matches the clinically-related index admission and readmission diagnoses which may indicate readmissions resulting from problems with the quality of care on admission or after discharge from hospital. They found no significant difference in the quality of care, as measured by processes of care received during the index admission and after discharge, between cases flagged as PPRs and those cases not flagged. This contrasted with their hypothesis. Therefore, reviewing medical records seems necessary in order to reveal the underlying causes of readmissions. This might be a crucial step in refining the readmission indicator. Furthermore, concerning case mix adjustment, it is advisable to take into account the severity of the principal diagnosis in the prediction of readmissions. Finally, in order to understand potential differences in readmission rates between countries, a comparison between countries could be made.
CONCLUSIONS

Our study showed that after adjusting for the relevant case mix variables a small part of the explained variation in readmissions for some diagnosis groups can be found on the level of the hospital. However, the C-statistics of the prediction models are moderate, so the discriminative ability is limited. The contribution of the hospital level to a slightly better model, indicates that there might be differences between the hospitals, especially for the diagnosis groups with the largest difference in C-statistic. A readmission indicator might be useful for identifying areas for improving the quality of care within hospitals on the level of diagnosis or medical specialty. Further research is needed to distinguish between intended and unintended readmissions.
REFERENCES

Variations in readmission rates on the level of the hospital


## Appendix 1. Charlson Comorbidity Groups with Corresponding ICD9 Codes

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Charlson group</th>
<th>ICD9 codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comorbidity 1</td>
<td>Acute myocardial infarction</td>
<td>410, 412</td>
</tr>
<tr>
<td>Comorbidity 2</td>
<td>Congestive heart failure</td>
<td>428</td>
</tr>
<tr>
<td>Comorbidity 3</td>
<td>Peripheral vascular disease</td>
<td>441, 4439, 7854, V434</td>
</tr>
<tr>
<td>Comorbidity 4</td>
<td>Cerebral vascular accident</td>
<td>430–438</td>
</tr>
<tr>
<td>Comorbidity 5</td>
<td>Dementia</td>
<td>290</td>
</tr>
<tr>
<td>Comorbidity 6</td>
<td>Pulmonary disease</td>
<td>490, 491, 492, 493, 494, 495, 496, 500, 501, 502, 503, 504, 505</td>
</tr>
<tr>
<td>Comorbidity 7</td>
<td>Connective tissue disorder</td>
<td>7100, 7101, 7104, 7140, 7141, 7142, 71481, 5171, 725</td>
</tr>
<tr>
<td>Comorbidity 8</td>
<td>Peptic ulcer</td>
<td>531, 532, 533, 534</td>
</tr>
<tr>
<td>Comorbidity 9</td>
<td>Liver disease</td>
<td>5712, 5714, 5715, 5716</td>
</tr>
<tr>
<td>Comorbidity 10</td>
<td>Diabetes</td>
<td>2500, 2501, 2502, 2503, 2507</td>
</tr>
<tr>
<td>Comorbidity 11</td>
<td>Diabetes complications</td>
<td>2504, 2505, 2506</td>
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<td>Comorbidity 12</td>
<td>Paraplegia</td>
<td>342, 3441</td>
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<td>Comorbidity 13</td>
<td>Renal disease</td>
<td>582, 5830, 5831, 5832, 5836, 5837, 5834, 585, 586, 588</td>
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<tr>
<td>Comorbidity 15</td>
<td>HIV</td>
<td>042, 043, 044</td>
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<tr>
<td>Comorbidity 17</td>
<td>Severe liver disease</td>
<td>5722, 5723, 5724, 5728</td>
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### APPENDIX 2. CONTRIBUTION CASE MIX VARIABLES MODELS WITH HOSPITAL LEVEL

#### Model with hospital level

<table>
<thead>
<tr>
<th>Patient characteristic</th>
<th>Odds Ratio (95% CI)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Patient characteristic</td>
</tr>
<tr>
<td></td>
<td>Biliary tract disease (149)</td>
</tr>
<tr>
<td></td>
<td>Osteoarthritis (203)</td>
</tr>
<tr>
<td></td>
<td>Fracture of neck of femur (hip) (226)</td>
</tr>
<tr>
<td></td>
<td>Complications of procedures or medical care (238)</td>
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<tr>
<td></td>
<td>Appendicitis and other abdominal conditions (142)</td>
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<td></td>
<td>Calculus of urinary tract (160)</td>
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<td></td>
<td>Abdominal hernia (143)</td>
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<tr>
<td></td>
<td>Hyperplasia of prostate (144)</td>
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<tr>
<td></td>
<td>Cardiac dysrhythmias (106)</td>
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<th>Age</th>
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<tr>
<td></td>
<td>Female</td>
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<table>
<thead>
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<th>Gender</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>Female</td>
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<table>
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<tr>
<th>Urgency</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>Non-acute</td>
</tr>
<tr>
<td></td>
<td>Acute</td>
</tr>
<tr>
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<tr>
<th>SES</th>
<th>Odds Ratio (95% CI)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Lowest</td>
</tr>
<tr>
<td></td>
<td>Below average</td>
</tr>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Above average</td>
</tr>
<tr>
<td></td>
<td>Highest</td>
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<table>
<thead>
<tr>
<th>Year of discharge</th>
<th>Odds Ratio (95% CI)</th>
</tr>
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<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>2012</td>
</tr>
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</table>

<table>
<thead>
<tr>
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<th>Odds Ratio (95% CI)</th>
</tr>
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<tr>
<td></td>
<td>1.56 (1.23-1.98)</td>
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<table>
<thead>
<tr>
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<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>2.26 (1.38-3.70)</td>
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<th>Comorbidity 3</th>
<th>Odds Ratio (95% CI)</th>
</tr>
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<tr>
<td></td>
<td>1.78 (1.08-2.92)</td>
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<table>
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<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>1.30 (1.13-1.50)</td>
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<table>
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<tr>
<th>Comorbidity 5</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>0.84 (0.71-0.98)</td>
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<table>
<thead>
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<th>Comorbidity 6</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>1.23 (1.06-1.44)</td>
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<table>
<thead>
<tr>
<th>Comorbidity 7</th>
<th>Odds Ratio (95% CI)</th>
</tr>
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<tr>
<td></td>
<td>0.86 (0.79-0.95)</td>
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<tr>
<th>Comorbidity 8</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>0.97 (0.86-1.09)</td>
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<table>
<thead>
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<th>Comorbidity 9</th>
<th>Odds Ratio (95% CI)</th>
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<td></td>
<td>1.08 (1.01-1.16)</td>
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<th>Comorbidity 10</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>1.47 (1.22-1.77)</td>
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<table>
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<tr>
<th>Comorbidity 11</th>
<th>Odds Ratio (95% CI)</th>
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<tr>
<td></td>
<td>1.20 (1.07-1.35)</td>
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<table>
<thead>
<tr>
<th>Comorbidity 12</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.25 (1.08-1.45)</td>
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</table>

<table>
<thead>
<tr>
<th>Comorbidity 13</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.22 (1.09-1.37)</td>
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<table>
<thead>
<tr>
<th>Comorbidity 14</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.13 (1.05-1.23)</td>
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<table>
<thead>
<tr>
<th>Comorbidity 15</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.13 (1.05-1.23)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Comorbidity 16</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.48 (1.17-1.86)</td>
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</table>

<table>
<thead>
<tr>
<th>Comorbidity 17</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.49 (1.61-3.84)</td>
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</table>

<table>
<thead>
<tr>
<th>Comorbidity 9_17</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.76 (1.57-1.96)</td>
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<table>
<thead>
<tr>
<th>Comorbidity 10_11</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.59 (1.27-2.00)</td>
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</table>

<table>
<thead>
<tr>
<th>Comorbidity 18</th>
<th>Odds Ratio (95% CI)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1.84 (1.38-2.45)</td>
</tr>
</tbody>
</table>
Chapter 3

What is the impact on the readmission ratio of taking into account readmissions to other hospitals?

A cross-sectional study

Karin Hekkert
Ine Borghans
Sezgin Cihangir
Gert P Westert
Rudolf B Kool

ABSTRACT

Objectives: Readmissions are used widespread as an indicator of the quality of care within hospitals. Including readmissions to other hospitals might have consequences for hospitals. The aim of our study is to determine the impact of taking into account readmissions to other hospitals on the readmission ratio.

Design and setting: We performed a cross-sectional study and used administrative data from 77 Dutch hospitals (2,333,173 admissions) in 2015 and 2016 (97% of all hospitals). We performed logistic regression analyses to calculate 30 day readmission ratios for each hospital (the number of observed admissions divided by the number of expected readmissions based on the case mix of the hospital, multiplied by 100). We then compared two models: one with readmissions only to the same hospital, and another with readmissions to any hospital in the Netherlands. The models were calculated on the hospital level for all in-patients and, in more detail, on the level of medical specialties.

Main outcome measures: Percentage of readmissions to another hospital, readmission ratios same hospital and any hospital and C-statistic of each model in order to determine the discriminative ability.

Results: The overall percentage of readmissions was 10.3%, of which 91.1% were to the same hospital and 8.9% to another hospital. Patients who went to another hospital were younger, more often men, and had fewer comorbidities. The readmission ratios for any hospital versus the same hospital were strongly correlated (r = 0.91). There were differences between the medical specialties in percentage of readmissions to another hospital and C-statistic.

Conclusions: The overall impact of taking into account readmissions to other hospitals seems to be limited in the Netherlands. However, it does have consequences for some hospitals. It would be interesting to explore what causes this difference for some hospitals and if it is related to the quality of care.
INTRODUCTION

Widespread use is made of readmissions as an indicator of the quality of care within hospitals.\(^1\)\(^-\)\(^4\) Hospitals themselves use the indicator to measure and improve their quality of care,\(^5\)\(^,\)\(^6\) while governments use readmissions for rankings and financial penalties.\(^7\)\(^,\)\(^8\) Because of their presumed relationship to the quality of care, and the extra costs associated with them, hospitals should monitor the number of readmissions carefully.\(^1\)\(^,\)\(^9\)\(^-\)\(^12\) Monitoring readmissions can be done using existing administrative data without an additional burden for health care professionals.\(^13\)

However, the interpretation of readmissions is complicated by the fact that there are many reasons for them.\(^14\) Moreover, there are several ways of calculating readmission rates, depending on the objective of the readmission measure and the data availability.\(^2\)\(^,\)\(^15\)

One of the issues in the existing readmission indicators is the inclusion of readmissions to other hospitals. Hospitals can assess, monitor, and analyse their own readmissions, and track down their causes, in order to improve quality and safety. However, it is plausible that patients are also readmitted to other hospitals. This may occur, for example, after a complication in the first hospital or when patients are not satisfied with the care delivered in the original hospital. It is important to be aware of the impact of readmissions to other hospitals in order to benchmark readmissions fairly. This impact can differ per hospital.\(^16\) In addition, that part of readmissions which are to other hospitals might differ per medical specialty. For example, a difference might exist between surgical and diagnostic specialties. It is important to take this into account when interpreting readmission outcomes if one is to seek potential improvements. We expect that the impact of taking into account readmissions to other hospitals differs between hospitals and medical specialties, and that this can reveal additional opportunities for improvement.

Several studies have shown a substantial impact when readmissions to other hospitals are included. Depending on its definition, readmissions occurring in other hospitals can vary from between 17% and 32% of the total number of readmissions.\(^16\)\(^-\)\(^23\) Halfon et al\(^17\) and Nasir et al\(^16\) specifically mentioned that the part of the readmissions that occurred in another hospital varied substantially between hospitals. This is an additional reason to take this mechanism into account. However, most of these studies are performed in the USA so it is not known if these results are also applicable for European countries with different health care systems, such as the Netherlands. The Dutch health care system is based on mandatory private health insurance with an important role for the general practitioner (GP) acting as the gatekeeper of secondary care. They play a crucial role in referrals to hospitals and can be directive in their choice of hospitals. The question is therefore whether the abovementioned impact, resulting from the inclusion of readmissions to other hospitals, is the same for other countries. It is important to answer this question because, in the Netherlands, readmissions are an indicator of the quality of care. The Dutch Health and Youth Care Inspectorate requires that hospitals publicly submit their overall
number of readmissions each year. There are no financial penalties for hospitals with more readmissions than the national average (readmission ratio >100). At the moment, this concerns only readmissions within the same hospital.

The aim of this study is to assess the difference between case mix adjusted readmission ratios for each hospital including readmissions to other hospitals and those based solely on readmissions which occur in the same hospital. The research question is: what is the impact on the readmission ratio of taking into account readmissions to other hospitals?

METHODS

DATABASE AND STUDY POPULATION
We used data from the National Database of Hospital Care (LBZ). This database provides data from all 79 general and university hospitals in the Netherlands - at the time of the study period - and contains all hospital admissions. Dutch Hospital Data, the national organisation that administers the data from all the hospitals, gave permission to use the data anonymously. We selected index admissions with a discharge date from 1 January 2015 to 31 October 2016, and all subsequent readmissions until a discharge date of 31 December 2016. The data used in this study is fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands (CBS). We had permission of all hospitals to use the data anonymously.

The definition of a readmission was a clinical admission to the same hospital, within 30 days of discharge, following the clinical index admission - that is, the original hospital stay. We chose this time frame in accordance with the international literature. We calculated all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation. We used the index admission as the unit of analysis. This means that each readmission of the same patient is again an index admission for a subsequent readmission.

Index admissions and readmissions were linked with a unique patient number obtained by a Trusted Third Party (Zorg TTP) which allows an individual’s information in health care to be exchanged without compromising their privacy. Readmissions were assigned to the hospital of the index admission. Transfers, which are defined as readmissions to another hospital within 1 day, were not counted as readmissions but included as an index admission of the second hospital.

We excluded hospitals that did not register unique patient numbers. We also excluded admissions that were not registered completely in the database (for example missing diagnosis). Patients not living in the Netherlands were excluded as either their index admission or their
Impact on the readmission ratio of taking into account readmissions to other hospitals

readmission, could have taken place in their country of residence, and therefore readmissions could be underestimated. Patients who died during their index admission were excluded from the population at risk. Furthermore, we excluded admissions where data were missing on one of the variables that we used in the analyses. Based on previous literature, we also excluded admissions in which the principal diagnosis involved either cancer care, obstetrics or psychiatric care. Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data, we investigated the following criteria: there should be at least 12 consecutive months of data registration; not more than 2% of vague diagnoses; at least 30% acute admissions; and at least 0.5 comorbidities, on average, per admission. We assessed these variables because they are subject to variations in coding between different hospitals and are important in the calculation of readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of readmission. Hospitals that did not meet one or more criteria were excluded from the analyses.

**DESIGN**

We performed logistic regression analyses to calculate readmission ratios for each hospital based on the administrative data. We did not perform hierarchical modelling, as a recent study showed that adding a hospital level had only a very small impact on the results. The following predicting covariates for the adjustment for case mix were used: severity of main diagnosis (a categorisation depending on the seriousness in terms of mortality), gender, age category, urgency of the admission, Charlson comorbidities (17 groups of comorbidity), socioeconomic status (based on the postal code of the patients’ residence), month of admission and place of residence before admission. All variables concern the index admission.

**PATIENT AND PUBLIC INVOLVEMENT**

Patients were not involved in the design of this study.

**ANALYSIS**

We calculated the baseline characteristics of the subset of readmissions in the dataset, comparing these characteristics for readmissions to the same hospital with readmissions to other hospitals. We calculated readmission ratios for each hospital by dividing the observed number of readmissions by the expected number of readmissions, multiplied by 100. The expected number of readmissions is based on the case mix of the hospital. Two models were designed, one including only readmissions to the same hospital, while the other included readmissions to any hospital. We compared the readmission ratios of both models and calculated the correlation between both models with r.

We calculated 95% CIs for the readmission ratio of each hospital to analyse if it differed from the national average (readmission ratio of 100). Subsequently, we calculated the number of hospitals
whose position of significance compared with the national average changed when taking into account readmissions to any hospital compared with the same hospital. A change in position of significance can be, for example, from significantly lower than the national average to no significant difference from the national average.

The models were calculated on the hospital level for all in-patients and in more detail on the level of medical specialties. The C-statistic of each model was calculated in order to determine the discriminative ability. We analysed the difference in C-statistic between the models including only readmissions to the same hospital, and the models with readmissions to any hospital, for each medical specialty.

Variables with fewer than 50 admissions in a category were merged with the smallest nearby category. This was done to prevent the SEs of the regression coefficients becoming too large. Comorbidities 9 and 17 (liver disease and severe liver disease), and 10 and 11 (diabetes and diabetes complications), were merged into one when there were fewer than 50 admissions where the comorbidity was present. Comorbidities with fewer than 50 admissions were not included in the regression analysis. We calculated the part of the readmissions to other hospitals for each medical specialty. Furthermore, we analysed which part of the readmissions to other hospitals concerned readmissions to general hospitals, leading hospitals undertaking clinical research, and university hospitals.

The data were analysed using R 3.2.3. The package pROC was used to calculate the C-statistic.
RESULTS

The database contained 2,333,173 admissions in 77 hospitals eligible for further analyses. See Figure 1 for all factors which resulted in hospitals or admissions being excluded from the study.

Figure 1. Flowchart admissions in the dataset

The mean age of the patients was 55 years and there were slightly more women. The admissions were more often acute than non-acute. This was especially the case with readmissions (Table 1).
### Table 1. Baseline characteristics of all admissions and readmissions in the dataset (N = 77 hospitals)

<table>
<thead>
<tr>
<th>Variable</th>
<th>All admissions</th>
<th>Only readmissions</th>
<th>Readmission other hospitals (without transfer) (99.7% CI)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median 5th percentile</td>
<td>95th percentile</td>
<td>Readmission same hospital (99.7% CI)</td>
<td>Readmission other hospitals (without transfer) (99.7% CI)</td>
</tr>
<tr>
<td>Mean age</td>
<td>55.41 50.64</td>
<td>59.17</td>
<td>59.86 (59.70-60.01)</td>
<td>56.09 (55.58-56.60)</td>
</tr>
<tr>
<td>% Women</td>
<td>50.59 47.49</td>
<td>53.60</td>
<td>46.72 (46.40-47.04)</td>
<td>43.70 (42.69-44.72)</td>
</tr>
<tr>
<td>% Admissions that was registered as acute</td>
<td>60.18 47.57</td>
<td>70.49</td>
<td>71.62 (71.33-71.91)</td>
<td>68.48 (67.53-69.43)</td>
</tr>
<tr>
<td>% Readmissions that was registered as acute</td>
<td>74.38 66.09</td>
<td>81.10</td>
<td>75.85 (75.57-76.12)</td>
<td>59.97 (58.97-60.97)</td>
</tr>
<tr>
<td>Mean number of comorbidities</td>
<td>0.47 0.28</td>
<td>0.67</td>
<td>0.76 (0.76-0.77)</td>
<td>0.64 (0.62-0.66)</td>
</tr>
</tbody>
</table>

1 In the LBZ an acute admission is an admission that cannot be postponed because immediate observation, examination and/or treatment within 24 hours is necessary.

* Significant difference of concerning variable between readmission same hospital compared with readmission other hospitals (99.7% CI)

There were differences in the characteristics of readmissions to the same hospital versus readmissions to other hospitals (Table 1). Patients readmitted to another hospital were younger, more often men, and had fewer comorbidities. It concerned more often a non-acute index admission, but, the readmission, especially, was more often non-acute. The three most frequently occurring diagnosis groups of the readmission to the same hospital were complications of surgical procedures or medical care; chronic obstructive pulmonary disease and bronchiectasis; and complications with a medical device, implant or graft. The three most frequently occurring diagnosis groups of the readmission to another hospital were coronary atherosclerosis and other heart disease; cardiac dysrhythmias and complications of surgical procedures or medical care.

The percentage readmissions of all admissions was 10.3%, of which 91.1% was to the same hospital and 8.9% to another hospital (Table 2). When looking at acute admissions only, the percentage readmissions was lower (9.4%), of which a smaller percentage occurred in other hospitals (5.2%).
Impact on the readmission ratio of taking into account readmissions to other hospitals

Table 2. Number of readmissions and percentage of admissions, which of these occurs in other hospital, all admissions versus acute admissions only (N = 77 hospitals)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All admissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admissions total</td>
<td>2,333,173</td>
<td></td>
</tr>
<tr>
<td>Readmissions &lt; 30 days (% of admissions)</td>
<td>240,122</td>
<td>10.29</td>
</tr>
<tr>
<td>Readmissions &lt; 30 days of which in other hospital (% of readmissions &lt; 30 days)</td>
<td>21,440</td>
<td>8.93</td>
</tr>
<tr>
<td><strong>Acute admissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute admissions total</td>
<td>1,370,628</td>
<td></td>
</tr>
<tr>
<td>Acute readmissions &lt; 30 days (% of acute admissions)</td>
<td>128,439</td>
<td>9.37</td>
</tr>
<tr>
<td>Acute readmissions &lt; 30 days of which in other hospital (% of acute readmissions &lt; 30 days)</td>
<td>8604</td>
<td>5.20</td>
</tr>
</tbody>
</table>

1 Transfers to another hospital were not counted as a readmission.

The readmission ratios for any hospital versus the same hospital were strongly correlated (Figure 2).

![Readmission ratios - any hospital versus same hospital](image)

Figure 2. The plot readmission ratios for any hospital versus those readmissions for the same hospital, per hospital for all diagnosis groups
In total 14% (11 of 77, marked grey in Table 3) of the hospitals changed their position of significance compared with the national average when taking into account readmissions to any hospital compared with the same hospital (Table 3).

Table 3. Change of position of hospitals when using the readmission ratio\(^1\) to same hospital versus that to any hospital

<table>
<thead>
<tr>
<th>Readmission ratio - any hospital</th>
<th>Readmission ratio - same hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Significantly lower (-1)</td>
</tr>
<tr>
<td>Significantly lower (-1)(^2)</td>
<td>35</td>
</tr>
<tr>
<td>No significant difference (0)</td>
<td>2</td>
</tr>
<tr>
<td>Significantly higher (1)(^3)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
</tr>
</tbody>
</table>

\(^1\) Readmission ratio is the observed number of readmissions divided by the expected number of readmissions based on the case mix of the hospital, multiplied by 100.

\(^2\) Significantly lower readmission ratio means less readmissions compared with the national average.

\(^3\) Significantly higher readmission ratio means more readmissions compared with the national average.

When looking at the different types of hospital, such as university hospital, leading clinical hospital, or general hospital, it is only the leading clinical hospitals that changed their position of significance compared with the national average in a positive way, that is, to say from significantly higher, to no significant difference, or from no significant difference, to significantly lower. A change in position of significance in a negative way, that is from significantly lower, to no significant difference, or from no significant difference, to significantly higher, was seen, especially, in university hospitals. This concerned 2 out of 7 university hospitals compared with 1 out of 42 for general hospitals and 2 out of 28 of teaching hospitals.

The percentage readmissions of all admissions differed between the medical specialities, from 2.9% of readmissions for oral and maxillofacial surgery, to 18.5% readmissions for dermatology (Table 4). The percentage of readmissions to other hospitals differed even more between the medical specialties, from 5.0% of readmissions to other hospitals for urology, to 24.2% readmissions for cardiothoracic surgery. The type of hospital into which the patient was readmitted also differed per medical specialty. Patients discharged from cardiothoracic surgery were mainly readmitted to general and leading clinical hospitals, whereas patients discharged from paediatrics were mainly readmitted to university hospitals.
<table>
<thead>
<tr>
<th>Discharge medical specialty index admission</th>
<th>Hospitals (N)</th>
<th>Admissions (N)</th>
<th>Readmissions &lt;30 days without transfer (N)</th>
<th>Readmissions &lt;30 days (%)</th>
<th>Readmissions to other hospital &lt;30 days (N)</th>
<th>Readmissions to other hospital &lt;30 days (%)</th>
<th>Readmissions to other general hospitals &lt;30 days (N)</th>
<th>Readmissions to other general hospitals &lt;30 days (%)</th>
<th>Readmissions to other leading clinical hospitals &lt;30 days (N)</th>
<th>Readmissions to other leading clinical hospitals &lt;30 days (%)</th>
<th>Readmissions to other university hospitals &lt;30 days (N)</th>
<th>Readmissions to other university hospitals &lt;30 days (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surgery</td>
<td>77</td>
<td>403,806</td>
<td>43,003</td>
<td>10.6</td>
<td>2686</td>
<td>6.2</td>
<td>1022</td>
<td>2.4</td>
<td>1172</td>
<td>2.7</td>
<td>492</td>
<td>1.1</td>
</tr>
<tr>
<td>Cardiology</td>
<td>77</td>
<td>345,162</td>
<td>38,878</td>
<td>11.3</td>
<td>5739</td>
<td>14.8</td>
<td>1915</td>
<td>4.9</td>
<td>2674</td>
<td>6.9</td>
<td>1150</td>
<td>3.0</td>
</tr>
<tr>
<td>Internal medicine</td>
<td>77</td>
<td>258,781</td>
<td>37,276</td>
<td>14.4</td>
<td>2552</td>
<td>6.8</td>
<td>778</td>
<td>2.1</td>
<td>1071</td>
<td>2.9</td>
<td>703</td>
<td>1.9</td>
</tr>
<tr>
<td>Pulmonology</td>
<td>77</td>
<td>186,936</td>
<td>25,830</td>
<td>13.8</td>
<td>1479</td>
<td>5.7</td>
<td>476</td>
<td>1.8</td>
<td>599</td>
<td>2.3</td>
<td>404</td>
<td>1.6</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>76</td>
<td>228,300</td>
<td>18,860</td>
<td>8.3</td>
<td>2092</td>
<td>11.1</td>
<td>410</td>
<td>2.2</td>
<td>655</td>
<td>3.5</td>
<td>1027</td>
<td>5.4</td>
</tr>
<tr>
<td>Gastroenterology &amp; Hepatology</td>
<td>74</td>
<td>109,518</td>
<td>18,722</td>
<td>17.1</td>
<td>1348</td>
<td>7.2</td>
<td>450</td>
<td>2.4</td>
<td>518</td>
<td>2.8</td>
<td>380</td>
<td>2.0</td>
</tr>
<tr>
<td>Neurology</td>
<td>77</td>
<td>193,469</td>
<td>15,224</td>
<td>7.9</td>
<td>2076</td>
<td>13.6</td>
<td>522</td>
<td>3.4</td>
<td>920</td>
<td>6.0</td>
<td>634</td>
<td>4.2</td>
</tr>
<tr>
<td>Urology</td>
<td>77</td>
<td>100,582</td>
<td>13,350</td>
<td>13.3</td>
<td>664</td>
<td>5.0</td>
<td>276</td>
<td>2.1</td>
<td>255</td>
<td>1.9</td>
<td>133</td>
<td>1.0</td>
</tr>
<tr>
<td>Orthopaedic surgery</td>
<td>76</td>
<td>212,608</td>
<td>11,020</td>
<td>5.2</td>
<td>649</td>
<td>5.9</td>
<td>238</td>
<td>2.2</td>
<td>284</td>
<td>2.6</td>
<td>127</td>
<td>1.2</td>
</tr>
<tr>
<td>Obstetrics and gynaecology</td>
<td>77</td>
<td>74,190</td>
<td>3413</td>
<td>4.6</td>
<td>226</td>
<td>6.6</td>
<td>82</td>
<td>2.4</td>
<td>94</td>
<td>2.8</td>
<td>50</td>
<td>1.5</td>
</tr>
<tr>
<td>Cardiothoracic surgery</td>
<td>15</td>
<td>27,320</td>
<td>2564</td>
<td>9.4</td>
<td>621</td>
<td>24.2</td>
<td>311</td>
<td>12.1</td>
<td>292</td>
<td>11.4</td>
<td>18</td>
<td>0.7</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>54</td>
<td>37,312</td>
<td>2534</td>
<td>6.8</td>
<td>377</td>
<td>14.9</td>
<td>196</td>
<td>7.7</td>
<td>151</td>
<td>6.0</td>
<td>30</td>
<td>1.2</td>
</tr>
<tr>
<td>Ear, Nose and Throat clinic</td>
<td>77</td>
<td>62,973</td>
<td>2473</td>
<td>3.9</td>
<td>289</td>
<td>11.7</td>
<td>134</td>
<td>5.4</td>
<td>89</td>
<td>3.6</td>
<td>66</td>
<td>2.7</td>
</tr>
<tr>
<td>Clinical geriatrics</td>
<td>39</td>
<td>25,426</td>
<td>2416</td>
<td>9.5</td>
<td>131</td>
<td>5.4</td>
<td>48</td>
<td>2.0</td>
<td>62</td>
<td>2.6</td>
<td>21</td>
<td>0.9</td>
</tr>
<tr>
<td>Plastic surgery</td>
<td>72</td>
<td>31,261</td>
<td>1412</td>
<td>4.5</td>
<td>147</td>
<td>10.4</td>
<td>70</td>
<td>5.0</td>
<td>58</td>
<td>4.1</td>
<td>19</td>
<td>1.3</td>
</tr>
<tr>
<td>Anaesthesiology</td>
<td>70</td>
<td>9231</td>
<td>1094</td>
<td>11.9</td>
<td>140</td>
<td>12.8</td>
<td>48</td>
<td>4.4</td>
<td>61</td>
<td>5.6</td>
<td>31</td>
<td>2.8</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>57</td>
<td>4386</td>
<td>741</td>
<td>16.9</td>
<td>42</td>
<td>5.7</td>
<td>21</td>
<td>2.8</td>
<td>13</td>
<td>1.8</td>
<td>8</td>
<td>1.1</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>69</td>
<td>5872</td>
<td>414</td>
<td>7.1</td>
<td>69</td>
<td>16.7</td>
<td>28</td>
<td>6.8</td>
<td>30</td>
<td>7.2</td>
<td>11</td>
<td>2.7</td>
</tr>
<tr>
<td>Dermatology</td>
<td>63</td>
<td>2127</td>
<td>394</td>
<td>18.5</td>
<td>30</td>
<td>7.6</td>
<td>11</td>
<td>2.8</td>
<td>14</td>
<td>3.6</td>
<td>5</td>
<td>1.3</td>
</tr>
<tr>
<td>Oral and Maxillofacial Surgery</td>
<td>71</td>
<td>11,835</td>
<td>347</td>
<td>2.9</td>
<td>57</td>
<td>16.4</td>
<td>31</td>
<td>8.9</td>
<td>12</td>
<td>3.5</td>
<td>14</td>
<td>4.0</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>28</td>
<td>1310</td>
<td>110</td>
<td>8.4</td>
<td>17</td>
<td>15.5</td>
<td>5</td>
<td>4.5</td>
<td>9</td>
<td>8.2</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>Other medical specialty</td>
<td>30</td>
<td>808</td>
<td>47</td>
<td>5.8</td>
<td>9</td>
<td>19.1</td>
<td>4</td>
<td>8.5</td>
<td>4</td>
<td>8.5</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>77</td>
<td>2,333,173</td>
<td>240,122</td>
<td>10.3</td>
<td>21,440</td>
<td>8.9</td>
<td>7076</td>
<td>2.9</td>
<td>9037</td>
<td>3.8</td>
<td>5327</td>
<td>2.2</td>
</tr>
</tbody>
</table>
The C-statistics differed between the medical specialties (Table 5). There were slight differences between the C-statistics of the models with readmissions to any hospital compared with the models with readmissions to the same hospital. For most medical specialties, the C-statistics of the models with readmissions to the same hospital were higher. The largest significant difference was found for cardiothoracic surgery. For some medical specialties, the C-statistics of the models with readmissions to any hospital were higher. The largest significant difference for this group was found in pediatrics.

Table 5. C-statistics of the models per medical specialty, any hospital versus the same hospital

<table>
<thead>
<tr>
<th>Discharge medical specialty index admission</th>
<th>C-statistic model any hospital</th>
<th>95% CI</th>
<th>C-statistic model same hospital</th>
<th>95% CI</th>
<th>Significance</th>
<th>r readmission ratios same versus any hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>General surgery</td>
<td>0.627</td>
<td>0.624-0.629</td>
<td>0.627</td>
<td>0.624-0.630</td>
<td>-</td>
<td>0.948</td>
</tr>
<tr>
<td>Cardiology</td>
<td>0.610</td>
<td>0.607-0.613</td>
<td>0.623</td>
<td>0.620-0.627</td>
<td>*</td>
<td>0.787</td>
</tr>
<tr>
<td>Internal medicine</td>
<td>0.600</td>
<td>0.597-0.603</td>
<td>0.606</td>
<td>0.603-0.609</td>
<td>*</td>
<td>0.916</td>
</tr>
<tr>
<td>Pulmonology</td>
<td>0.625</td>
<td>0.621-0.628</td>
<td>0.630</td>
<td>0.626-0.633</td>
<td>*</td>
<td>0.930</td>
</tr>
<tr>
<td>Paediatrics</td>
<td>0.587</td>
<td>0.582-0.591</td>
<td>0.581</td>
<td>0.577-0.586</td>
<td>*</td>
<td>0.901</td>
</tr>
<tr>
<td>Gastroenterology &amp; Hepatology</td>
<td>0.599</td>
<td>0.594-0.603</td>
<td>0.598</td>
<td>0.594-0.603</td>
<td>-</td>
<td>0.956</td>
</tr>
<tr>
<td>Neurology</td>
<td>0.613</td>
<td>0.608-0.618</td>
<td>0.616</td>
<td>0.611-0.621</td>
<td>-</td>
<td>0.820</td>
</tr>
<tr>
<td>Urology</td>
<td>0.624</td>
<td>0.619-0.629</td>
<td>0.624</td>
<td>0.619-0.629</td>
<td>-</td>
<td>0.944</td>
</tr>
<tr>
<td>Orthopaedic surgery</td>
<td>0.669</td>
<td>0.664-0.675</td>
<td>0.670</td>
<td>0.665-0.675</td>
<td>-</td>
<td>0.961</td>
</tr>
<tr>
<td>Obstetrics and gynaecology</td>
<td>0.620</td>
<td>0.610-0.630</td>
<td>0.619</td>
<td>0.608-0.629</td>
<td>-</td>
<td>0.957</td>
</tr>
<tr>
<td>Cardiothoracic surgery</td>
<td>0.633</td>
<td>0.623-0.644</td>
<td>0.665</td>
<td>0.653-0.677</td>
<td>*</td>
<td>0.802</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>0.629</td>
<td>0.617-0.641</td>
<td>0.630</td>
<td>0.617-0.643</td>
<td>-</td>
<td>0.994</td>
</tr>
<tr>
<td>Ear, Nose and Throat clinic</td>
<td>0.669</td>
<td>0.658-0.681</td>
<td>0.659</td>
<td>0.647-0.671</td>
<td>-</td>
<td>0.914</td>
</tr>
<tr>
<td>Clinical geriatrics</td>
<td>0.595</td>
<td>0.583-0.607</td>
<td>0.593</td>
<td>0.581-0.606</td>
<td>-</td>
<td>0.986</td>
</tr>
<tr>
<td>Plastic surgery</td>
<td>0.633</td>
<td>0.617-0.648</td>
<td>0.632</td>
<td>0.616-0.648</td>
<td>-</td>
<td>0.740</td>
</tr>
<tr>
<td>Anaesthesiology</td>
<td>0.600</td>
<td>0.582-0.617</td>
<td>0.621</td>
<td>0.603-0.639</td>
<td>*</td>
<td>0.955</td>
</tr>
<tr>
<td>Rheumatology</td>
<td>0.664</td>
<td>0.642-0.687</td>
<td>0.665</td>
<td>0.642-0.688</td>
<td>-</td>
<td>0.763</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>0.610</td>
<td>0.582-0.638</td>
<td>0.596</td>
<td>0.566-0.626</td>
<td>-</td>
<td>0.648</td>
</tr>
<tr>
<td>Dermatology</td>
<td>0.826</td>
<td>0.802-0.851</td>
<td>0.851</td>
<td>0.827-0.874</td>
<td>*</td>
<td>0.994</td>
</tr>
<tr>
<td>Oral and Maxillofacial Surgery</td>
<td>0.679</td>
<td>0.648-0.709</td>
<td>0.685</td>
<td>0.653-0.718</td>
<td>-</td>
<td>0.369</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>0.670</td>
<td>0.613-0.728</td>
<td>0.700</td>
<td>0.642-0.757</td>
<td>-</td>
<td>0.920</td>
</tr>
<tr>
<td>Total</td>
<td>0.641</td>
<td>0.640-0.642</td>
<td>0.646</td>
<td>0.645-0.647</td>
<td>*</td>
<td>0.905</td>
</tr>
</tbody>
</table>

* Significant difference between C-statistic of model any hospital compared with model same hospital (95% CI)
DISCUSSION

This study investigated the impact on the readmission ratio of taking into account readmissions to other hospitals.

COMPARISON WITH OTHER STUDIES

We found 10.3% of admissions resulted in readmissions to any hospital, which is comparable with a study of Davies et al which came up with a figure of 10.1% all-cause readmissions. However, the Davies study was limited to acute care hospitals. In our analysis, we found fewer, 9.4% readmissions when only looking at acute admissions and acute readmissions. Our analysis showed that 8.9% of the readmissions, both acute and non-acute, were in another hospital. This is low compared with the 17%-32% reported in other studies. These studies, however, concerned only acute care and were mainly carried out in the USA. When we limited our analysis to acute care, we found even fewer, 5.2%, readmissions to other hospitals. This might indicate that the impact of taking into account readmissions to other hospitals is not comparable across different countries with different health care systems.

For most medical specialties, we found C-statistics of the models with readmissions to the same hospital that were significantly higher. The largest significant difference was for cardiothoracic surgery. This indicates better prediction of the same hospital ratio compared with the any hospital ratio. However, Gonzalez et al concluded that same hospital readmission rates provided unstable estimates of all-hospital readmission rates following coronary artery bypass grafting.

For some medical specialties, the C-statistics of the models with readmissions to any hospital we found were higher, with the largest significant difference for paediatrics. This indicates better prediction of the any hospital ratio compared with the same hospital ratio. A study by Kahn et al also concluded that different-hospital readmissions differentially affect hospitals’ paediatric readmission rates. Our study found that 14% of the hospitals changed their position of significance compared with the national average when taking into account readmissions to any hospital compared with the same hospital. This is quite comparable with the finding of Kahn et al (2015) that excluding different-hospital readmissions incorrectly anticipated penalties for 11% of hospitals.

THE DUTCH HEALTH CARE SYSTEM

The small amount of readmissions to another hospital might be caused by the strong gatekeeping and referral role played by GPs in the Netherlands. These GPs usually have consistent addresses for referring patients. Each hospital has a wide range of medical specialities, and each hospital delivers emergency as well as elective care. Some hospitals are specialised and deliver, for example, more complex care in the field of heart disease. However, when this concerns patients...
from other hospitals, it often concerns a transfer. Therefore, they are not taken into the analysis and do not have an effect on the readmission rate to any hospital.

The high level of patient satisfaction in the Netherlands can also be a reason for the low percentage of readmissions to another hospital. In contrast to patients in the USA, Canada, the UK or Switzerland, in the Netherlands, more patients report that their regular doctor has spent enough time on their consultation, has given explanations which are easy to understand and has involved them in decisions about care or treatment. 37 This high level of patient satisfaction could result in Dutch patients usually going to the same hospital.

**Strengths and Limitations**

We believe the current study is the first in the Netherlands that analyses the impact of taking readmissions to other hospitals into account. Our finding that the impact is much smaller compared with the literature, could also apply to other countries with a comparable health care system to the Netherlands.

Another strength is the completeness of the national administrative database which covers all hospital admissions. In this study, we used 2,333,173 admissions from 77 hospitals, which is 97% of the general and university hospitals.

A limitation of the study is that not all hospitals register the unique patient numbers completely. In some hospitals, a few per cent of the readmissions do not have a unique patient number. This affects the results from surrounding hospitals as when one of their patients is readmitted to another hospital that did not register the unique patient number, this readmission could not be taken into account. Therefore, the readmission rate of these hospitals could be underestimated. We decided not to exclude the hospitals with incomplete unique patient number registrations, because then the impact on the readmission rate of the surrounding hospitals would be much larger. However, we had to exclude one hospital from our analysis, because they did not register unique patient numbers for all admissions. We expect that this has a negligible impact on our overall findings, however, it does affect the results from the surrounding hospitals.

It should also be mentioned that the National Database of Hospital Care, the LBZ, does not contain a variable that distinguishes between intended and unintended readmissions. In the LBZ, we do have the variable ‘urgency’ (acute versus non-acute admission) that indicates whether care within 24 hours is needed. 25 A recent study reviewed medical records of readmissions to evaluate the accuracy of a classification of potentially preventable readmissions with LBZ data. 38 It appeared that a larger proportion of acute readmissions was classified as potentially preventable compared with non-acute readmissions (28.5% versus 5.0%). Nevertheless, we included both acute and non-acute admissions and readmissions in our study because complications might also result in readmissions that do not have a real 24 hour urgency and to avoid hospitals considering not to code the admission as acute in order to decrease their readmission ratio.
IMPLICATIONS FOR PRACTICE

Although the impact of taking into account readmissions to other hospitals is limited, this impact differs between hospitals. Therefore, these readmissions should be included in the readmission ratio, used in the Netherlands as a quality indicator, for a fair comparison between hospitals. However, its impact on the construct validity of the indicator is not known. It is important to include only readmissions that are related to the quality of care in the indicator and not readmissions that are a necessary part of the delivered care. Based on the results of this study, it is not certain if readmissions in other hospitals reflect substandard quality of care. Therefore, it is advisable to explore the readmissions in other hospitals by record reviewing to reveal the reason for readmission, before it can be decided if these readmissions should be part of the readmission indicator.

Besides, there are two concerns when applying this in practice. First, hospitals cannot calculate their own readmission rate which includes readmissions to other hospitals. Therefore, a national organisation is needed that monitors the data from all hospitals in a specific country and which can apply case mix adjustment to readmission ratios, required if a fair comparison between hospitals is to be achieved. Second, it is illegal in the Netherlands to share information about the readmission to another hospital with the hospital to which the patient was first admitted, without specific consent from the patient. This means that learning from readmissions to other hospitals is complicated. As a result of these concerns, we advise not to take into account readmissions to other hospitals in the Dutch readmission indicator.

FUTURE RESEARCH

In order to identify areas for improvement it is necessary to assess unintended readmissions. However, based on administrative data only, it is difficult to assess whether a readmission was unintended. Previous research showed that about 30% of the readmissions are potentially preventable. However, it is not known if this also applies to readmissions to other hospitals. Therefore, reviewing the records of readmissions to other hospitals is needed in order to analyse whether the readmission is a result of substandard care in the hospital where the original admission took place.

The group of patients who most often switch hospital, young men with relatively few comorbidities, may be interesting to explore further. For example, by using interviews to examine why they chose another hospital for their subsequent admission, in order to learn where quality can be improved.
CONCLUSIONS

Overall, the impact on the readmission ratio of taking into account readmissions to other hospitals seems to be limited. We found 8.9% of the readmissions occur in another hospital, while 91.1% of the readmissions occur in the same hospital. However, for some hospitals, it does have consequences as 14% of the hospitals change their position of significance compared with the national average on the readmission ratio when taking into account readmissions to other hospitals. For these hospitals, it is interesting to explore what causes this difference and if it is related to the quality of care.
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Chapter 4

How to identify potentially preventable readmissions by classifying them using a national administrative database

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ABSTRACT

Importance: Hospital readmissions are being used increasingly as an indicator of quality of care. However, it remains difficult to identify potentially preventable readmissions.

Objectives: To evaluate the identification of potentially preventable hospital readmissions by using a classification of readmissions based on administrative data.

Design and setting: We classified a random sample of 455 readmissions to a Dutch university hospital in 2014 using administrative data. We compared these results to a classification based on reviewing the medical records of these readmissions to evaluate the accuracy of classification by administrative data.

Main outcome measures: Frequencies of categories of readmissions based on reviewing records versus those based on administrative data. Cohen's kappa for the agreement between both methods. The sensitivity and specificity of the identification of potentially preventable readmissions with classification by administrative data.

Results: Reviewing the medical records of acute readmissions resulted in 28.5% of the records being classified as potentially preventable. With administrative data this was 44.1%. There was slight agreement between both methods: $k = 0.08$ (95% CI: 0.02-0.15, $p<0.05$). The sensitivity of the classification of potentially preventable readmissions by administrative data was 63.1% and the specificity was 63.5%.

Conclusions: This explorative study demonstrated differences between categorising readmissions based on reviewing records compared to using administrative data. Therefore, this tool can only be used in practice with great caution. It is not suitable for penalising hospitals based on their number of potentially preventable readmissions. However, hospitals might use this classification as a screening tool to identify potentially preventable readmissions more efficiently.
INTRODUCTION

Readmissions are used increasingly worldwide as an indicator of the quality of care.\textsuperscript{1-5} Hospitals in the UK, USA and Germany may even suffer financial penalties for high readmission rates.\textsuperscript{6,7} This is because readmissions due to complications are a burden for patients and account for high health care costs. Readmissions can, for example, be a result of insufficient nurse staffing or the result of a substandard work environment.\textsuperscript{8} Therefore, a readmission indicator can offer hospitals insight into potential areas of improvement.\textsuperscript{9} Recent research has shown that programmes to reduce payments to hospitals with excess readmissions had a significant effect on the inpatient readmission for pneumonia, acute myocardial infarction and heart failure in US hospitals.\textsuperscript{10}

However, there are two difficulties in improving patient safety based on readmissions. Firstly, there are different types of readmissions and not all of them are preventable or even reflect the quality of care.\textsuperscript{1,11,12} Readmissions could be caused by an adverse event, but could also be part of regular planned aftercare in accordance with guidelines. Neither are all readmissions related to their original hospital stay, called the index admission. Secondly, identifying preventable readmissions by studying the records and learning what went wrong, is time consuming. Internationally, readmission rates throughout the hospital vary from 4 to 29\%\textsuperscript{13} depending on the definition of a readmission. Consequently, many records need to be reviewed when aiming to improve patient safety by using readmission data. This is not feasible given the limited time of hospital doctors who are most likely to be the reviewers because of their medical expertise. A more efficient and reliable way to identify potentially preventable readmissions is needed for hospitals as part of their patient safety policy.

Recently, a classification has been developed using administrative data which can distinguish between potentially preventable readmissions and other reasons for readmissions within 30 days.\textsuperscript{14} This classification distinguishes six categories:

- potentially preventable readmissions, meaning that the readmission might be the result of substandard care during the index admission;
- anticipated but unpredictable readmissions such as patients with a chronic disease or those likely to need long-term care;
- readmissions related to patient and staff preferences;
- coding errors in data collection;
- readmissions as a result of an accident, coincidence or related to a different body system;
- broadly related readmissions that is those related to the same body system.

The authors found that 30\% of the emergency readmissions are classified as potentially preventable. Such a classification could help hospitals to identify potentially preventable readmissions and patient safety issues without an increase in the registration of admissions or the burden of reviewing medical records. However, administrative data give only a limited
representation of the facts. Therefore, it is necessary to verify quite how useful this classification is by checking it against a retrospective review of medical records.

A recent study of Sacks et al\textsuperscript{15} evaluated an administrative readmission measure by reviewing medical records. They examined the accuracy of administrative codes in determining the diagnosis of readmission. This study, however, only concerned general surgery and mainly evaluated the accuracy and not the utility of the administrative data.

We aim to evaluate how applicable a classification of readmissions is based on administrative data to identify potentially preventable readmissions. We verified the results by reviewing and categorising the patient records of these readmissions. Such a classification based on administrative data could be of great value in creating a readmission indicator that can be used as a screening tool for improvements in the quality of care.

**METHODS**

**SAMPLE AND SETTING**

We looked at readmissions to a Dutch university hospital, taking a random sample of 455 out of all of its readmissions in 2014. The hospital has about 1000 beds and nearly 30,000 clinical admissions each year.

**DEFINITION AND EXCLUSIONS**

We used the following definition of a readmission: a clinical admission to the same hospital within 30 days of discharge following the clinical index admission.\textsuperscript{14,16} We took into account all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation.\textsuperscript{15,16} We used the index admission as the unit of analysis. This means that each readmission of the same patient is again an index admission for a second readmission.\textsuperscript{17} We excluded cancer care, obstetrics and psychiatric care in the principal diagnoses, because a major part of the readmissions for these patients is considered as part of the usual care path.\textsuperscript{18} In our study we included readmissions which are not acute (N = 160) to verify this commonly applied exclusion.\textsuperscript{18}

To evaluate the accuracy of classification by administrative data, compared to that by reviewing medical records, we looked only at the acute readmissions (N = 295).

**DESIGN**

The admissions are registered in the National Database of Hospital Care (LBZ).\textsuperscript{19} We classified the random sample of 455 readmissions using the information that was available in the administrative data. This concerned information about the diagnoses and patterns of
readmissions. The complete details of codes used for the classification are given in Appendix 2. We compared these results with a classification of the sample achieved by reviewing the records of these readmissions retrospectively to reveal the reason for the readmission.

CLASSIFICATION
We used the classification of Blunt et al., developed previously, and made a couple of modifications. We focused on categories A, ‘Potentially preventable’, which means that the readmission might be the result of substandard care arising during the index admission, and B, ‘Anticipated but unpredictable hospital care’. We only used the total A-category and total B-category as a review of the medical records could not make the distinction between sub-categories of category A and B of the original classification. Additionally, for reviewing medical records, we divided category A into five sub-categories based on a classification by Halfon et al.\(^\text{20}\) This was to gain more insight into the reason for readmission. We added a category ‘Planned care’ to the classification as the original classification has been designed only for acute readmissions.\(^\text{14}\) Our study also takes into account the readmissions which are not acute. Furthermore, we combined infrequent reasons for readmissions according to the original classification - readmissions related to the patient or staff preferences and coding errors in data collection - into a new category, ‘Other’. This category does not exist in the classification based on administrative data, because when a record does not belong to category A or B, it is automatically classified in either category C ‘related to a different body system’ or D ‘related to the same body system’. The final classification can be found in Appendix 1.

REVIEWING MEDICAL RECORDS
The records from the readmission and the index admission were studied in the electronic patient record system by the record reviewer (FvdB) to determine to which category the readmission belonged. Part of the records was also reviewed by a second reviewer (CZ) to explore and assure consistency in reviewing. Firstly, the two reviewers scored the first 10 records together. Next, the readmissions that could not be categorised obviously by the first reviewer were also reviewed by the second reviewer. This occurred in 18% of the cases. These records were discussed until a consensus was achieved. Of all readmissions where no consultation took place, an additional random 10% of the records were categorised, blindly, by the second reviewer to investigate the agreement in the classification. In total, 27% of the records (10 + 78 + 36) were reviewed by both reviewers. The inter-rater reliability of the classification by the two reviewers was calculated by Cohen’s kappa using SPSS version 22. The reviewers were authorised by the hospital to access the relevant patient records. The hospital’s ethics committee responsible for human experimentation decided that no legal permission was necessary for this study.
ANALYSIS
We compared the frequencies of the categories based on administrative data with those based on reviewing medical records and calculated 95% confidence intervals. The agreement between both methods was calculated by Cohen’s kappa. We calculated the sensitivity and specificity of the identification of potentially preventable readmissions through the classification by administrative data. Therefore, we considered classification by administrative data as a test and classification by reviewing medical records as the truth, to determine the true positives and true negatives. The sensitivity was calculated by dividing the true positives by the total number of admissions classified as potentially preventable by reviewing records. The specificity was calculated by dividing the true negatives by the total number of admissions classified as not potentially preventable by reviewing records.

RESULTS
CLASSIFICATION
The inter-rater reliability of the classification by the two reviewers showed substantial agreement: $k$ 0.63 (95% CI: 0.44-0.83, $p<0.001$). It appeared that 44.1% of the acute readmissions were classified as potentially preventable with administrative data, while based on reviewing medical records, this was 28.5% (Figure 1).

Figure 1: Classification of readmissions,\(^1\) based on administrative data versus based on reviewing medical records (acute readmissions, $N = 295$)

\(^1\) More detailed information about the classification of readmissions is given in Appendix 1
How to identify potentially preventable readmissions by classifying them

There was slight agreement for the classification of record reviewing versus administrative data: $k = 0.08$ (95% CI: 0.02-0.15, $p<0.05$). In total, 36.9% ($N = 109$) of these records were classified in the same category by using administrative data compared to reviewing medical records (Table 1). The proportion of the classification which was the same, determined using both methods, was highest in category A, namely 63.1%.

Table 1: Classification of readmissions, based on administrative data versus reviewing medical records and the proportion of the classification which was the same (acute readmissions, $N = 295$)

<table>
<thead>
<tr>
<th>Category</th>
<th>Administrative data</th>
<th>Reviewing records</th>
<th>Same classification with administrative data compared to reviewing records</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>95% CI</td>
</tr>
<tr>
<td>A  Potentially preventable</td>
<td>130</td>
<td>44.1</td>
<td>42.9 - 45.2</td>
</tr>
<tr>
<td>B  Anticipated but unpredictable hospital care</td>
<td>73</td>
<td>24.7</td>
<td>23.6 - 25.9</td>
</tr>
<tr>
<td>Other categories</td>
<td>92</td>
<td>31.2</td>
<td>30.0 - 32.3</td>
</tr>
<tr>
<td>Total</td>
<td>295</td>
<td>100</td>
<td>95% CI</td>
</tr>
</tbody>
</table>

1 More detailed information about the classification of readmissions is given in Appendix 1

The administrative tool recognised 40.8% (53 of 130) of all readmissions that by reviewing medical records were classified as potentially preventable (Table 2). This means that the sensitivity of classification by administrative data was 63.1% (53/(53 + 31)) and the specificity was 63.5% (134/(134 + 77)).
Table 2: Sensitivity and specificity of categorisation by administrative data compared to reviewing medical records (acute readmissions, N = 295)

<table>
<thead>
<tr>
<th></th>
<th>Potentially preventable by reviewing records</th>
<th>NOT potentially preventable by reviewing records</th>
<th>Total</th>
</tr>
</thead>
</table>
| Potentially preventable by administrative data | True positive = 53  
Sensitivity = 63.1%  
(53 of 84) | False positive = 77 | 130 |
| NOT potentially preventable by administrative data | False negative = 31  
Specificity = 63.5%  
(134 of 211) | True negative = 134 | 165 |
| **Total**                     | 84                                          | 211                                             | 295   |

**SUB-CLASSIFICATION**
Most acute readmissions classified as potentially preventable through a review of medical records (N = 84), appeared to be a complication of surgical care (65.5%). A smaller part of the potentially preventable readmissions was a result of premature discharge or other inadequate discharge (15.5%), complication of care other than surgery (7.1%), drug-related adverse events (6.0%) or other reasons (6.0%).

**NON-ACUTE READMISSIONS**
Most of the non-acute readmissions were classified through reviewing medical records as ‘planned care’ (Table 3). Besides, 5.0% (N = 8) of the non-acute readmissions were classified as potentially preventable.
How to identify potentially preventable readmissions by classifying them

Table 3: Classification\(^1\) of non-acute readmissions (N = 160), based on reviewing medical records

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  Potentially preventable</td>
<td>8</td>
<td>5.0</td>
</tr>
<tr>
<td>B  Anticipated but unpredictable hospital care</td>
<td>32</td>
<td>20.0</td>
</tr>
<tr>
<td>C  Accident or coincidence related to different body system</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D  Broadly related</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>E  Other</td>
<td>9</td>
<td>5.6</td>
</tr>
<tr>
<td>F  Planned care</td>
<td>110</td>
<td>68.8</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>

\(^1\) The classification of readmissions is explained in Appendix 1

DISCUSSION

CLASSIFICATION

We aimed to evaluate the identification of potentially preventable readmissions gained through a classification based on administrative data,\(^{14}\) by reviewing and categorising these records. By administrative data 44.1% of the acute readmissions were classified as potentially preventable, versus 28.5% by reviewing medical records. The sub-classification of this category showed that most readmissions were a complication of surgical care (65.5%). This is understandable as surgical specialties do have to take many calculated risks into account, especially in emergency surgery.\(^{21}\)

The percentage of the records that were classified in the same category by both methods was modest. However, it was highest in category A, which is most relevant for the purpose of identifying potential improvements in the quality of care.

The proportion of readmissions, classified by administrative data as potentially preventable in our study (44.1%), is higher than the 30.0% found by Blunt et al.\(^{14}\) Part of this difference may be explained by the definition of emergency admissions in the UK being slightly different from that in the Netherlands. The classification based on administrative data was recently applied to eighteen Dutch hospitals.\(^{22}\) Their results are comparable with our study.

A previous study examined the accuracy of administrative codes in determining the diagnosis of readmission.\(^{15}\) It reviewed the medical records of a cohort of general surgery patients. They found that the data of administrative claims are often inaccurate in describing the readmission diagnosis and fail to identify the true number of planned readmissions. This is in line with our finding that, for a considerable part of the readmissions, administrative data are not able to classify these correctly.
ACUTE VERSUS NON-ACUTE READMISSIONS
When looking only at the non-acute readmissions, 5.0% were classified as potentially preventable. This is low compared to the 28.5% of the acute readmissions which were classified in this category. This finding might imply that the quality of care is more reflected through acute readmissions compared to non-acute readmissions. Therefore, the commonly applied exclusion of non-acute readmissions seems reasonable. Another option would be to include in the readmission indicator all the non-acute readmissions which are classified as potentially preventable.

STRENGTHS AND LIMITATIONS
Our study breaks new ground in comparing a classification based on administrative data with that based on a review of medical records. As such it creates the opportunity to explore the practical use of the administrative means of classification. Literature states that reviewing medical records is a reliable method for determining the main cause of a readmission.20 We reviewed 455 records, which compares well with other studies such as Sacks et al (315 readmissions reviewed).15 This study is limited to only one university hospital. The results may be different for general hospitals as they differ in several aspects from university hospitals.

A limitation of the study is that only one reviewer has reviewed all records. This might have caused reviewer bias. We tried to restrict this bias in three ways: 1) the first 10 records were reviewed together with a second reviewer; 2) the readmissions that could not obviously be categorised by the first record reviewer were also reviewed by the second reviewer and; 3) a random sample of the records not discussed in 1) or 2) was investigated by the second reviewer. The inter-rater reliability of the classification (ƙ 0.63) was high compared with previous record reviewing studies,23 but smaller than a study specifically concerned with reviewing readmissions.20

While reviewing medical records is seen as the gold standard when determining the cause of readmission,20 reviewer bias might occur as specialists tend to attribute a complication to the patient’s illness and the circumstances. A recent study showed that the agreement among physicians about the predictability of readmission was moderate to good, while the agreement about the preventability of readmission was poor.24 Therefore, very precise rules are necessary in order to make a justified decision on to which category a readmission belongs. The distinction between category A and B can sometimes only be made when all details from the medical and nursing records are available. An example from this study is a patient with diverticulitis who underwent colectomy and was readmitted as an acute patient after three weeks. An analysis was needed to see whether the readmission resulted from the chronic illness that recurred (category B) or was a complication of the colectomy (category A).

Furthermore, a correct classification of readmissions is only possible when the registration of the data is accurate. A check on the data quality of the LBZ was performed recently. This concerned,
How to identify potentially preventable readmissions by classifying them

among other criteria, sufficient registration of comorbidities, the proportion of acute care and avoiding the use of vague diagnoses in the registrations. The quality of the hospital data for our study is comparable with the national average.25

Finally, our study was limited in its ability to track patients across hospitals because the database has no reliable information about transfers between different hospitals or readmissions to other hospitals. Research has shown that about one fifth of all readmissions occur in a different hospital and these patients have different characteristics compared to patients who were readmitted to the same hospital.26

**IMPLICATIONS FOR PRACTICE**

This study shows a sensitivity of 63.1% for identifying potentially preventable readmissions and a specificity of 63.5% for rejecting not potentially preventable readmissions with administrative data.

Therefore, this tool can only be used in practice with great caution. It is definitely not suitable for penalising hospitals based on their number of potentially preventable readmissions. However, it might be used as a screening tool to identify potentially preventable readmissions more efficiently.

When using the administrative method to look at only the records classified as potentially preventable, fewer records need to be reviewed. Yet the chance of finding potentially preventable readmissions is increased.

The sub-classification of category A shows several causes for this type of readmission. Some readmissions are a result of known complications of a procedure, which is a calculated risk. This kind of readmission can never be totally prevented but may give insight into which part of these readmissions might be prevented when looking, for example, over time within a hospital, or between hospitals. Therefore, the classification might be used to identify variation on the level of the hospital or medical specialty compared to the national average or peer group of hospitals.

**FUTURE RESEARCH**

The classification based on administrative data has the potential to be an efficient method of identifying potentially preventable readmissions. However, an improvement in the classification is required. The algorithms for identifying potentially preventable readmissions could be further specified. More extensive reviewing of medical records is needed as this reveals relevant further input for the classification with administrative data. This classification is based on readmissions within 30 days after the initial admission. Whether the results of the classification change when another timeframe is chosen could be investigated further.

As this study is applied to only one university hospital, future research is needed to determine to what extent these results are applicable to general hospitals. General hospitals differ in several aspects from university hospitals, so this might be reflected in a different distribution of the categories of readmissions.
CONCLUSIONS

The classification by administrative data delivers significantly different results to that based on reviewing medical records and can therefore only be used with great caution. However, by using the classification, the reviewing of medical records will identify potentially preventable readmissions in a more efficient, though less accurate, way. It might be used as a screening tool requiring less of health care professionals’ time to achieve a first insight into the main causes of potentially preventable readmissions. In this way, it could offer opportunities for improvement of the quality of care.
REFERENCES


Appendix 1 – Classification of readmissions, used for reviewing medical records

**Category A: Potentially preventable**
This concerns both probable and possible substandard care. It includes primary diagnosis of readmission concerning complications after surgical and medical care. It also concerns readmissions with a diagnosis of common avoidable complications or without evidence that symptoms were caused by care performed during index admission.

Example: a patient is admitted for a heart valve replacement because of an atherosclerotic heart disease and is readmitted eight days later because of a sepsis.

- **A1: Premature discharge or other inadequate discharge**
  New clinical problem or complication at time of discharge, patient is clinically unstable at time of discharge
- **A2: Complication of surgical care**
  Haemorrhage, disruption of wound, infection, obstruction or thrombosis of a surgical site, fistulae, pseudarthrosis, other surgical failure
- **A3: Complication of non-surgical care**
  Urinary device infection or obstruction, post lumbar puncture reaction, dialysis or catheterism complication, failure of medical devices
- **A4: Drug-related adverse events**
  Agranulocytosis (antitumor drug), haemorrhage (anticoagulants), other drug-related adverse events
- **A5: Miscellaneous**
  Administrative errors, other potentially preventable readmissions not otherwise specified

**Category B: Anticipated but unpredictable hospital care**
For some patients, frequent emergency admissions are common as part of an anticipated plan or pattern of care. These patients are sometimes readmitted multiple times per year, but with variability over time. This category includes patients with an underlying chronic condition or patients with non-medical risk factors (e.g. alcohol or drug abuse).

Examples: patients with COPD or atrial fibrillation, or individuals known to have potential health hazards related to their socioeconomic and psychosocial circumstances or behaviour issues (non-medical risk factors).

**Category C: Accident or coincidence related to different body system**
These readmissions were defined as emergency 30 day readmissions in a different ICD10 chapter from the index admission. For these readmissions, coding does not indicate a common factor between index admission and readmission

Examples: transport accidents and falls are coincidental readmissions.

**Category D: Broadly related (related to same body system)**
This category contains readmissions that are broadly related to the previous admission where index and readmission diagnoses match within ICD10 chapter.

Example: a patient is admitted for inflammatory bowel disease (IBD) and readmitted 10 days later with related bowel symptoms.

**Category E: Other**
This category includes readmissions not classified in category A-D or F.

Example: readmission falsely coded as unplanned (acute) due to an error in coding (artefact). It also includes self-discharge and identifiable patterns of discharge and readmission around public holidays and weekends.

**Category F: Planned care**
This category includes patients with a planned readmission for follow-up care of a previously known condition.

Example: a patient is scheduled for surgery and a readmission is planned.

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1 Sub-categories of Blunt et al A1 ‘Probable suboptimal care’ and A2 ‘Possible suboptimal care’ were merged into category A as this difference is hard to make with reviewing medical records. Categories A1 to A5 are only used with reviewing medical records.

2 Sub-categories of Blunt et al B1 ‘Ill but stable’, B2 ‘Unstable deterioration’ and B3 ‘Non-medical risk factors’ were merged into category B as this difference is hard to make with reviewing medical records.

3 Includes categories C ‘Preference’ and D ‘Artefact’ from Blunt et al.

4 Additional category not included by Blunt et al. We added this category because not acute readmissions were part of our study. This category is only used with reviewing medical records.
APPENDIX 2 – COMPLETE DETAILS OF CODES USED FOR THE CLASSIFICATION OF READMISSIONS

This classification is based on Blunt et al\textsuperscript{14} and is adjusted for this study.

NB: This classification is hierarchical. For example a readmission for a phlebitis after an index admission because of an acute cerebrovascular disease that is captured in category A ‘Potentially preventable’, will not be counted in category D ‘Broadly related - related to the same body system’.

A: Potentially preventable: probable or possible substandard care

Combinations of diagnosis codes were used to indicate where readmission might result from substandard care arising in the index admission.

- Readmission with primary diagnosis of ‘complications of surgical and medical care not elsewhere classified’ (T80-T88), while this was not the primary diagnosis of the index admission.
- Primary diagnosis occurring in the readmission but not the index admission:
  - sequelaes of injuries of poisoning and other consequences (T90-T98);
  - thromboembolism (I26.0, I26.9, I63.1, I63.4, I74, I80, I81, I82, T79.0, T79.1);
  - pneumonia (J13, J14, J153, J154, J157, J159, J168, J181, J188);
  - pressure sores (L89);
  - poisoning by drugs medicaments and biological substances (T36-T50).
- Primary diagnosis on index admission of ‘symptoms and signs’ (R-codes in ICD10 chapter XVIII) with a definite primary diagnosis on readmission.
- Single emergency readmission for same primary diagnosis where patient has just one recorded emergency readmission in the study period (this study one year). This excludes cancer and chronic conditions in the primary diagnosis. Cancer was defined as ICD10 chapter C and D00-D48. The list of chronic condition diagnostic categories was drawn from Blunt et al.\textsuperscript{14}
- Emergency readmission on day of discharge (discharge date = readmission date).

B: Anticipated but unpredictable hospital care

For some patients, multiple emergency admissions or readmissions within 30 days are common as part of an anticipated plan or pattern of care. This excludes obstetric conditions in the primary diagnosis. It also excludes patients with one readmission every two weeks or more in the study period – equivalent to 26 or more readmissions in a year, these are considered artefacts (category E).

- Ill but stable: individuals with two or more readmissions in a year but with relatively little variability over time (defined as a coefficient of variation of annual numbers of readmissions < 2.5)
• Unstable deterioration: individuals with two or more readmissions in a year with variability over time (defined as a coefficient of variation of annual numbers of readmissions exceeding 2.5), or more than 10 readmissions in a single year.

• Non-medical risk factors: individuals known to have potential health hazards related to their socioeconomic and psychosocial circumstances or behavioural issues (Z55-Z76, Z91 in either index admission or readmission and in either primary or secondary diagnosis). This represents individuals where substantial factors in their readmission may be beyond the control of the health service.

C: Accident or coincidence - related to a different body system
These readmissions were defined as emergency 30 day readmissions in a different ICD10 chapter from the index admission and excluding codes for ‘factors influencing health status and contact with health services’ (ICD10 Z codes). For these readmissions coding does not indicate a common factor between index admission and readmission. Two common anecdotal examples of coincidental readmissions are transport accidents and falls.

D: Broadly related - related to the same body system
This category contains readmissions which are broadly related to the previous admission where primary index and readmission diagnoses match within ICD10 chapter. Readmissions with primary diagnosis of ‘symptoms and signs’ (R-codes in ICD10 chapter XVIII) or ‘factors influencing health status and contact with health services’ (ICD10 Z codes) are also included in this category.

E: Other
• Primary readmission diagnosis of ‘follow up’ (Z08, Z09, Z42, Z47, Z48) or patients with an excessively high number of emergency readmissions (one emergency readmission every two weeks or more in the study period - equivalent to 26 or more readmissions in a year).
• Everything that could not be classified in the above mentioned categories.
Chapter 5

Readmission patterns in England and the Netherlands: a comparison based on administrative data of all hospitals

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Aileen Clarke
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Rudolf B Kool

ABSTRACT

Background: Examining variation in patterns of readmissions between countries can be valuable for mutual learning in order to reduce unnecessary readmissions. The aim of this study was to compare readmission rates and reasons for readmissions between England and the Netherlands.

Methods: We used data from 85 Dutch hospitals (1,355,947 admissions) and 451 English hospitals (5,260,227 admissions) in 2014 (96% of all Dutch hospitals and 100% of all English NHS hospitals). Readmission data from England and the Netherlands were compared for all hospital patients and for specific diagnosis groups: pneumonia, urinary tract infection, chronic obstructive pulmonary disease, coronary atherosclerosis, biliary tract disease, hip fracture and acute myocardial infarction. Readmissions were categorised using a classification system developed on administrative data. The classification distinguishes between potentially preventable readmissions and other reasons for readmission.

Results: England had a higher 30 day readmission rate (adjusted for age and gender) compared to the Netherlands: 11.17% (95% CI 11.14-11.20%) versus 9.83% (95% CI 9.77-9.88%). The main differences appeared to be in readmissions for the elderly (England 17.2% versus the Netherlands 10.0%) and in emergency readmissions (England 85.3% of all 30 day readmissions versus the Netherlands 66.8%). In the Netherlands, however, more emergency readmissions were classified as potentially preventable compared to England (33.8% versus 28.8%).

Conclusions: The differences found between England and the Netherlands indicate opportunities to reduce unnecessary readmissions. For England this concerns more expanded palliative care, integrated social care and reduction of waiting times. In the Netherlands, the use of treatment plans for daily life could be increased.
INTRODUCTION

Hospital readmissions are used as an indicator of quality of care in many countries. Several studies have shown that premature discharge or substandard care during the initial hospitalisation increases the chance of being readmitted to a hospital. Hospital readmissions are also a burden to patients and costly for health care. Given this presumed negative relationship between readmissions and the quality of prior hospital care, insight into readmissions might help hospitals to identify areas where quality of care could be improved.

The number of readmissions is influenced on three levels: (i) the individual patient level - for example by diagnosis and illness severity; (ii) the quality of care received during the initial hospital stay and after discharge and (iii) the health care system – for example patient logistics and financing of health care. Comparing readmissions internationally can help to provide insight into the impact of the third level: systemic differences in health care systems. If health care systems are comparable, countries can learn from each other, for example, how readmissions should be defined in order to be a useful quality indicator and how the number of readmissions can be reduced.

A readmission indicator was recently introduced in the Netherlands. This created opportunities for quality improvement by comparing patterns of readmissions between hospitals and between countries. England is a good candidate for this comparison because it has a long history of using readmissions as a quality indicator with the most publications on readmissions in Europe in recent years. England has also introduced a system of financial penalties for hospitals with high readmission rates. Finally, a classification of readmissions using administrative data has been developed in England to distinguish between potentially preventable readmissions and other readmissions.

The English and Dutch health care system share several characteristics. They both have universal coverage of health care, a strong gate keeping role of general practitioners and systems for assessing emergency cases in hospitals. Lastly, the two countries have roughly similar demographics.

However, there are also differences between the two countries. In England the accessibility of elective care continues to be a problem in the NHS (National Health Service) as waiting times are increasing, whereas the Netherlands has some of the shortest waiting times of all OECD countries. Furthermore, in England, most health care services are commissioned for a local area by a Clinical Commissioning Group (CCG). Funding for this is on an adjusted capitation basis allocating funds derived from central taxation. The Netherlands has a system of compulsory comprehensive insurance through private health care insurance companies. The Dutch health care system is mainly financed by these compulsory contributions and premiums, followed by
private expenditure and the government. Health insurers can negotiate to a certain extent with health care providers on price, volume and quality of care, and are allowed to make a profit. They are, however, not allowed to share their profits with shareholders. Appendix 1 shows relevant statistics of both health care systems in 2014. Many aspects are very comparable, however, the Netherlands has more practising physicians and nurses compared to England and more general practitioners as a percentage of total physicians.

An international comparison of readmissions was performed previously by Nolte et al. They compared the readmission indicators of the UK, USA, Australia and the Netherlands. They demonstrated different ways of calculating and using readmission indicators. Readmission rates vary depending on the diagnosis group but in this study they did not conduct analysis based on diagnosis groups. Another international study of hospital readmissions in Europe and the USA found a general level of agreement between readmission rates in different countries. This study was performed in 2002 but the Dutch health care system was reformed in 2006, which could affect the comparison between countries. The current study breaks new ground in comparing reasons for readmissions. Our research questions were: are there differences in readmission rates between England and the Netherlands, overall, for specific diagnosis groups, age groups and the proportion of preventable readmissions? The aim was to gain more specific insight into readmission patterns, the preventability of readmissions and differences between the countries, which can reveal opportunities for improvement.

**METHODS**

**ADMINISTRATIVE DATABASE**

Our comparative datasets were based on all clinical admissions to the English NHS and Dutch hospitals with a discharge date in 2014. Two national databases were used: the Hospital Episode Statistics (HES) data from NHS Digital in England and the National Database of Hospital Care (LBZ). The LBZ provides data from 87 out of 89 general and university hospitals in the Netherlands in 2014 and contains all hospital admissions. The HES contains data on admissions to all NHS hospitals in England and admissions to independent hospitals commissioned by the NHS, in total 451 hospitals in 2014.

**DEFINITION OF A READMISSION AND EXCLUSIONS**

A readmission was defined as a clinical admission to the same hospital within 30 days after discharge following the clinical index admission. This timeframe is in accordance with the international literature. We took into account all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation. We used the index admission as the unit of analysis, which means that each readmission of the same patient is again an index
admission for a subsequent readmission.25 The units of analysis were complete hospital stays. We did not include readmissions to other hospitals and did not account for transfers between hospitals.

Inclusion criteria were clinical admissions with a discharge date in 2014. We included readmissions with a discharge date in 2015 when the index admission had a discharge date in 2014. We excluded hospitals with incomplete data and admissions with no valid age, no valid gender and length of stay < 1 day. Patients who died during their index admission were excluded from the population at risk. Based on previous literature, we excluded admissions and readmissions in which the principal diagnosis was either cancer, obstetrics or psychiatrics (Appendix 2).20 These specific admissions were included in the categorisation of readmissions, for both the index admission and readmission.

In the HES there are different types of emergency admissions, for example admissions to the accident and emergency department of another provider.26 In the Dutch LBZ the variable ‘urgency’ (acute versus non-acute admission) indicates whether care within 24 hours was needed.22 In both datasets, this variable does not reflect the difference between unintended and intended readmissions, as readmissions that are not acute can still be unintended. Therefore, both emergency (which is the same as acute in our dataset) and elective admissions and readmissions are included in this study. We only used the categorisation to analyse emergency readmissions, not elective readmissions. This is because we believe that differences in the organisation of elective care in the two countries might lead to results not being comparable.

**Main Outcome Measures**

Main outcome measures were mean readmission rates overall and for seven selected diagnosis groups, and the classification into readmission categories (Appendix 3). We used the Clinical Classifications Software (CCS) for the analysis of the diagnosis groups.27 The conditions pneumonia, urinary tract infection, chronic obstructive pulmonary disease (COPD), coronary atherosclerosis and biliary tract disease were chosen because they were the diagnosis groups where readmissions occur most frequently in our datasets. Hip fracture and acute myocardial infarction (AMI) were added to the list because readmissions for these diagnoses are often used as quality indicators due to their presumed relationship with quality of care.28-31 These seven diagnosis groups represent chronic as well as elective hospital care.

**Classification**

We used a classification-system, developed in England using administrative data, to distinguish between potentially preventable and other readmissions14 and adapted it to fit LBZ data requirements (Appendix 3, coding used see Appendix 4).
DATA ANALYSIS
SAS 9.4® was used for the data analysis of the HES data and R 3.2.1® for the LBZ data. Readmission rates were calculated overall and for seven selected diagnosis groups. We calculated readmission rates adjusted for age and gender with direct standardisation using a standard population drawn from both countries datasets.

RESULTS

BASELINE CHARACTERISTICS AND READMISSION RATES
Two hospitals were excluded from the Dutch database because of incomplete data. In the English database no hospitals were excluded. The readmission rate, standardised for age and gender, was 11.17% for England compared to 9.83% for the Netherlands (Table 1). The length of stay during the index admission was longer in England (6.2 days versus 4.3 days) and England had more emergency readmissions (85% versus 67%).

Table 1 Patient and readmission characteristics at baseline, England versus the Netherlands

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>The Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study population size - admissions (N)</td>
<td>5,260,227</td>
<td>1,355,947</td>
</tr>
<tr>
<td>Study population size - unique patients (N)</td>
<td>3,791,117</td>
<td>1,080,847</td>
</tr>
<tr>
<td>Admission characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age (years) ± SD</td>
<td>50.1 ± 30.3</td>
<td>51.8 ± 27.6</td>
</tr>
<tr>
<td>Male (N and %)</td>
<td>2,535,748 (48.2%)</td>
<td>679,445 (50.1%)</td>
</tr>
<tr>
<td>Age group (N and % of total)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00-19 years</td>
<td>1,150,983 (21.9%)</td>
<td>241,256 (17.8%)</td>
</tr>
<tr>
<td>20-39 years</td>
<td>630,318 (12.0%)</td>
<td>135,652 (10.0%)</td>
</tr>
<tr>
<td>40-59 years</td>
<td>974,132 (18.5%)</td>
<td>305,086 (22.5%)</td>
</tr>
<tr>
<td>60-74 years</td>
<td>1,063,504 (20.2%)</td>
<td>361,053 (26.6%)</td>
</tr>
<tr>
<td>75+ years</td>
<td>1,441,290 (27.4%)</td>
<td>312,900 (23.1%)</td>
</tr>
<tr>
<td>Readmission characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All 30 day readmissions (N)</td>
<td>588,348</td>
<td>135,295</td>
</tr>
<tr>
<td>Crude RR %</td>
<td>11.18%</td>
<td>9.88%</td>
</tr>
<tr>
<td>Adjusted RR % ¹ (95% CI)</td>
<td>11.17% (11.14-11.20%)</td>
<td>9.83% (9.77-9.88%)</td>
</tr>
<tr>
<td>Emergency readmissions (N and % of all 30 day readmissions)</td>
<td>501,960 (85.3%)</td>
<td>90,385 (66.8%)</td>
</tr>
<tr>
<td>Crude emergency RR %</td>
<td>9.54%</td>
<td>6.67%</td>
</tr>
<tr>
<td>Adjusted emergency RR % ¹ (95% CI)</td>
<td>9.51% (9.48-9.54%)</td>
<td>6.63% (6.59-6.68%)</td>
</tr>
<tr>
<td>Mean length of stay during index admission (days) ± SD</td>
<td>6.2 ± 12.5</td>
<td>4.3 ± 6.5</td>
</tr>
<tr>
<td>Mean days between index admission and readmission ± SD</td>
<td>11.1 ± 8.8</td>
<td>11.3 ± 8.3</td>
</tr>
</tbody>
</table>

SD: Standard Deviation; RR: Readmission Rate; CI: Confidence Interval

¹ Adjusted for age and gender
The readmission rate per age group (Figure 1) was significantly different at almost all age groups between the two countries. The most striking difference was after the age of 85: readmission rates further increased in England, whereas in the Netherlands readmission rates dropped. When looking only at emergency readmissions, the pattern changed, but the difference in readmissions among the elderly remained the same.

Most patients went to their usual place of residence after their initial discharge (92.1% of admissions in England and 90.3% of admissions in the Netherlands). However, the proportion of patients discharged to an intermediate care facility was slightly higher in the Netherlands (6.0% versus 2.5% of admissions). In England, 5.0% (29,610) of those readmitted died in hospital compared to 2.8% (3761) in the Netherlands.

The readmission rates were higher in England than in the Netherlands for all diagnosis groups, (Table 2) except for acute myocardial infarction and coronary atherosclerosis, readmission rates were higher in the Netherlands. England had more emergency readmissions for all diagnosis groups. This difference is most pronounced for acute myocardial infarction and coronary atherosclerosis (England 84.7% versus the Netherlands 54.7% and 78.4% versus 46.3%, respectively).
Table 2. Readmission rates, percentage emergency readmissions, days between index admission and readmission and length of stay during index admission, for the selected diagnosis groups, England versus the Netherlands

<table>
<thead>
<tr>
<th>Diagnosis group index admission</th>
<th>No. R EN</th>
<th>RR EN (%) (95% CI)</th>
<th>No. R NL</th>
<th>RR NL (%) (95% CI)</th>
<th>ER EN (% of all 30 day readmissions)</th>
<th>ER NL (% of all 30 day readmissions)</th>
<th>DbIR EN</th>
<th>DbIR NL</th>
<th>LoS EN (days)</th>
<th>LoS NL (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>29,460</td>
<td>17.1 (16.9-17.2)</td>
<td>3321</td>
<td>11.5 (11.1-11.9)</td>
<td>94.4</td>
<td>97.3</td>
<td>11.9</td>
<td>11.7</td>
<td>10.5</td>
<td>7.1</td>
</tr>
<tr>
<td>COPD</td>
<td>27,235</td>
<td>24.3 (24.0-24.6)</td>
<td>5615</td>
<td>19.0 (18.6-19.5)</td>
<td>96.4</td>
<td>98.1</td>
<td>12.3</td>
<td>13.3</td>
<td>6.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>26,766</td>
<td>17.1 (16.9-17.3)</td>
<td>2917</td>
<td>12.8 (12.4-13.3)</td>
<td>91.9</td>
<td>74.4</td>
<td>12.0</td>
<td>13.0</td>
<td>9.4</td>
<td>6.2</td>
</tr>
<tr>
<td>Biliary tract disease</td>
<td>15,245</td>
<td>14.4 (14.2-14.6)</td>
<td>4629</td>
<td>13.1 (12.8-13.5)</td>
<td>78.3</td>
<td>59.2</td>
<td>11.7</td>
<td>23.8</td>
<td>5.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Coronary atherosclerosis</td>
<td>9856</td>
<td>10.2 (10.0-10.4)</td>
<td>5821</td>
<td>13.6 (13.3-13.9)</td>
<td>78.4</td>
<td>46.3</td>
<td>11.6</td>
<td>10.7</td>
<td>5.1</td>
<td>4.0</td>
</tr>
<tr>
<td>AMI</td>
<td>9194</td>
<td>12.2 (12.0-12.5)</td>
<td>4212</td>
<td>14.3 (13.9-14.7)</td>
<td>84.7</td>
<td>54.7</td>
<td>10.1</td>
<td>9.4</td>
<td>6.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>7035</td>
<td>10.6 (10.3-10.8)</td>
<td>1250</td>
<td>7.0 (6.6-7.4)</td>
<td>82.8</td>
<td>85.8</td>
<td>9.9</td>
<td>11.6</td>
<td>19.0</td>
<td>7.3</td>
</tr>
</tbody>
</table>

EN: England; NL: the Netherlands; No. R: Number of Readmissions; RR: Readmission Rate; CI: 95% Confidence Interval; ER: Emergency Readmission; DbIR: Days between Index admission and Readmission; LoS: Length of Stay during index admission; AMI: Acute Myocardial Infarction; COPD: Chronic Obstructive Pulmonary Disease.
CATEGORISATION OF EMERGENCY READMISSIONS

The English dataset contained 593,585 emergency readmissions eligible for categorisation and the Dutch dataset 120,727 (Table 3). In total 28.8% of the emergency readmissions in England were categorised as potentially preventable compared to 33.8% in the Netherlands.

Table 3. Distribution of categories of emergency readmissions for both countries

<table>
<thead>
<tr>
<th>Category</th>
<th>England</th>
<th>The Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>% (95% CI)</td>
</tr>
<tr>
<td>A: Potentially preventable</td>
<td>170,937</td>
<td>28.8 (28.6-29.0)</td>
</tr>
<tr>
<td>A1: Probable suboptimal care</td>
<td>25,746</td>
<td>4.3 (4.1-4.5)</td>
</tr>
<tr>
<td>A2: Possible suboptimal care</td>
<td>145,191</td>
<td>24.5 (24.3-24.7)</td>
</tr>
<tr>
<td>B: Anticipated but unpredictable hospital care</td>
<td>169,107</td>
<td>28.5 (28.3-28.7)</td>
</tr>
<tr>
<td>D: Artefact</td>
<td>618</td>
<td>0.1 (0.0-0.3)</td>
</tr>
<tr>
<td>E: Accident or coincidence – related to a different body system</td>
<td>169,791</td>
<td>28.6 (28.4-28.8)</td>
</tr>
<tr>
<td>F: Broadly related – related to the same body system</td>
<td>83,132</td>
<td>14.0 (13.8-14.2)</td>
</tr>
<tr>
<td>Total</td>
<td>593,585</td>
<td>100</td>
</tr>
</tbody>
</table>

DISCUSSION

In this study, we aimed to compare readmission rates and reasons for readmissions between England and the Netherlands in order to obtain insight into opportunities to reduce unnecessary readmissions.

READMISSION RATES

Our analysis showed that on average England had a higher overall readmission rate compared to the Netherlands, 11.2% versus 9.8% when adjusted for age and gender. For most diagnosis groups, readmission rates in England were higher compared to the Netherlands, however, readmission rates for acute myocardial infarction and coronary atherosclerosis were higher in the Netherlands. This is in line with a relevant previous international comparison that found higher readmission rates for Scotland compared to the Netherlands for all conditions except for stroke (England was not compared).3

Our finding that the length of stay in England was longer compared to the Netherlands, is in accordance with previous comparisons of health statistics.32
We also analysed readmission rates when taking into account only readmissions for the same diagnosis. It appeared that the Netherlands has a higher rate of such readmissions compared to England (3.7% versus 2.9%). This applied also for the elderly. However, this result should be interpreted with care, as the coding of primary diagnosis differs between the two countries.

**Emergency and Elective Readmissions**

In this study we included emergency and elective admissions and readmissions. A previous study reviewed medical records of readmissions to evaluate the accuracy of the classification used in this study. It appeared that a larger proportion of acute or emergency readmissions was classified as potentially preventable compared to elective readmissions (28.5% versus 5.0%). England appeared to have relatively more readmissions classed as emergency admissions compared to the Netherlands (85% versus 67%). In the Netherlands waiting lists are shorter compared to England. This might result in more planned readmissions within 30 days in the Netherlands, and therefore a smaller proportion of emergency readmissions. Furthermore, as mentioned in the methods, the definition of emergency is not identical in the LBZ and the HES. This might affect the proportions we found in this study.

**Readmissions in the Elderly and Adolescents**

The difference between adjusted readmission rates for different age groups was remarkable. Especially towards the end of life, patients in England were more likely to be readmitted compared with those in the Netherlands. This large difference was also apparent when looking only at emergency readmissions. The scale of these differences suggests that there are differences in the range of supporting services available to prevent or substitute for hospital care. For example for services at the end of life: in England, 58.1% of people die in hospital, compared to 33.9% in the Netherlands. This difference between England and the Netherlands becomes even larger in the elderly: 49.8% of people aged 90 and over die in hospital in England, compared to 16.3% in the Netherlands. In England, palliative care is provided through the voluntary sector as well as by the NHS and provision is patchy. In the Netherlands most palliative care is integrated into the regular health care system and provided by GPs, home care, nursing homes, hospitals, hospices and voluntary workers. Until recently, palliative care in England was focused on cancer care and not available for other conditions. Palliative care seems to be more extensive with 309 hospices and palliative care units in hospitals in the Netherlands providing inpatient care for adults (2014), compared to 173 in England (2009). Besides, social care for older people is currently under substantial pressure in England; increasing numbers of people are not receiving the help they need. More integrated care could help to reduce unnecessary readmissions and improve care for the elderly.

Furthermore, there were more readmissions in England than in the Netherlands for adolescents (10-19 years). These readmissions were mostly because of holiday relief care and unspecified
illness. This might be due to a coding difference between both countries, or this service is provided in England by organisations classified as hospitals but by different organisations in the Netherlands.

**CLASSIFICATION OF READMISSIONS**

The categorisation of readmissions showed that approximately 30% of emergency readmissions within 30 days are potentially preventable across both countries. This is comparable to the original classification. The proportion of potentially preventable emergency readmissions was higher in the Netherlands compared to England. In the Netherlands, the number of discharges per 1000 inhabitants is lower compared to England (119 and 129, respectively, in 2014). This might indicate that in England the threshold for admission is lower, and this may also pertain for readmission. However, emergency readmissions in the Netherlands are more likely to be potentially preventable, according to our findings in this study.

**STRENGTHS AND LIMITATIONS**

The current study breaks new ground in comparing the categories of readmissions between England and the Netherlands. Exactly the same definition of readmission was used in both countries to ensure equal comparison. Another strength is the completeness of the national administrative databases of both countries, which cover nearly all hospital admissions within the countries.

A possible limitation of the present study, as in all international comparisons, is the comparability of the data. The two different datasets each hold differences in coding and data collection, which complicate direct comparison and accurate interpretation.

We were restricted to calculating readmissions where the patient returned to the admitting hospital. Transfers are registered in the HES data, however we were not able to track patients across hospitals with the LBZ data. From the HES data it appeared that the crude readmission rate to any hospital was 13.6% compared to 11.2% for readmissions to the same hospital. This might affect the results of our comparison. We could also not take into account what happens to patients outside the hospital after discharge. When comparing hospital performance internationally, this is potentially a confounding factor as this differs between the two countries, particularly in the very elderly. England and the Netherlands both have a wide variety of community care services. However, the accessibility of general practitioners might differ between the countries. The Netherlands places more emphasis on the GPs, as is shown by the higher percentage GPs of total physicians. Another limitation of our study concerned the lack of mortality data after discharge. A better estimate of the population at risk for readmissions could have been made with these data.
IMPLICATIONS FOR PRACTICE
An international comparison can help us to understand differences between countries in order to improve the quality of care. The marked differences in readmission in the oldest age group for example, can prompt useful questions about the underlying patterns of service provision, and present opportunities for effective change using international exemplars. England might learn from the Dutch health care system when aiming to reduce readmissions for, among others, patients with pneumonia and hip fracture. A longitudinal study showed that the English readmission rate for pneumonia is increasing in England (+2.7% from 2006 to 2016).\(^\text{37}\) Concerning hip fracture, short waiting times are important to prevent complications. In the Netherlands, the waiting time for total hip replacement is shorter compared to England (49–56 days versus 78 days).\(^\text{38}\) This might contribute to higher readmission rates for hip fracture in England. Furthermore, palliative care could also be expanded in England in order to reduce unnecessary readmissions and improve care in general.

On the other hand, the Netherlands might learn from England when trying to reduce readmissions for heart conditions. According to the Commonwealth Fund, more older patients requiring chronic care management in the UK had a treatment plan they could carry out in daily life compared to Dutch patients (73% versus 41%).\(^\text{39}\) Expanding use of treatment plans for these patients in the Netherlands might reduce unnecessary readmissions and improve quality of care. Learning might be facilitated by visits of doctors, managers and policymakers to each other’s countries. In addition we anticipate that lessons learned regarding readmissions are applicable more broadly for health systems which are comparable to those of England and the Netherlands.

FUTURE RESEARCH
Future research should take into account readmissions to other hospitals, as this might be a source of differences between countries. Finally, future case studies should focus on how patients move through the different components of health systems in order to measure hospital and health system performance more specifically and to account for factors outside of the hospital’s control.

CONCLUSIONS
The differences found between England and the Netherlands indicate opportunities to reduce unnecessary readmissions. For England this concerns more expanded palliative care, integrated social care and reduction of waiting times. In the Netherlands the use of treatment plans for daily life could be increased.
Readmission patterns in England and the Netherlands

REFERENCES


## APPENDIX 1 - RELEVANT STATISTICS FOR ENGLAND AND THE NETHERLANDS IN 2014

<table>
<thead>
<tr>
<th></th>
<th>England (United Kingdom)</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population</td>
<td>64,613,200</td>
<td>16,865,000</td>
</tr>
<tr>
<td>Land area (km²)</td>
<td>242,500</td>
<td>33,700</td>
</tr>
<tr>
<td>Population density (population per km²)</td>
<td>266</td>
<td>500</td>
</tr>
<tr>
<td>Health expenditure (% GDP)</td>
<td>9.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Hospital beds (per 10,000 population)</td>
<td>27.3</td>
<td>25.1 ¹</td>
</tr>
<tr>
<td>Life expectancy at birth: women</td>
<td>83.2</td>
<td>83.5</td>
</tr>
<tr>
<td>Life expectancy at birth: men</td>
<td>79.2</td>
<td>80.0</td>
</tr>
<tr>
<td>Elderly population (percentage)</td>
<td>17.5</td>
<td>17.3</td>
</tr>
<tr>
<td>Practicing physicians (per 1000 inhabitants)</td>
<td>2.79</td>
<td>3.31 (2013 data)</td>
</tr>
<tr>
<td>General practitioners as a percentage of total physicians</td>
<td>28.72</td>
<td>44.12</td>
</tr>
<tr>
<td>Practicing nurses (per 1000 inhabitants)</td>
<td>8.19</td>
<td>12.23 (2013 data)</td>
</tr>
<tr>
<td>Inpatient care discharges (all hospitals, per 100,000 population)</td>
<td>13,245.8</td>
<td>13,189.9</td>
</tr>
<tr>
<td>Type of health system</td>
<td>Beveridge</td>
<td>Bismarck</td>
</tr>
</tbody>
</table>

Source: OECD.Stat (accessed on 30-4-2018)

¹ Kengetallen DHD. https://www.nvz-ziekenhuizen.nl/_library/33659/RapportageKengetallen2014.pdf
## Appendix 2 - Exclusion of Diagnosis Groups

### Psychiatric diagnosis groups

<table>
<thead>
<tr>
<th>Diagnosis CCS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>657</td>
<td>Mood disorders</td>
</tr>
<tr>
<td>659</td>
<td>Schizophrenia and other psychotic disorders</td>
</tr>
<tr>
<td>651</td>
<td>Anxiety disorders</td>
</tr>
<tr>
<td>670</td>
<td>Miscellaneous disorders</td>
</tr>
<tr>
<td>654</td>
<td>Developmental disorders</td>
</tr>
<tr>
<td>650</td>
<td>Adjustment disorders</td>
</tr>
<tr>
<td>658</td>
<td>Personality disorders</td>
</tr>
<tr>
<td>652</td>
<td>Attention-deficit, conduct, and disruptive behavior disorders</td>
</tr>
<tr>
<td>656</td>
<td>Impulse control disorders, NEC</td>
</tr>
<tr>
<td>655</td>
<td>Disorders usually diagnosed in infancy, childhood, or adolescence</td>
</tr>
<tr>
<td>662</td>
<td>Suicide and intentional self-inflicted injury</td>
</tr>
</tbody>
</table>

### Cancer diagnosis groups

<table>
<thead>
<tr>
<th>Diagnosis CCS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Cancer of head and neck</td>
</tr>
<tr>
<td>12</td>
<td>Cancer of esophagus</td>
</tr>
<tr>
<td>13</td>
<td>Cancer of stomach</td>
</tr>
<tr>
<td>14</td>
<td>Cancer of colon</td>
</tr>
<tr>
<td>15</td>
<td>Cancer of rectum and anus</td>
</tr>
<tr>
<td>16</td>
<td>Cancer of liver and intrahepatic bile duct</td>
</tr>
<tr>
<td>17</td>
<td>Cancer of pancreas</td>
</tr>
<tr>
<td>18</td>
<td>Cancer of other GI organs; peritoneum</td>
</tr>
<tr>
<td>19</td>
<td>Cancer of bronchus; lung</td>
</tr>
<tr>
<td>20</td>
<td>Cancer; other respiratory and intrathoracic</td>
</tr>
<tr>
<td>21</td>
<td>Cancer of bone and connective tissue</td>
</tr>
<tr>
<td>22</td>
<td>Melanomas of skin</td>
</tr>
<tr>
<td>23</td>
<td>Other non-epithelial cancer of skin</td>
</tr>
<tr>
<td>24</td>
<td>Cancer of breast</td>
</tr>
<tr>
<td>25</td>
<td>Cancer of uterus</td>
</tr>
<tr>
<td>26</td>
<td>Cancer of cervix</td>
</tr>
<tr>
<td>27</td>
<td>Cancer of ovary</td>
</tr>
<tr>
<td>28</td>
<td>Cancer of other female genital organs</td>
</tr>
<tr>
<td>29</td>
<td>Cancer of prostate</td>
</tr>
<tr>
<td>30</td>
<td>Cancer of testis</td>
</tr>
<tr>
<td>31</td>
<td>Cancer of other male genital organs</td>
</tr>
<tr>
<td>32</td>
<td>Cancer of bladder</td>
</tr>
<tr>
<td>33</td>
<td>Cancer of kidney and renal pelvis</td>
</tr>
<tr>
<td>34</td>
<td>Cancer of other urinary organs</td>
</tr>
<tr>
<td>35</td>
<td>Cancer of brain and nervous system</td>
</tr>
<tr>
<td>36</td>
<td>Cancer of thyroid</td>
</tr>
<tr>
<td>37</td>
<td>Hodgkin’s disease</td>
</tr>
<tr>
<td>38</td>
<td>Non-Hodgkin’s lymphoma</td>
</tr>
<tr>
<td>39</td>
<td>Leukemias</td>
</tr>
<tr>
<td>40</td>
<td>Multiple myeloma</td>
</tr>
<tr>
<td>41</td>
<td>Cancer; other and unspecified primary</td>
</tr>
<tr>
<td>42</td>
<td>Secondary malignancies</td>
</tr>
<tr>
<td>43</td>
<td>Malignant neoplasm without specification of site</td>
</tr>
<tr>
<td>44</td>
<td>Neoplasms of unspecified nature or uncertain behaviour</td>
</tr>
<tr>
<td>45</td>
<td>Maintenance chemotherapy; radiotherapy</td>
</tr>
</tbody>
</table>
### Obstetric diagnosis groups excluded from the readmission indicator

<table>
<thead>
<tr>
<th>Diagnosis CCS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>177</td>
<td>Spontaneous abortion</td>
</tr>
<tr>
<td>178</td>
<td>Induced abortion</td>
</tr>
<tr>
<td>179</td>
<td>Postabortion complications</td>
</tr>
<tr>
<td>180</td>
<td>Ectopic pregnancy</td>
</tr>
<tr>
<td>181</td>
<td>Other complications of pregnancy</td>
</tr>
<tr>
<td>182</td>
<td>Hemorrhage during pregnancy; abruptio placenta; placenta previa</td>
</tr>
<tr>
<td>183</td>
<td>Hypertension complicating pregnancy; childbirth and the puerperium</td>
</tr>
<tr>
<td>184</td>
<td>Early or threatened labor</td>
</tr>
<tr>
<td>185</td>
<td>Prolonged pregnancy</td>
</tr>
<tr>
<td>186</td>
<td>Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the puerperium</td>
</tr>
<tr>
<td>187</td>
<td>Malposition; malpresentation</td>
</tr>
<tr>
<td>188</td>
<td>Fetopelvic disproportion; obstruction</td>
</tr>
<tr>
<td>189</td>
<td>Previous C-section</td>
</tr>
<tr>
<td>190</td>
<td>Fetal distress and abnormal forces of labor</td>
</tr>
<tr>
<td>191</td>
<td>Polyhydramnios and other problems of amniotic cavity</td>
</tr>
<tr>
<td>192</td>
<td>Umbilical cord complication</td>
</tr>
<tr>
<td>193</td>
<td>OB-related trauma to perineum and vulva</td>
</tr>
<tr>
<td>194</td>
<td>Forceps delivery</td>
</tr>
<tr>
<td>195</td>
<td>Other complications of birth; puerperium affecting management of mother</td>
</tr>
<tr>
<td>196</td>
<td>Normal pregnancy and/or delivery</td>
</tr>
</tbody>
</table>
**APPENDIX 3 - CATEGORIES OF READMISSION**

A. **Potentially preventable**—Combinations of diagnosis codes were used to indicate where readmission might result from substandard care arising in the index admission.

   - **Category A1: Probable suboptimal care**: primary readmission diagnosis of ‘complications of surgical & medical care not elsewhere classified’.
   - **Category A2: Possible suboptimal care**: readmission diagnosis of common avoidable complications; diagnoses of ‘symptoms and signs’ in the index admission and returned with a more specific diagnosis; patient with one recorded emergency readmission for the same condition within 30 days (excluding cancer and chronic conditions) in the study period; emergency readmission on the day of discharge.

B. **Anticipated but unpredictable hospital care**—For some patients, multiple emergency admissions are common as part of an anticipated plan or pattern of care. This category also includes individuals where substantial factors in their readmission may be beyond the control of the health service because of potential health hazards related to their socioeconomic and psychosocial circumstances or behavioural issues (e.g., alcohol misuse).

D. **Artefact**—Readmissions in this category are likely to be planned but have been mistakenly coded as an emergency readmission.

E. **Accident or coincidence related to different body system**—These readmissions were defined as emergency 30 day readmissions in a different ICD10 chapter from the index admission. For these readmissions, coding does not indicate a common factor between index admission and readmission.

F. **Broadly related (related to same body system)**—This residual category contains readmissions that are broadly related to the previous admission where index and readmission diagnoses match within ICD10 chapter.

---

1 Category C of the original classification was not adopted, see explanation in Appendix 4.
APPENDIX 4 – COMPLETE DETAILS OF CODES USED FOR THE CLASSIFICATION OF READMISSIONS

This classification is based on Blunt et al.\textsuperscript{14} and is adjusted for this study. The readmissions were categorised hierarchically, meaning that category A1 readmissions were identified first, followed by A2, etcetera. Consequently, if readmissions did not fit in categories A, B, or D, they were classified into category E or F, dependent on whether or not the index admission and readmission matched within the ICD10 chapter.

A: Potentially preventable: probable or possible substandard care

**Category A1: Probable suboptimal care**
Readmission with primary diagnosis of “complications of surgical and medical care not elsewhere classified” (T80-T88), while this was not the primary diagnosis of the index admission.

**Category A2: Possible suboptimal care**
- Primary diagnosis occurring in the readmission but not the index admission:
  - sequelae of injuries of poisoning and other consequences (T90-T98);
  - thromboembolism (I26.0, I26.9, I63.1, I63.4, I74, I80, I81, I82, T79.0, T79.1);
  - pneumonia (J13, J14, J153, J154, J157, J159, J168, J181, J188);
  - pressure sores (L89);
  - poisoning by drugs medicaments and biological substances (T36-T50).
- Primary diagnosis on index admission of “symptoms and signs” (R-codes in ICD10 chapter XVIII) with a definite primary diagnosis on readmission.
- Single emergency readmission for same primary diagnosis where patient has just one recorded emergency readmission in the study period (this study one year). This excludes cancer and chronic conditions in the primary diagnosis. Cancer was defined as ICD10 chapter C and D00-D48. The list of chronic condition diagnostic categories was drawn from Blunt et al.\textsuperscript{14}
- Emergency readmission on day of discharge (discharge date = readmission date).

B: Anticipated but unpredictable hospital care

This category excludes obstetric conditions in the primary diagnosis (see Appendix 2 for the list of exclusions). It also excludes patients with one readmission every two weeks or more in the study period – equivalent to 26 or more readmissions in a year, these are considered artefacts (category E).

- Ill but stable: individuals with two or more readmissions in a year but with relatively little variability over time. This is defined as a coefficient of variation of annual numbers of readmissions < 2.5. The stability of the patient's condition was determined using months as a time measure instead of years. Therefore, a cut-off value of 2.5 for the coefficient of variation was chosen instead of 0.5 from the original classification. This was because we used one year of data instead of six years.
Readmission patterns in England and the Netherlands

- Unstable deterioration: individuals with two or more readmissions in a year with variability over time. This is defined as a coefficient of variation of annual numbers of readmissions exceeding 2.5. Or individuals with more than ten readmissions in a single year.
- Non-medical risk factors: individuals known to have potential health hazards related to their socioeconomic and psychosocial circumstances or behavioural issues (Z55-Z76, Z91 in either index admission or readmission and in either primary or secondary diagnosis).

In the original classification, the variability was calculated over a period of six years. In this study it was only possible to calculate variability over one year. Because it is difficult to distinguish different readmission patterns in such a short period, the sub-classification of category B is not displayed in this study.

**C: Preference**
This category of the original classification covers both patient and staff preferences. It includes self-discharge and identifiable patterns of discharge and readmission around public holidays, Christmas etc. This is not applied in the current study, because self-discharge is not coded in LBZ data. This also appeared to be the reason for readmission in only a small proportion of the readmissions.\(^{14}\)

**D: Artefact**
- Primary readmission diagnosis of “follow up” (Z08, Z09, Z42, Z47, Z48) or patients with an excessively high number of emergency readmissions (one emergency readmission every two weeks or more over the one year data collection period - equivalent to 26 or more readmissions).

Category D2 from the original classification (defined periodicity) was not adopted, because this is not measured on the patient level and therefore not of interest for our study.

**E: Accident or coincidence - related to a different body system**
These readmissions were defined as emergency 30 day readmissions in a different ICD10 chapter from the index admission and excluding codes for “factors influencing health status and contact with health services” (ICD10 Z codes). Two common anecdotal examples of coincidental readmissions are transport accidents and falls.

**F: Broadly related - related to the same body system**
This category contains readmissions which are broadly related to the previous admission where primary index and readmission diagnoses match within ICD10 chapter. Readmissions with primary diagnosis of “symptoms and signs” (R-codes in ICD10 chapter XVIII) or “factors influencing health status and contact with health services” (ICD10 Z codes) are also included in this category.
Chapter 6

General discussion
MAIN FINDINGS

This thesis examines how a quality indicator based on readmissions should be defined in order to be of use to hospitals in identifying problems with the quality of care. It could then be used by the Inspectorate for its supervision. The research questions in this thesis and the corresponding answers are given in the table below.

Table 1. Research questions and conclusions

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Research question</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>To what degree are hospitals accountable for the variation in readmission rates?</td>
<td>Hospitals seem to make only a small contribution to the risk that a patient is readmitted.</td>
</tr>
<tr>
<td>3</td>
<td>What is the impact on the readmission ratio of taking into account readmissions to other hospitals in the Netherlands?</td>
<td>The overall impact of taking into account readmissions to other Dutch hospitals is limited.</td>
</tr>
<tr>
<td>4</td>
<td>How applicable is a classification of readmissions based on administrative data for identifying potentially preventable readmissions?</td>
<td>The classification by administrative data delivers significantly different results to that based on reviewing medical records and should therefore be used with caution. It could be used as a screening tool to identify potentially preventable readmissions more efficiently.</td>
</tr>
<tr>
<td>5</td>
<td>Are there differences between England and the Netherlands in readmission rates, and reasons for readmissions, which can indicate opportunities to reduce unnecessary readmissions?</td>
<td>England had a higher 30 day readmission rate compared to the Netherlands, mainly among the elderly. In the Netherlands, however, more emergency readmissions were classified as potentially preventable compared to England.</td>
</tr>
</tbody>
</table>

INTERPRETATION OF FINDINGS

CONSIDERATIONS FOR THE CALCULATION OF THE READMISSION RATIO

Correction for case mix

We found that almost all variation in readmissions was on the patient level. This means that patient characteristics play a large role in the chance of being readmitted. As a consequence, correction for case mix variables is of utmost importance when comparing readmissions between hospitals. Even when only looking at readmissions over time in one hospital, case mix is important to consider. An increase in readmissions over several years could also be explained by a patient population becoming increasingly old. The contribution of the different case mix variables in the prediction of a readmission varied between the diagnosis groups we studied. Variables which consistently contributed to a relatively large degree were: urgency of the admission, comorbidities, and age. These variables were also mentioned as consistent risk factors on the patient level in a systematic review by Vest et al. Furthermore, gender, socioeconomic status, and the year of discharge, were significant predictors in one or more diagnosis groups in our study. However, a
systematic review of Kansagara et al showed that basic sociodemographic variables such as age and gender did not make an important contribution in most studies. Of the seven studies that evaluated age, but did not include it in the final model, two studies included only patients of 65 years or older and three studies included only patients with congestive heart failure, which is more common in the elderly. This might explain the small influence of age in these models.

Hospital level in the model
We found that only a small part of the variation in readmissions was on the hospital level. The intraclass correlation coefficients (ICCs) were quite low, ranging from 0.48% to 2.70% for the different diagnosis groups studied. These values are comparable with the literature. The ICCs for outcome measures on the hospital level are usually 1% or even 0.1%. Another method to quantify that part of the variation in readmissions which takes place on the hospital level is by comparing the C-statistics for discriminative ability between models, with and without a hospital level. We found that the C-statistics of the models that included the hospital level were slightly higher compared with the models without a hospital level. This finding, together with the small ICCs, indicate that only a small part of the variation is explained by the hospital. This means that, when calculating the readmission ratio, it is not absolutely necessary to add a hospital level in the logistic regression analysis. As the influence of this level appeared to be only small in the Netherlands, it does not considerably affect the expected number of readmissions calculated.

Inclusion of acute and non-acute readmissions
Most studies only include emergency readmissions. However, complications might also result in readmissions that do not have to be treated immediately, and thus an admission is planned within a few days. To analyse the inclusion of non-acute readmissions in the indicator, we classified these readmissions through record reviewing. It appeared that only a small part of the non-acute readmissions, 5%, was classified as potentially preventable. This is low compared to the 29% of the acute readmissions originally classified in this category (Chapter 4). This finding might imply that the quality of care is reflected more through acute readmissions compared with non-acute readmissions. Therefore, the commonly applied exclusion of non-acute readmissions seems reasonable. However, by including both acute and non-acute admissions, gaming or coding variability can be avoided.

Classification for identifying potentially preventable readmissions
It is only the potentially preventable readmissions that should be included in the indicator. These could be identified with a classification of readmissions. We evaluated the identification of potentially preventable readmissions with a classification based on administrative data by reviewing and categorising the records of the same readmissions. We found a sensitivity of 63% for identifying potentially preventable readmissions and a specificity of 64% for rejecting readmissions that were not potentially preventable through administrative data. This means that
the classification cannot precisely identify potentially preventable readmissions. Consequently, when including only the readmissions classified as potentially preventable in the indicator, a substantial part of these readmissions will appear to be not potentially preventable. On the other hand, readmissions that are potentially preventable might be missed as they are incorrectly not classified as such. Therefore, it seems that the classification does not yet make this distinction with enough precision to use it for the calculation of the readmission ratio.

The impact of readmissions to other hospitals
We found that, in the Netherlands, the impact of readmissions to other hospitals was limited. In our study 9% of the readmissions occurred in another hospital, while 91% of the readmissions occurred in the same hospital. This is low compared to the 17% to 32% reported in other studies.7-14 This might indicate that the impact of taking into account readmissions to other hospitals is not comparable across different countries with different health care systems. The small amount of readmissions to another hospital might be caused by the strong gatekeeping and referral role played by GPs in the Netherlands. These GPs usually have consistent addresses for referring patients. Our study was limited to an analysis of the administrative database and did not include record reviewing of the readmissions in other hospitals. Therefore, it is uncertain if these readmissions actually reflect the quality of care. Additionally, there are practical concerns about how to include readmissions to other hospitals in the indicator. Firstly, hospitals cannot calculate their own readmission rate which includes readmissions to other hospitals. Secondly, it is illegal in the Netherlands to share information about the readmission to another hospital with the hospital of the initial admission, without specific consent from the patient. This makes a readmission ratio that does not include readmissions to other hospitals more feasible.

DOES AN INDICATOR BASED ON HOSPITAL READMISSIONS REFLECT THE QUALITY OF CARE?

Accountability of hospitals for readmissions
An important aspect of an indicator of the quality of care is the extent to which hospitals are accountable for the variation in the outcome measure. The ICCs on the hospital level we found ranged from 0.48% to 2.70% for the different diagnosis groups. This means that only a small part of the variation is explained by the hospital. This suggests that hospitals make only a small contribution to the risk that a patient is readmitted. While the low ICCs are in line with the literature,3,4 they are, however, in contrast to findings that readmissions are a result of a substandard quality of care.15-20 Balla et al analysed 30 day readmissions to the department of medicine in a university hospital. They found problems with the quality of care in 33% of the readmissions studied, of which all were considered preventable.16 This finding suggests a much stronger relationship between readmissions and the quality of care compared to the low ICCs we found. A part of this difference might be explained by the different settings and because they analysed only emergency admissions, while we also included elective admissions. Also the meta-analysis of Ashton et al suggests a stronger relationship as they showed that the risk of early
General discussion

Readmission is increased by 55% when the process of inpatient care is of relatively low quality.\textsuperscript{20} The quality and accessibility of care delivered by Dutch hospitals is generally good,\textsuperscript{21} which might be reflected in the small variability in readmissions on the hospital level. However, a deviation from the national average on the level of a diagnosis group or medical specialty might indicate a substandard quality of care.

The share of potentially preventable readmissions
To gain more insight into that part of the readmissions that reflects substandard quality of care, the focus should be on potentially preventable readmissions. Our study showed that a review of patient records indicated 29% of the acute readmissions to a university hospital were classified as potentially preventable. This suggests that this part of the readmissions might be related to the quality of care. This is high compared to a Dutch national record reviewing study of deceased patients in which only 4.3% of the records included potentially adverse events.\textsuperscript{22} Our percentage of potentially preventable readmissions seems however low in comparison with a record reviewing study of unexpectedly long lengths of stay (ULLOS). Here, in the records of patients with colorectal cancer, who had a ULLOS, 51% of the records contained one or more adverse events compared with 9% in the reference group of non-ULLOS patients.\textsuperscript{23} This result is, however, only marginally comparable to our study as it was performed in a single diagnosis group, colorectal cancer, and did not analyse the degree to which the adverse events were preventable.

Determining preventable readmissions from administrative data
In order to use readmissions as a valuable indicator of the quality of care, the preventability of a readmission should be able to be determined solely from administrative data. Below are three cases of a readmission to illustrate that this is not always possible.

Text box 3. Readmission case A
“A patient is admitted because of an acute stomach pain. An echo of the upper abdomen is made, but the reason for the pain remains unclear. After a day the patient is discharged. The patient is admitted with the same condition two days later. This time a bowel obstruction is diagnosed, which is remedied with a laparotomy.”

Registered administrative data:
- Main diagnosis index admission: R10.9 Unspecified abdominal pain
- Main diagnosis readmission: K56.6 Other and unspecified intestinal obstruction

In case A (Text box 3), diagnosing the problem accurately during the first hospital stay could have prevented the second admission. This can be derived from the administrative data, as during the index admission an indefinite diagnosis is determined, while during the readmission a definite diagnosis is determined.
In case B (Text box 4), the problems are related to the specific disease, and are not a result of the care provided during the index admission. This is, however, not clear from the registered administrative data.

**Text box 4. Readmission case B**

“A patient is admitted with a bowel obstruction and undergoes an ileocaecal resection (surgical removal of a part of the bowel). After four days the patient is admitted as an acute case, once again with diverticulitis.”

Registered administrative data:
- Main diagnosis index admission: K56.6 Other and unspecified intestinal obstruction
- Main diagnosis readmission: K91.3 Postprocedural intestinal obstruction

In case C (Text box 5), a review of the record is needed to determine whether the readmission resulted from the chronic illness that recurred (not preventable) or was a complication of the colectomy (potentially preventable). Therefore, we can conclude that a readmission ratio based solely on administrative data can probably never identify exactly the readmissions that are preventable. Even when the complete information from the medical record is available there may still be several cases where it is unclear if the readmission is related to the patient or the hospital. Consequently, quantifying that part of readmissions that is a result of care delivered by the hospital is extremely complex. Different factors play a role in the chance of being readmitted, which might also be interrelated. There is, however, convincing evidence from the literature, and this thesis, that readmissions are indeed related the quality of care to a certain extent.

**Text box 5. Readmission case C**

“A patient with diverticulitis is admitted for a colectomy. After three weeks the patient is readmitted as an acute case, once again with diverticulitis.”

Registered administrative data:
- Main diagnosis index admission: K57.0 Diverticulitis of small intestine with perforation and abscess
- Main diagnosis readmission: K57.0 Diverticulitis of small intestine with perforation and abscess
METHODOLOGICAL CONSIDERATIONS

DATA QUALITY
This study is based on data from the National Database of Hospital Care (LBZ). This is an administrative database where patient and admission characteristics are routinely collected and processed in order to gain insight into the health care provided in hospitals across the country. Data of satisfactory quality is crucial in order to obtain reliable study results. We minimised bias caused by differences in registration between hospitals by excluding hospitals with data of inadequate quality. We used the following criteria, which are the same as those used for the calculation of the Hospital Standardised Mortality Ratio (HSMR) in the Netherlands. The data should involve: at least six consecutive months of data registration; not include more than 2% of vague diagnoses; should include at least 30% acute admissions, and, at least 0.5 comorbidities, on average, per admission. There might however be differences in registration between hospitals that are not easily identified as being inadequate, for example, if the main diagnosis is registered correctly.

THE DISCRIMINATIVE ABILITY OF PREDICTION MODELS
The C-statistics of the models with a random effect on the hospital level were modest ranging from 0.58 to 0.65, which is comparable with the international literature. These moderate C-statistics suggest that the risk of a readmission cannot be predicted accurately with the predictors commonly used. Literature has shown that the chance of being readmitted is also influenced by factors other than those which are available in administrative databases. Examples are social characteristics, such as marital status, employment status, and having friends who are living nearby.

THE CHOICE OF 30 DAY ALL-CAUSE READMISSIONS
We used all-cause readmissions in this thesis because using just the database does not provide any reliable method for identifying the readmissions that are related to their initial admission. It is not desirable to include unrelated readmissions in the indicator. Therefore, we limited the time frame between initial admission and readmission to 30 days. The longer the time frame chosen, the higher the chance of including unrelated readmissions. In our record reviewing study, we found that 91% of the 500 readmissions studied, both acute and non-acute, were related to their index admission. This result shows that the choice for 30 day all-cause readmissions seems justified.

THE CHOICES OF INCLUSIONS AND EXCLUSIONS
Despite many studies in the field of readmissions, it remains difficult to exclude the intended readmissions from the indicator. We chose an unrefined approach by excluding cancer care, psychiatric care, and obstetrics, because in these diagnosis groups readmissions are often a result of necessary care. However, as a result, readmissions are excluded that are nonetheless
unintended, while on the other hand, other readmissions are still in the indicator that are intended. It is difficult, based on the available variables in the administrative database, to identify these intended readmissions through the use of just one variable such as urgency. In the LBZ, an admission is registered ‘acute’ if care is needed within 24 hours. This, therefore, does not seem to reflect the difference between intended and unintended readmissions. One could consider flagging up admissions in the registration at the time of discharge that are expected to result in intended readmissions. A drawback of this solution is that it might introduce gaming and coding variation. With the current exclusions applied, roughly 20% of clinical admissions are excluded. This means that a large share of hospital care remains invisible when using this indicator. For example, complications after surgery in cancer patients or side effects of oncolytics could be relevant when seeking potential improvements. On the other hand, other patient groups with many readmissions, likely to be caused by the patients and their illnesses, are still in the indicator. An important group are the vulnerable elderly. More precise inclusions and exclusions could improve the indicator further. Therefore, a comprehensive registration, and similarity in the methods of registration in all hospitals, is needed.

**Readmissions to other hospitals**
Most parts of our study were limited in their ability to track patients across hospitals. In the beginning of our research project, the database had no reliable unique patient number that was exchangeable between health care organisations. During the research project, the quality of the database improved, especially in the reliability of this exchangeable unique patient number. Our study that evaluated the impact of taking into account readmissions to other hospitals showed, however, that this impact is limited. Therefore, we do not expect different results for our other studies when taking into account readmissions to other hospitals.

**Limited to Dutch hospitals**
The main part of our study was limited to Dutch hospitals. Therefore, we could not take into account readmissions in other countries after an index admission in the Netherlands. Neither could we include readmissions in the Netherlands when the index admission took place in another country. In addition, it is possible that readmission rates in other countries differ from those in our study because of differences in health care systems or financial incentives. Our comparison with England showed that the readmission rates in both countries do, indeed, differ (Chapter 5). Another international comparison also shows differences in readmission rates between countries. In addition, the impact of taking into account readmissions to other hospitals seems to differ between the Netherlands (Chapter 3) and other countries. However, we do not expect a different outcome regarding our finding of the small variation of readmissions on the hospital level, as the relatively low ICCs are in line with the international literature.
IMPLICATIONS FOR POLICY

HOW TO CALCULATE THE READMISSION RATIO
To use the readmission ratio as an effective quality indicator, it is important that it includes, as much as is possible, the readmissions that actually reflect the quality of care. Based on the literature and our own studies we advise calculating the readmission ratio as clarified in Text box 6. The considerations for choosing this method of calculating the readmission ratio are discussed in the paragraph ‘Interpretation of findings’.

Text box 6. Calculation of the Readmission ratio

Readmission ratio = \frac{\text{Observed number of readmissions}}{\text{Expected number of readmissions}} \times 100

- The observed number of readmissions is the total number of clinical admissions, within a time frame of 30 days of discharge, following the clinical index admission.
- Readmissions are all-cause readmissions. This means that they do not need to be related to the cause of the initial hospitalisation.
- Admissions in which the principal diagnosis is either cancer care, obstetrics, or psychiatric care are excluded. Patients who died during their index admission are excluded from the population at risk.
- The expected number of readmissions is calculated with logistic regression analysis. The following case mix variables are used: age category; gender; the urgency of the admission; Charlson comorbidities (17 groups of comorbidity); the severity of the main diagnosis, that is a categorisation based on the seriousness of admission regarding mortality; socioeconomic status, based on the postal code of the patient’s residence; month of admission; and place of residence before admission. All variables concern the index admission.
- It is not absolutely necessary to add a hospital level in the logistic regression analysis.
- The indicator includes both acute and non-acute admissions and readmissions.
- The indicator includes all the reasons for readmissions as categorised by the classification of readmissions.
- Readmissions to other hospitals are not taken into account. However, transfers, which are defined as readmissions to another hospital on the same day, are not counted as readmissions.
LEARNING FROM A QUALITY INDICATOR BASED ON READMISSIONS

Using the indicator to improve internal processes and coordination in the chain of care
This thesis shows that a quality indicator based on readmissions can be used by hospitals as a screening tool. This can identify diagnosis groups or medical specialties that have relatively more readmissions than might be expected compared to the national average or peers - that is comparable hospitals. Even if readmissions seem largely dependent on the patient’s health status, or the quality of care after the patient’s discharge, hospitals can take responsibility for factors outside of their organisation. For example, when the cardiology department has relatively many readmissions, record reviewing of the readmissions concerned might reveal the underlying cause of this excess of readmissions. For instance, this could reveal that the cardiology department could make improvements to the communication between the department and the general practitioner, or to the discharge planning process. Several studies have already shown that hospital strategies to reduce readmissions can be successful.30,31 A good example is that hospitals that routinely discharged patients when a follow-up appointment was already scheduled, experienced significant reductions in unplanned readmission rates.30 A recommendation, which would be easy for health care providers to implement, is to ask the patient at an appropriate moment far in advance of their discharge if they feel ready to go home. Recent research has shown that a patient reporting not feeling ready for discharge is strongly associated with the degree to which a readmission can be prevented or predicted.32 This shows that the indicator could be used to improve internal processes and also the aftercare and coordination in the health care chain.

Giving attention to patients who have a high risk of readmission
When comparing readmission rates with the national average or comparable hospitals, it is important to correct for case mix. However, it is important to be aware of the characteristics of the patient population in a hospital. By identifying diagnosis groups and patient groups with a high risk of readmission, hospitals can take this into account both in the planning of their care and also around these patients’ discharge. In this way, analysing the chance of a readmission on the patient level and acting upon it, contributes to the organisation being able to learn from its experiences.

Increasing the efficiency of record reviewing with a classification of readmissions
Our evaluation of the classification of readmissions showed that it cannot precisely identify those that are potentially preventable. On the patient level, the classification may not always identify correctly the degree to which a readmission can be prevented. Record reviewing might be seen as the gold standard to judge whether a readmission was preventable.33 However, research has shown that agreement among physicians on the degree to which a readmission could be prevented is poor.34 Additionally, there is no consensus between readmitted patients, their caregivers, nurses, and physicians about both the degree to which readmissions can be predicted and prevented, nor about the associated risk factors.32 Another recent study showed that there is
substantial discrepancy between patients and their health care providers about the degree to which their readmission could have been prevented. Patients identified issues with the system of health care, defined as factors controlled by the hospital discharge process, as contributors to their readmission in 58% of cases studied. By contrast, providers identified these system issues as a contributor to a patient’s readmission in only 2% of cases. An extensive review by a nurse case manager, which could be seen as a gold standard, determined that in 48% of cases the system had contributed to some degree to a patient’s readmission. This was comparable with the patients’ view. Despite this discussion about the degree to which readmissions are preventable on the patient level, we think that the classification can help when analysing readmissions on a higher level. This discussion could identify diagnosis groups or medical specialties where relatively more potentially preventable readmissions occur compared to the national average or comparable hospitals. When analysis of the readmissions focuses on the records that are classified as potentially preventable, it makes record reviewing less time consuming. In this way, it facilitates learning from the indicator by increasing the chance of finding areas for improvement rather than analysing all readmissions.

Learning from other countries
Differences in readmission rates, and their underlying reasons, can indicate opportunities for reducing unnecessary readmissions on a higher, national level, too. The most remarkable difference we found in our international comparison was in the elderly. Towards the end of their lives, patients in England were more likely to be readmitted compared to those in the Netherlands. This difference was of such a degree that it suggests there are differences in the range of supporting services available to prevent or substitute for hospital care. We deduce that in England, palliative care could be expanded in order to reduce unnecessary readmissions and improve care in general. On the other hand, our results suggest that the Netherlands might learn from England when trying to reduce readmissions for heart conditions. In England, relatively more patients requiring chronic care management have a treatment plan to adhere to in daily life compared to Dutch patients. Expanding the use of treatment plans for these patients in the Netherlands might reduce unnecessary readmissions and in this way improve the quality of care.

Learning from readmissions in relation to mortality and the length of stay
Excess readmissions, death or the length of stay might indicate a substandard quality of care
When learning from readmissions they should be considered as part of a cohesive set of indicators, together with the mortality and length of stay, because of their substitutable and complementary relationship. Mortality has already been used for several years in hospitals as an indicator of the quality of care (HSMR). Also the length of stay is used for some years as an indicator of the quality of care (ULLOS). This thesis shows that readmissions can be used as a valuable additional indicator. In every hospital, readmissions, as well as death and longer length of stay, occur in a certain percentage of the admissions. This is probably more a reflection of the underlying disease
and patient characteristics than a reflection of the quality of care. However, if a hospital has more unintended readmissions, death or longer length of stay, compared to the expected degree of occurrence, then this might indicate a substandard quality of care. It is not sufficient to look only at readmissions. Having relatively few readmissions, could be related to having relatively long lengths of stay or relatively more deaths.

The Inspectorate observes if hospitals are learning organisations using indicators
For supervision by the Inspectorate, readmissions are a valuable addition to their indicator framework. A hospital whose results deviate from one or more of these indicators, might indicate that it delivers a substandard quality of care. The Inspectorate analyses the divergent results of these three indicators in respect to the results of other quality indicators of the Inspectorate. In this way it forms a comprehensive picture of the quality of hospital care. It is important to the Inspectorate that hospitals are organisations geared towards learning which use the results of these indicators to examine the underlying cause of deviations from the expected values. In addition, hospitals should ask how this subsequently can be used to improve their quality of care. In fact, the ability of a hospital to learn might be a valuable indicator of good and safe care. Because, in the end, it is important that hospitals tackle weaknesses in their process of care and actually improve the quality and care.

A toolbox based on indicators for improving the quality of care
A hospital should analyse these three indicators together, and on a profound level, for example diagnosis group, patient group, or medical specialty, to identify potential improvements. Hospitals register all admissions in the National Database of Hospital Care. DHD, the national organisation administering this data, provides hospitals with an annual report which includes the indicators, HSMR, ULLOS and Readmission ratio. This offers insight into the diagnosis groups and medical specialties that deviate from the national average and therefore need attention. Together with this report, a file with all admissions and their relevant characteristics is provided so that hospitals can analyse these indicators on the level of the admission. Additionally, an online instrument that enables more profound analysis of these indicators is available with recent data. This makes more direct monitoring and action, based on these indicators, possible. These different instruments give hospitals the opportunity to analyse their number of readmissions, deaths and lengths of stay. Subsequent record reviewing of diagnosis groups or medical specialties in which there are more readmissions, deaths or longer lengths of stay than expected, could reveal opportunities for improving the quality of care.
FUTURE RESEARCH

IMPROVING THE CLASSIFICATION OF READMISSIONS
One of the most important aspects for improving further the usefulness of the indicator is the exclusion of intended readmissions from the indicator. Therefore, a classification to identify potentially preventable readmissions is a promising tool (Chapter 4). However, given the moderate sensitivity and specificity we found, an improvement in the classification is required. For example, it is unknown if the current classification misses particular types of preventable readmissions. Further specification of the algorithm for identifying potentially preventable readmissions could improve the classification. Therefore, an extensive review of a substantial number of medical records is needed as this reveals relevant additional input that would improve the classification with administrative data. Our study was conducted in one Dutch university hospital. Further research is needed to analyse if these results are also applicable to general hospitals and hospitals in other countries.

DETERMINING THE OPTIMAL TIME FRAME PER DIAGNOSIS GROUP
We chose a time frame of 30 days after the initial admission in our studies as this accords with what is most common in the literature.\textsuperscript{2,25} However, it is likely that the optimal time frame depends on the diagnosis of the initial admission.\textsuperscript{42} Therefore, additional research is needed in order to determine the optimal time frame per diagnosis group.

USE THE SPECIFIC SEVERITY OF ILLNESS FOR READMISSION IN THE PREDICTION MODEL
We used a categorisation for the severity of illness in the case mix correction which depended on the seriousness of cases based on their mortality. This was because there was no specific alternative for readmissions available. Even though we found this variable contributed to the chance of a readmission, it is plausible that a severity which is calculated specifically on the seriousness in terms of a readmission, would gain a better prediction of a readmission. It was not feasible within our research project to use this specific severity. It is, however, worthwhile investigating, given the presumed association of the severity of illness with readmissions.\textsuperscript{1}

EXPLORING THE INCLUSION OF READMISSIONS AFTER DAY CARE IN THE INDICATOR
Regarding the choice of which admissions to include in the indicator, it is worthwhile exploring clinical readmissions after day care. This type of care is usually not involved in readmission measures. However, especially when day care results in a clinical admission within 30 days, this could indicate that a complication has arisen after discharge. Another reason for considering the inclusion of day care in the indicator is the fact that, in recent years, more and more treatments take place in day care instead of a clinical admission.\textsuperscript{43} Moreover, hospitals might differ in this aspect, some hospitals treating patients in a clinical admission, while others treat comparable patients in day care. Including both types of care could eliminate bias because of this discrepancy. Another solution for this discrepancy could be to add a variable to the prediction model which
includes the percentage of day care admissions that is hospital and diagnosis specific.\textsuperscript{44} In this way, the hospital policy of treating patients in a clinical admission or in day care does not result in differences in readmission rates. Further research is needed to explore whether and how readmissions after day care should be included in the indicator.

**EXPLORING THE USEFULNESS OF A QUALITY INDICATOR BASED ON REOPERATIONS**

It is assumed in the literature that reoperations are more often related to complications and substandard care than readmissions in general.\textsuperscript{45-47} This is because unplanned reoperations are often caused by problems related to the procedure itself.\textsuperscript{45} A reoperation is defined as a subsequent operation within a given time frame from the initial operation. Because unplanned reoperations are highly procedure specific, differentiation in the indication for the operation is needed in order to be a valuable indicator of the quality of care.\textsuperscript{45} Insights obtained from this indicator might give more specific indications for improvements in quality, for example changing perioperative action. A disadvantage of reoperations as a quality indicator compared to readmissions is the lower incidence. When the total number of events is low, it may be difficult to determine whether high reoperation rates reflect actual problems with the quality of care or mere chance. It is, however, worthwhile exploring if an indicator based on reoperations could be a useful addition to that based on readmissions, and how it should be defined in order to be a valuable indicator of the quality of care.

**EVALUATING THE ADDED VALUE OF THE INDICATOR**

The added value of the indicator based on readmissions can be evaluated once practical experience has been gained. To evaluate if this indicator truly reveals problems with the quality of care, the records of specific diagnosis groups or medical specialties should be reviewed which are selected because of a higher readmission ratio compared with the national average. When these records contain relatively more adverse events, compared to a randomly selected control group, it indicates that the indicator can reveal problems with the quality of care. Additionally, with qualitative research, it could be investigated if this indicator contributes to a system of learning within the hospital. Therefore, it should be investigated if hospitals use this indicator to analyse the care they provide and if it is imbedded in a continuous cycle of quality improvement. Finally, the added value of the indicator within a hospital’s total effort to improve its quality of care could be evaluated.
FINAL CONCLUSIONS

This thesis shows that an indicator based on readmissions can be used by hospitals to identify problems with the quality of care. Consequently, this is a valuable addition to the indicator framework of the Inspectorate. It can take its place next to the existent indicators for mortality and length of stay. The Inspectorate can investigate if hospitals are organisations geared towards learning, using these indicators in their management of the quality of care.

While correction for the relevant case mix variables is needed for the calculation of the readmission ratio, it is not, however, absolutely necessary to add a hospital level in the logistic regression analysis or to include readmissions to other hospitals. Record reviewing showed that the share of potentially preventable readmissions is substantial, despite the fact that we demonstrated the small degree of accountability of hospitals in the chance of a readmission.

A major challenge remains the identification of potentially preventable readmissions based on administrative data. Although algorithms to identify these readmissions are not perfect on the patient level, they can help when analysing readmissions on a higher level. For example to identify diagnosis groups or medical specialties where relatively more potentially preventable readmissions occur by comparison to the national average or comparable hospitals, or even internationally. In this way, it facilitates learning from the indicator by indicating areas that need attention.
REFERENCES


Summary
Summary

Unintended hospital readmissions are presumed to be related to problems with the quality of care. An indicator based on readmissions can therefore be used by hospitals to gain insight into complications and substandard quality of care in order to improve care for patient groups with more readmissions than expected. The Dutch Health and Youth Care Inspectorate (IGJ) can use the indicator as part of its framework for the supervision of hospitals. This thesis aims to examine how a quality indicator based on readmissions should be defined in order to be of use to hospitals in identifying problems with their quality of care and consequently by the Inspectorate for its supervision. Therefore, we examined the following factors: which case mix variables should be taken into account when calculating the readmission ratio; which part of the variation in readmission rates is attributable to the hospital; should readmissions to other hospitals be taken into account; how potentially preventable readmissions can be identified, and, finally; how an international comparison can help to identify areas for reducing unnecessary readmissions.

Despite the widespread use of hospital readmissions as an indicator of the quality of care, it is not clear which part of the variation in readmissions can be attributed to the standard of care hospitals provide. In order to quantify this, we assessed in Chapter 2 the variation in readmissions on the hospital level after adjusting for the relevant case mix factors. Therefore, we performed multilevel logistic regression analyses with a random intercept for the factor ‘hospital’. We used administrative data from 53 Dutch hospitals from 2010 to 2012. Previous studies have shown that unintended readmissions after surgical procedures are mainly the result of complications, therefore we focused on the top ten diagnosis groups with the highest number of readmissions after an index admission for a surgical procedure. We calculated intraclass correlation coefficients (ICC) per diagnosis group in order to explore the variation in readmissions between hospitals. It appeared that the ICCs on the hospital level ranged from 0.48% to 2.70% per diagnosis group. Furthermore, we determined C-statistics for the models with, and without, a random effect on the hospital level to determine the discriminative ability. We found that the C-statistics of the models with a random effect on the hospital level ranged from 0.58 to 0.65 for the different diagnosis groups. The C-statistics of the models that included the hospital level were higher compared to the models without this level. This shows that, after adjusting for case mix variables, a small part of the explained variation in readmissions was found on the hospital level. This suggests that hospitals only make a small contribution to the risk that a patient is readmitted. Therefore, this indicator might be useful for identifying areas for improving quality within hospitals on the level of the diagnosis or medical specialty.

It is important to be aware of the impact of readmissions that take place in other hospitals in order to benchmark readmissions fairly, and identify the potential for improvement. Therefore, we assessed in Chapter 3 the difference between case mix adjusted readmission ratios, including readmissions to other hospitals, and those based solely on readmissions which occur in the same hospital. In order to do this, we performed logistic regression analyses to calculate 30 day
Summary

readmission ratios for each hospital. We compared two models, one with only readmissions to the same hospital, and another with readmissions to any hospital in the Netherlands. We used administrative data from 77 Dutch hospitals in 2015 and 2016. It appeared that the percentage of readmissions of all admissions was 10.3%, of which 91.1% were to the same hospital and 8.9% to another hospital. Patients who went to another hospital were younger, more often men, and had fewer comorbidities. The readmission ratios for any hospital versus the same hospital were strongly correlated (r = 0.91). There were differences between the medical specialties in the percentage of readmissions to another hospital and C-statistic. Overall, the impact of taking into account readmissions to other hospitals seems to be limited in the Netherlands. However, it does have consequences as, when taking into account readmissions to other hospitals, 14% of the hospitals change their position of significance compared with the national average.

Out of all readmissions the potentially preventable readmissions are most valuable when seeking potential areas of improvement. An algorithm to classify readmissions is promising, however reviewing medical records is needed to reveal the underlying causes of readmissions. Therefore, in Chapter 4 we evaluated the identification of potentially preventable readmissions with a classification of readmissions based on administrative data by record reviewing. We classified a random sample of 455 readmissions to a Dutch university hospital in 2014 using administrative data. We compared these results to a classification based upon reviewing the medical records of the same readmissions, to evaluate the accuracy of classification by administrative data. This showed that with reviewing the medical records of acute readmissions, 28.5% of the records were classified as potentially preventable. With administrative data this was 44.1%. There was slight agreement between both methods: $k = 0.08$ (95% CI: 0.02–0.15). As the sensitivity and specificity of the classification of potentially preventable readmissions by administrative data were moderate (63.1% respectively 63.5%), this tool can only be used in practice with caution. It is not a suitable tool for penalising hospitals based on their number of potentially preventable readmissions. However, hospitals might use this classification as a screening tool to identify potentially preventable readmissions more efficiently.

Additionally, examining variation in patterns of readmissions between countries can be valuable for mutual learning in order to reduce unnecessary readmissions. Therefore, in Chapter 5, we compared readmission rates and reasons for readmissions in England with those in the Netherlands. We used data from 85 Dutch hospitals and 451 English hospitals in 2014. Readmission data from England and the Netherlands were compared for all hospital patients and for specific diagnosis groups: pneumonia, urinary tract infection, chronic obstructive pulmonary disease, coronary atherosclerosis, biliary tract disease, hip fracture, and acute myocardial infarction. Readmissions were categorised using the classification described in Chapter 4. This study showed that hospitals in England had a higher 30 day readmission rate (adjusted for age and gender) compared to the Netherlands: 11.17% (95% CI 11.14–11.20%) versus 9.83% (95% CI 9.77–9.88%).
The main differences appeared to be in readmissions among the elderly (England 17.2% versus the Netherlands 10.0%) and in emergency readmissions (England 85.3% of all 30 day readmissions versus the Netherlands 66.8%). In the Netherlands, however, more emergency readmissions were classified as potentially preventable compared to England (33.8% versus 28.8%). These differences indicate opportunities to reduce unnecessary readmissions. For England, this could mean a greater role for palliative care, more integrated social care, and a reduction in waiting times. In the Netherlands, there could be greater use of treatment plans for patients daily lives.

This thesis shows that an indicator based on readmissions can be used by hospitals to identify problems with the quality of care. Consequently, this is a valuable addition to the indicator framework of the Inspectorate, next to the existent indicators for mortality and length of stay. It could enable the Inspectorate to investigate if hospitals are organisations geared towards learning through the use of these indicators in their management of the quality of care. There are, however, a couple of weaknesses that should be considered when using this indicator. The moderate C-statistics we found, suggest that the risk of readmission cannot be predicted accurately. Readmissions are probably influenced by other patient factors not available in administrative databases. Even though we demonstrated the small degree of accountability of hospitals in the chance of a readmission, efforts made by hospitals to reduce the number of readmissions have, according to the literature, proven to be effective. Furthermore, it is challenging to accurately derive potentially preventable readmissions using administrative data. Although algorithms to distinguish preventable readmissions are not perfect on the patient level, they are helpful when analysing readmissions on a higher level. They can help identify diagnosis groups or medical specialties where relatively more potentially preventable readmissions occur in comparison to the national average or comparable hospitals, or even internationally. In this way, it facilitates the improvement of the quality of care by indicating areas that need attention.
Samenvatting
Samenvatting

Onbedoelde heropnamen in het ziekenhuis kunnen duiden op problemen met de kwaliteit van zorg. Ziekenhuizen kunnen daarom met een kwaliteitsindicator gebaseerd op heropnamen inzicht krijgen in complicaties en verminderte kwaliteit van zorg. Hierdoor kunnen ze de zorg aan patiëntengroepen met meer heropnamen dan verwacht verbeteren. De Inspectie Gezondheidszorg en Jeugd (IGJ) kan de indicator gebruiken voor het toezicht op ziekenhuizen. Dit proefschrift geeft antwoord op de vraag hoe een indicator gebaseerd op heropnamen moet worden gedefinieerd, zodat ziekenhuizen deze kunnen gebruiken om problemen met de kwaliteit van zorg aan het licht te brengen en de IGJ het voor haar toezicht kan gebruiken. Hiervoor hebben we onderzocht welke casemixvariabelen meegenomen moeten worden bij het berekenen van de heropnamenratio, welk deel van de verschillen in heropnamenpercentages kan worden toegeschreven aan het ziekenhuis, of er rekening moet worden gehouden met heropnamen in andere ziekenhuizen en hoe potentieel vermijdbare heropnamen kunnen worden opgespoord. Tot slot is bekeken hoe een internationale vergelijking kan helpen bij het in kaart brengen van mogelijkheden voor het terugdringen van onnodige heropnamen.

Ziekenhuisheropnamen worden al veelvuldig gebruikt als indicator voor de kwaliteit van zorg. Het is echter nog niet duidelijk welk deel van de verschillen in heropnamen kan worden toegeschreven aan verschillen in de kwaliteit van de geleverde zorg door ziekenhuizen. Om dit te bepalen, hebben we in hoofdstuk 2 de variaties in heropnamen op ziekenhuisniveau berekend na correctie voor de relevante casemixfactoren. Hiervoor gebruikten we administratieve data van 2010 tot en met 2012 van 53 Nederlandse ziekenhuizen. Uit eerdere studies bleken onbedoelde heropnamen na chirurgische ingrepen voornamelijk het gevolg te zijn van complicaties. We hebben ons daarom gericht op de top tien diagnosegroepen met het grootste aantal heropnamen na een chirurgische ingreep. Om de verschillen in heropnamen tussen ziekenhuizen te onderzoeken, hebben we per diagnosegroep intraclass correlatie coëfficiënten (ICC) berekend. Dit is een maat voor het aandeel van de variantie dat kan worden toegeschreven aan het ziekenhuisniveau (met waarden van 0 tot 100%). De gevonden ICC's op ziekenhuisniveau varieerden van 0,48% tot 2,70% per diagnosegroep. Dit laat zien dat na correctie voor casemixvariabelen een klein deel van de verklaarde variantie in heropnamen op ziekenhuisniveau zit. Dit veronderstelt dat ziekenhuizen een kleine bijdrage leveren aan de kans dat een patiënt wordt heropgenomen. De indicator kan daarom worden gebruikt om mogelijkheden voor kwaliteitsverbetering binnen ziekenhuizen op het niveau van diagnose of specialisme op te sporen.

Om heropnamen eerlijk te kunnen vergelijken tussen ziekenhuizen en het verbeterpotentieel in kaart te brengen, moet ook worden gekeken naar de impact van heropnamen die in een ander ziekenhuis plaatsvinden. In hoofdstuk 3 hebben we daarom de verschillen onderzocht tussen casemix-gecorrigeerde heropnamenratio's met en zonder heropnamen in andere ziekenhuizen. We hebben twee modellen vergeleken: een waarbij uitsluitend heropnamen in hetzelfde

Het percentage heropnamen van alle opnamen was 10,3%. Hiervan vond 91,1% in hetzelfde ziekenhuis plaats en 8,9% in een ander ziekenhuis. Patiënten waarvan de heropnamen plaatsvonden in een ander ziekenhuis waren jonger, vaker man en hadden minder nevendiagnosen. Verder verschilden specialismen in het aandeel heropnamen dat in een ander ziekenhuis plaatsvond.

Over het geheel genomen bleek de impact van het meerekenen van heropnamen in andere ziekenhuizen op de heropnamenratio's beperkt te zijn in Nederland.

Van alle heropnamen geven de potentieel vermijdbare heropnamen de meeste mogelijkheden om van te leren. Om deze heropnamen te selecteren, hebben we in hoofdstuk 4 een veelbelovend algoritme dat heropnamen classificeert, toegepast op administratieve data. Om te bepalen hoe accuraat deze classificatie heropnamen indeelt, hebben we dit geëvalueerd met dossieronderzoek om de onderliggende redenen van de heropnamen te achterhalen.

Hiervoor classificeerden we een aselecte steekproef van 455 heropnamen in 2014 in een Nederlands academisch ziekenhuis op basis van administratieve data. Deze heropnamen zijn ook via dossieronderzoek geclassificeerd om te bepalen of het om een potentieel vermijdbare heropname ging. We hebben de resultaten van de classificatie aan de hand van het algoritme vergeleken met de resultaten van de classificatie via dossieronderzoek. Hieruit bleek dat met dossieronderzoek van acute heropnamen 28,5% van de dossiers werd geclassificeerd als potentieel vermijdbaar. Met behulp van het algoritme op administratieve data was dit 44,1%. Er bleek een beperkte overeenstemming tussen beide methoden te zijn.

De sensitiviteit (in hoeverre het algoritme heropnamen terecht classificeert als potentieel vermijdbaar) en de specificiteit (in hoeverre het algoritme heropnamen terecht classificeert als niet potentieel vermijdbaar) van de classificatie van potentieel vermijdbare heropnamen op basis van administratie data waren matig (respectievelijk 63,1% en 63,5%). Daarom moet dit instrument zorgvuldig worden gebruikt in de praktijk. Het is bijvoorbeeld niet geschikt om ziekenhuizen te rangschikken op basis van het aantal potentieel vermijdbare heropnamen. Ziekenhuizen kunnen deze classificatie echter wel als een screeningsinstrument gebruiken om potentieel vermijdbare heropnamen op efficiëntere wijze op te sporen.

Ook het in kaart brengen van de variatie in patronen van heropnamen tussen landen kan waardevol zijn om van elkaar te leren bij het terugdringen van onnodige heropnamen. In hoofdstuk 5 hebben we daarom een vergelijking gemaakt tussen de heropnamenpercentages en redenen voor heropnamen in Engeland en Nederland. Hiervoor hebben we data uit 2014 van 85 Nederlandse ziekenhuizen en 451 Engelse ziekenhuizen gebruikt. We vergeleken heropnamendata van Engeland en Nederland voor alle patiënten en voor specifieke diagnosegroepen: pneumonie,
Samenvatting

urineweginfecties, COPD, coronaire atherosclerose, galwegaandoeningen, heupfractuur en acuut myocardinfarct. De heropnamen zijn ingedeeld met de classificatie zoals beschreven in hoofdstuk 4.

Uit de resultaten bleken ziekenhuizen in Engeland een hoger 30-daags heropnamenpercentage (gecorrigeerd voor leeftijd en geslacht) te hebben dan Nederlandse ziekenhuizen: 11,2% versus 9,8%. De belangrijkste verschillen in heropnamenpercentages waren zichtbaar bij de groep ouderen (Engeland 17,2% versus Nederland 10,0%) en bij acute heropnamen (Engeland 85,3% versus Nederland 66,8% van alle 30-daagse heropnamen). In Nederland zijn echter meer acute heropnamen geclassificeerd als potentieel vermijdbare heropnamen dan in Engeland (33,8% versus 28,8%).

Deze verschillen tonen aan dat er mogelijkheden zijn om heropnamen te verminderen. Voor Engeland kan dit mogelijk via uitbreiding van de palliatieve zorg buiten het ziekenhuis, meer geïntegreerde sociale zorg en een afname van wachttijden. In Nederland kan mogelijk meer gebruik worden gemaakt van behandelplannen voor het dagelijkse leven van chronische patiënten om zelfmanagement te verbeteren.

Dit proefschrift laat zien dat ziekenhuizen een indicator gebaseerd op heropnamen kunnen gebruiken om problemen met de kwaliteit van zorg in kaart te brengen. Dit maakt het voor de IGJ een waardevolle toevoeging aan hun toezichtinstrumentarium, naast de huidige indicatoren voor ziekenhuissterfte (HSMR) en onverwacht lange opnameduur (OLO). Het stelt de IGJ in staat om met ziekenhuizen in gesprek te gaan over de wijze waarop zij deze indicatoren gebruiken om als lerende organisaties de kwaliteit van zorg te verbeteren en hierop te sturen.

Er zijn echter een aantal beperkingen bij het gebruik van heropnamen als indicator. Zo blijkt dat de kans op een heropname niet nauwkeurig kan worden voorspeld. Heropnamen worden waarschijnlijk mede beïnvloed door patiëntfactoren die niet beschikbaar zijn in administratieve databases. Hoewel onze analyses een kleine invloed van ziekenhuizen op de kans op een heropname laten zien, zijn inspanningen van ziekenhuizen om het aantal heropnamen terug te dringen wel effectief volgens de literatuur.

Daarnaast is het complex om op een juiste manier potentieel vermijdbare heropnamen af te leiden uit administratieve data. Hoewel algoritmes om vermijdbare heropnamen te onderscheiden niet perfect zijn op het niveau van de patiënt, kunnen ze wel behulpzaam zijn bij het analyseren van heropnamen op een hoger niveau. Ze kunnen helpen bij het opsporen van diagnosegroepen of specialismen waar relatief veel potentieel vermijdbare heropnamen plaatsvinden in vergelijking met het landelijk gemiddelde of vergelijkbare ziekenhuizen, of zelfs op internationaal niveau. Op deze manier faciliteert het kwaliteitsverbetering door het in kaart brengen van zorgprocessen die om aandacht vragen.
In three of the four studies in this thesis (Chapter 3, 4 and 5) we used data from the National Database of Hospital Care (Landelijke Basisregistratie Ziekenhuiszorg, LBZ). This database provides data from all general and university hospitals in the Netherlands and contains all hospital admissions. At the time of the first study (Chapter 2), we used the predecessor of the LBZ, the National Medical Registration (Landelijke Medische Registratie, LMR). These databases are administered by the national organisation Dutch Hospital Data (DHD). The data were obtained from DHD according to the regulations for the use of data. The use of the data is anonymous and only aggregated results can be published. Conform Dutch law, it is not necessary to require permission from the ethical review board, because it concerns administrative data. The metadata are available on the website of DHD (https://www.dhd.nl/productendiensten/lbz/Paginas/Datamodel-en-brontabellen-LBZ.aspx).

Additional data were collected for the record reviewing study (Chapter 4) in one hospital. The data of 500 readmissions were obtained from the hospital information system. The reviewers were authorized by the hospital to access the relevant patient records. The results from the analyses were stored in a secured environment only accessible by the researchers who performed the record reviewing study. The researchers applied to the Quality Management Handbook of IQ Healthcare during the research. The hospital's ethics committee responsible for human experimentation decided that no legal permission was necessary for this study.

The raw and processed data and accompanying files of all studies are stored in a secured environment of DHD and are only accessible by the main researchers of this project. The data will be saved for at least 10 years after publication of the last study (April 9, 2019).

The data used in this study are publicly available for researchers via Remote Access to Statistics Netherlands (CBS). The additional dataset from the study in Chapter 4 is available from the corresponding author on reasonable request.
Dankwoord
Dankwoord

Promoveren is als het beklimmen van een hoge berg. Het ene moment schijnt de zon, voel je je fit, en maak je flinke meters met een lach op je gezicht. Op het andere moment word je overvallen door een stortbui of raak je de weg kwijt en staat het huilen je nader dan het lachen. Er zijn pieken zoals een gepubliceerd artikel, maar ook dalen zoals analyses waar je helemaal in vastloopt. Soms lijkt de weg naar de top van het promotietraject een eenzame weg. Maar zonder de hulp van een groot aantal mensen onderweg was het mij zeker niet gelukt! Een aantal van hen wil ik hier in het bijzonder bedanken.


Bijzondere dank gaat uit naar mijn copromotoren: Tijn Kool, Ine Borghans en Sezgin Cihangir. Samen waren jullie voor mij een heel fijn team copromotoren. We kenden elkaar al langer toen we aan het traject begonnen, dus het voelde van het begin af aan vertrouwd. Ik heb onze maandelijkse besprekingen altijd als erg prettig ervaren. Als ik door alle cijfers en oplossingsrichtingen de juiste weg niet meer zag, was het na zo’n bespreking altijd weer helder welke kant ik op moest.

Beste Tijn, aan jou heb ik een geweldige copromotor gehad. Je was altijd optimistisch, ook als we weer een behoorlijk pittige review hadden teruggekregen. Het maakte niet uit wanneer ik je benaderde met een vraag, werktijd of geen werktijd, ik had binnen no-time een kraakhelder antwoord en kon weer verder. Ik ben ook bijzonder dankbaar voor al je hulp tijdens mijn zwangerschapsverlof, toen de reacties van de tijdschriften ineens achtereenvolgens kwamen binnenrollen. Geweldig dat je alles toen zo snel hebt opgepakt en ik mijn aandacht ondertussen kon richten op de kleine Huub. Zonder jou had ik dit proefschrift niet zo snel kunnen afronden!

Beste Ine, wat ben jij een fijne copromotor geweest, zo betrokken en gedreven. Je stond altijd klaar als ik advies nodig had en nam daar ook echt de tijd voor. Toen jij in 2012 in Nijmegen promoveerde op het onderwerp onverwacht lange ligduur, had je het al over een relatief nieuw terrein dat hierop aanstoet, namelijk heropnamen. Daar was in Nederland nog niet veel onderzoek naar gedaan. Destijds werd ik al enthousiast om hiermee verder te gaan. Toen je deze opdracht in 2014 vanuit de IGJ (Inspectie Gezondheidszorg en Jeugd) uit kon zetten en mij benaderde, was ik er snel van overtuigd dat deze opdracht mij op het lijf was geschreven. Ik vind het daarom des te meer bijzonder dat jij mij hebt kunnen begeleiden tijdens dit onderzoek en ik van al jouw kennis gebruik kon maken.

Beste Sezgin, jij bent wel de meest bijzondere copromotor geweest. Soms moest ik wat langer op je antwoord of je aanwezigheid tijdens een vergadering wachten. Maar je kon mij altijd op een verrassende wijze uit een bepaald denkpattroon halen en nieuwe oplossingsrichtingen laten zien. Ook met je humor en je filosofische gedachten liet je altijd een frisse wind waaien. Dat is voor mij
heel waardevol geweest. Daarnaast heb je je er altijd voor ingezet dat ik dit traject op een zo goed mogelijke manier kon afronden. Dank daarvoor!

Leden van manuscriptcommissie, prof. dr. van Laarhoven, prof. dr. Olde Rikkert en prof. dr. Van der Wal, bedankt voor het nemen van de tijd om mijn proefschrift te lezen en beoordelen.

Verder wil ik Jeroen Geelhoed bedanken voor het creëren van een plek voor dit promotieonderzoek bij de afdeling ‘Onderzoek en Innovatie’ van de IGJ waar hij destijds afdelingshoofd was. Sipko Mülder, die deze faciliterende rol heeft overgenomen na het vertrek van Jeroen, wil ik bedanken voor zijn ondersteuning en interesse in mijn onderzoek.

Tijdens mijn promotietraject hebben meerdere stagiairs mij geholpen met onderzoek naar een specifiek vraagstuk rondom heropnamen. Ik wil alle stagiairs bedanken voor hun inbreng, maar twee van hen in het bijzonder. Ten eerste Ester Rake. Jij was mijn eerste stagiaire, nog voordat ik startte met dit promotietraject. Destijds vroeg ik me af of het onderwerp heropnamen voldoende stof zou zijn voor een vijf maanden durende afstudeerstage Biomedische Wetenschappen. Ondertussen weet ik wel beter; er zouden nog wel een aantal promotietrajecten op dit onderwerp kunnen volgen. Jij was erg gedreven en jouw onderzoek heeft geleid tot een van de artikelen. Ook Femke van der Brug wil ik bedanken. Met jouw enthousiasme heb je je veel voor elkaar gekregen. Jouw onderzoekstraject was bijzonder, met een deel van je onderzoek in Nederland en een deel in Londen. Dat was een vruchtbare periode die uiteindelijk twee artikelen heeft opgeleverd!

Elke maandag was ik in Nijmegen bij IQ healthcare om aan mijn promotie te werken. Ik wil de promovendi bij IQ healthcare bedanken voor het sparren en het gewoon even gezellig babbelen op de momenten dat ik dat nodig had. En Jolanda van Haren voor alle hulp en adviezen bij het afronden en opmaken van mijn proefschrift.

Ook mijn collega’s bij DHD hebben een steentje bijgedragen aan het volbrengen van dit proefschrift. Een paar wil ik in het bijzonder bedanken: Gert-Jan voor het mogelijk maken om dit promotietraject naast mijn reguliere baan te doen. Jan en Emile voor het maken van de databestanden waarmie ik onderzoek heb gedaan en het schrijven van de query’s voor de classificatie van heropnamen. Ritva voor de onuitputtelijke kennis over de LBZ (Landelijke Basisregistratie Ziekenhuiszorg). Maarten voor de statistische hulp en het programmeren in R; ik kon een dag lang worstelen met een syntax in R en jij had het binnen vijf minuten opgelost. Verder dank aan mijn gezellige collega’s van communicatie, Moniek en Rudi, voor het redigeren van de Nederlandse teksten. En last but not least, Janine als meest trouwe maatje voor de lunchwandelingen waarbij we van alles kunnen bespreken.
Dankwoord

Verder wil ik Agnes de Bruin, Corine Witvliet-Penning en Jan van der Laan van het CBS bedanken voor het meedenken over allerlei aspecten rondom het berekenen van de indicator heropnamen. Het is en blijft een uitdagend onderwerp, waarbij je regelmatig je hersens moet kraken om tot een goede oplossing te komen. Dankzij jullie inbreng is de heropnamenratio een degelijke indicator geworden.

Daarnaast wil ik al mijn vrienden bedanken omdat jullie altijd klaarstonden om er even lekker tussenuit te gaan om te sporten, een gezellig avondje te eten of te borrelen en het (meestal) juist niet over werk te hebben. Dat heeft mij enorm geholpen om elke keer weer op te laden. In het bijzonder wil ik Anneke bedanken. Jij bent vanaf het begin van mijn studietijd in Nijmegen een waardevolle vriendin geweest en ik ben blij dat jij mij als paranimf bijstaat bij het behalen van mijn doctorstitel!

Lieve Martine en Amanda, wat ben ik blij met jullie als mijn zussen. Al zijn we als persoon best verschillend van elkaar, het is altijd ontzettend fijn om samen tijd door te brengen en te kletsen over alles wat ons bezighoudt. Ook mijn proefschrift. Jullie waren altijd de eersten die bericht van mij kregen als ik een artikel had gepubliceerd. En jullie deden zelfs dappere pogingen om ze te lezen. Martine, wij hebben een groot deel van onze studietijd gedeeld; jarenlang woonden we allebei in Nijmegen, waren we lid van dezelfde studentenvereniging en hebben we zelfs nog samen een keuzevak gevolgd. Hoe bijzonder om dat met je zus te kunnen delen! Daarom ben ik ook heel blij dat jij mij paranimf bent, op het nippertje voordat jullie derde kleine er is.


Lieve mam, ik vind het heel verdrietig dat je mijn promotietraject niet hebt kunnen meemaken. Maar ik weet zeker dat je mij daarin had gesteund en waar nodig opbeurende woorden had gehad. Vroeger stond je altijd voor ons klaar. ’s Middags uit school met een kopje thee luisteren hoe onze dag was. Je had het altijd meteen door als er iets was. En dan kon je mij er altijd weer snel bovenop helpen. Op een bepaalde manier heb je dit traject natuurlijk wel meegemaakt, omdat je altijd in mijn hart en gedachten bent.

Liefste Sjoerd, ik heb jou leren kennen toen ik een jaar met mijn promotietraject bezig was. Je had er altijd veel bewondering voor. Jij bent een van de redenen waarom het gelukt is om niet te veel van mijn vrije tijd aan mijn promotie te besteden, omdat tijd met jou doorbrengen nog zo veel
leuker is! Wat hebben we samen veel gewielrend, hardgelopen, gewandeld en vakanties doorgebracht. Binnen korte tijd wist ik dat jij de ware was en binnen twee jaar zijn we al getrouwd. Je bent zo’n ontzettend fijne man om mee samen te zijn. Je kon altijd veel geduld en begrip opbrengen als ik eens extra moest werken of mij opvrolijken als het eens tegen zat. Ik heb altijd maar even jouw aanwezigheid en positiviteit nodig en ik kan er weer tegenaan.

Allerliefste Huub, wat ben jij een grote verrijking van mijn leven. Eén lach van jou en mijn zorgen verdwijnen naar de achtergrond. Het is geweldig om jou de wereld te zien ontdekken. Er ligt nog zoveel voor je en ik hoop dat je daar op jouw eigen manier het beste uithaalt. Je zult niet hebben meegekregen dat ik bezig was om mijn promotie af te ronden toen jij op de wereld kwam. Hooguit dat je af en toe iets langer moest wachten op wat aandacht als ik nog even ergens mee bezig was. Toch heb ik zeker wel van jou geleerd tijdens deze fase. Jij doet mij realiseren dat het leven zo ontzettend snel gaat en dat het daarom zo belangrijk is om in het moment te leven en te genieten van wat je nu hebt. Want voor je het weet is die tijd alweer voorbij. Daarom is mijn voornemen, nu mijn proefschrift af is, om meer tijd met mijn fijne gezinnetje door te brengen en samen nieuwe bergen te beklimmen!
About the author
Karin Hekkert was born on September 5th, 1983 in Wierden the Netherlands, the second daughter of Herman Hekkert and Willy Ruiter. In 1995 she started pre-university education at the Carmel College Salland in Raalte. She gained her diploma cum laude in 2001. In the same year she started Biomedical Sciences at the Radboud University in Nijmegen. She attained an Erasmus program at the Aristotle University Thessaloniki at the Faculty of Law and Economics for half a year in 2006. Thereafter, she obtained a master’s degree in Biomedical Sciences in 2007, with a specialisation in Human Movement Sciences. Her eagerness to learn more brought her to Amsterdam, where she studied Health Sciences at the VU. In 2008 she obtained her second master’s degree, with a specialisation in Policy and Organisation of Health Care.

After graduation, she started working at Prismant, department Quality and Safety, in Utrecht. The major part of her research and consultancy work concerned quality indicators based on the National Medical Registration (LMR) in hospitals and client experiences in various sectors of the health care.

Excitement to travel brought her around the world, from South America to China. After travelling, she started working at DHD (Dutch Hospital Data) in Utrecht in 2013, where she still works at the time of writing. As an information analyst she is specialised in quality indicators based on the National Database of Hospital Care (LBZ): Hospital Standardised Mortality Ratio, Unexpectedly Long Length of Stay and Readmissions. She also supports hospitals with record reviewing based on these indicators.

Alongside this position at DHD, she started in 2015 her PhD research at the Scientific Center for Quality of Healthcare (IQ healthcare) at the Radboud University Medical Center in Nijmegen, commissioned by the Dutch Health and Youth Care Inspectorate (IGJ).

Karin is married to Sjoerd Wever and they have a son Huub (2018). Together they live in Maarsbergen, near Utrecht.
### PHD PORTFOLIO

**Name PhD candidate (external):** K.D. Hekkert  
**Department:** IQ healthcare  
**Graduate School:** Radboud Institute for Health Sciences  
**PhD period:** 01-01-2015 – dd-mm-2019  
**Promotor(s):** Prof. dr. G.P. Westert  
**Co-promotor(s):** Dr. R.B. Kool, Dr. H.J. Borghans, Dr. S. Cihangir

<table>
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<tr>
<th>Training Activities</th>
<th>Year(s)</th>
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<tr>
<td><strong>a) Courses &amp; Workshops</strong></td>
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<tr>
<td>- Course Relational databases and programming with SQL (KeenData)</td>
<td>2018</td>
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<tr>
<td>- Presentation course (De Presentatie-academie)</td>
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<td>- Online course programming in R (<a href="http://www.datacamp.com">www.datacamp.com</a>)</td>
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<tr>
<td>- Online course Global Trigger Tool, record reviewing in hospitals (IHI)</td>
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<td>- Radboudumc Introduction day for PhD students</td>
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<td><strong>b) Symposia &amp; congresses</strong></td>
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<tr>
<td>- National symposia on HSMR, Length of Stay and Readmissions, and record reviewing organised by DHD a</td>
<td>2018, 2017, 2016</td>
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<td>- ISQUA (International Society for Quality in Health Care) London b</td>
<td>2017</td>
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<td>- International Forum Quality and Safety London b</td>
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<td><strong>c) Lecturing</strong></td>
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<td>- Colloquia Academic Research Collaboration on Supervision (AWT) of the Dutch Health And Youth Care Inspectorate a, c</td>
<td>2018, 2017, 2016, 2015</td>
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| Teaching Activities |  |  |
|---------------------|  |  |
| **d) Supervision of internships** |  |  |
| - Bachelor internship Medical Informatics, AMC | 2018 | 1.0 |
| - Graduation internship Applied Mathematics, Haagse Hogeschool | 2017 | 1.0 |
| - Major internships Biomedical Sciences, Health Technology Assessment, Radboudumc | 2017, 2016, 2015, 2014 | 4.0 |

**TOTAL** 13.25

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List of publications


Hospital readmissions: Just a number or a stepping stone to quality improvement? 
Karin Hekkert