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*Title page*

# What is the impact on the readmission indicator of taking into account readmissions to other hospitals? A cross-sectional study.

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**Abstract**

**Objectives:** There is widespread use made of readmissions as an indicator of the quality of care within hospitals. However, there is no consensus on the inclusion of readmissions to other hospitals. The aim of our study is to identify differences in the outcomes from a readmission indicator, with or without including readmission to other hospitals.

**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 readmission ratios for each hospital and 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, per hospital and C-statistic of each model in order to determine the discriminative ability, per medical specialty.

**Results:** The readmission percentage 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 ($R^2 = 0.91$). 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.

**Key words:** Quality in health care, Health & safety, Health policy

**Article summary**

**Strengths and limitations of this study**

- First study in the Netherlands that analyses the impact of taking into account readmissions to other hospitals.
- The database contains all hospital admissions of nearly all Dutch hospitals (97% of the general and university hospitals).
- Not all hospitals register the unique patient numbers completely, which could affect the readmission rate when including readmissions to other hospitals.
- The database does not contain a variable that distinguishes between intended and unintended readmissions.

## 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 healthcare professionals.[13] However, the interpretation of readmissions is complicated by the fact that there are many reasons for them [14] and not all readmissions should be included in the indicator. There is, however, no consensus on which readmissions should be included or not.[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% to 32% of the total number of readmissions.[16-23] Halfon [17] and Nasir [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 United States so it is not known if these results are also applicable for European countries with different healthcare systems, such as the Netherlands. The Dutch healthcare 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 submit their overall number of readmissions each year.[24] 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 indicator of taking into account readmissions to other hospitals?

## Methods

*Database and study population*

We used data from the Dutch National Basic Registration of Hospital Care (LBZ).[25] 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.[14 26] We calculated all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation.[26 27] 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.[28]

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 healthcare 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 one day, were not counted as readmissions.[29]

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 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 was 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.[30]

Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data, we investigated the following criteria [31]: there should be at least twelve 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 [31] and are important in the calculation of readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of readmission.[1 13] 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. The following covariates for the adjustment for case mix were used: severity of main diagnosis; gender; age category; urgency of the admission; Charlson comorbidities (17 groups of comorbidity); socio-economic status; 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 after adjusting for case mix. 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-squared.

We calculated 95% confidence intervals for the readmission ratio of each hospital to analyse if it differed from the national average. 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 to 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 standard errors 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 version 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.

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 in the dataset and of the subset of readmissions in the dataset, N=77 hospitals

| | Database all admissions | | | Subset only readmissions | | |
|---|---|---|---|---|---|---|
| **Variable** | **Median** | **5th percentile** | **95th percentile** | **Readmission same hospital (99,7% CI)** | **Readmission other hospitals (without transfer) (99,7% CI)** | **Significance** |
| mean age | 55.41 | 50.64 | 59.17 | 59.86 (59.70 - 60.01) | 56.09 (55.58 - 56.60) | * |
| % women | 50.59 | 47.49 | 53.60 | 46.72 (46.40 - 47.04) | 43.70 (42.69 - 44.72) | * |
| % acute* admissions | 60.18 | 47.57 | 70.49 | 71.62 (71.33 - 71.91) | 68.48 (67.53 - 69.43) | * |
| % acute* readmissions | 74.38 | 66.09 | 81.10 | 75.85 (75.57 - 76.12) | 59.97 (58.97 - 60.97) | * |
| mean number of comorbidities | 0.47 | 0.28 | 0.67 | 0.76 (0.76 - 0.77) | 0.64 (0.62 - 0.66) | * |

* In the LBZ an admission is registered 'acute' if care is needed within 24 hours

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 readmission percentage 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 readmission percentage was lower (9.4%), of which a smaller percentage occurred in other hospitals (5.2%).

Table 2. Number and percentage of readmissions, which of these occurs in other hospital, the total dataset versus those for acute admissions only, N=77 hospitals

| | N | % |
|---|---|---|
| **Total dataset** | | |
| Admissions total | 2,333,173 | |
| Readmissions < 30 days (% of admissions) * | 240,122 | 10.29% |
| Readmissions < 30 days of which in other hospital* (% of readmissions < 30 days) | 21,440 | 8.93% |
| **Dataset acute admissions** | | |
| Acute admissions total | 1,370,628 | |
| Acute readmissions < 30 days (% of acute admissions) * | 128,439 | 9.37% |
| Acute readmissions < 30 days of which in other hospital* (% of acute readmissions < 30 days) | 8,604 | 5.20% |

* Transfers for readmissions to other hospital excluded

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

In total 14% (=11/77, marked grey in Table 3) of the hospitals changed their position of significance compared to the national average when taking into account readmissions to any hospital compared to the same hospital (Table 3).

Table 3. Significant difference from the national average: Readmission ratio to any hospital versus that to the same hospital

| | | **Readmission ratio - same hospital** | | |
|---|---|---|---|---|
| **Readmission ratio - any hospital** | Significantly lower (-1) | No significant difference (0) | Significantly higher (1) | Total |
| Significantly lower (-1) | 35 | 4 | 0 | 39 |
| No significant difference (0) | 2 | 14 | 2 | 18 |
| Significantly higher (1) | 0 | 3 | 17 | 20 |
| Total | 37 | 21 | 19 | 77 |

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 to 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 to 1 out of 42 for general hospitals and 2 out of 28 of teaching hospitals.

The readmission percentage 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 4. Readmission percentage and readmissions to other types of hospitals, per medical specialty

| Discharge medical specialty index admission | Hospitals (N) | Admissions (N) | Readmissions <30 days without transfer (N) | Readmissions (%) | Readmissions to other hospital <30 days (N) | Readmissions to other hospital <30 days (%) | Readmissions to general hospitals <30 days (N) | Readmissions to general hospitals <30 days (%) | Readmissions to leading clinical hospitals <30 days (N) | Readmissions to leading clinical hospitals <30 days (%) | Readmissions to university hospitals <30 days (N) | Readmissions to university hospitals <30 days (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General surgery | 77 | 403,806 | 43,003 | 10.6 | 2,686 | 6.2 | 1,022 | 2.4 | 1,172 | 2.7 | 492 | 1.1 |
| Cardiology | 77 | 345,162 | 38,878 | 11.3 | 5,739 | 14.8 | 1,915 | 4.9 | 2,674 | 6.9 | 1,150 | 3.0 |
| Internal medicine | 77 | 258,781 | 37,276 | 14.4 | 2,552 | 6.8 | 778 | 2.1 | 1,071 | 2.9 | 703 | 1.9 |
| Pulmonology | 77 | 186,936 | 25,830 | 13.8 | 1,479 | 5.7 | 476 | 1.8 | 599 | 2.3 | 404 | 1.6 |
| Paediatrics | 76 | 228,300 | 18,860 | 8.3 | 2,092 | 11.1 | 410 | 2.2 | 655 | 3.5 | 1,027 | 5.4 |
| Gastroenterology & Hepatology | 74 | 109,518 | 18,722 | 17.1 | 1,348 | 7.2 | 450 | 2.4 | 518 | 2.8 | 380 | 2.0 |
| Neurology | 77 | 193,469 | 15,224 | 7.9 | 2,076 | 13.6 | 522 | 3.4 | 920 | 6.0 | 634 | 4.2 |
| Urology | 77 | 100,582 | 13,350 | 13.3 | 664 | 5.0 | 276 | 2.1 | 255 | 1.9 | 133 | 1.0 |
| Orthopaedic surgery | 76 | 212,608 | 11,020 | 5.2 | 649 | 5.9 | 238 | 2.2 | 284 | 2.6 | 127 | 1.2 |
| Obstetrics and gynaecology | 77 | 74,150 | 3,413 | 4.6 | 226 | 6.6 | 82 | 2.4 | 94 | 2.8 | 50 | 1.5 |
| Cardiothoracic surgery | 15 | 27,320 | 2,564 | 9.4 | 621 | 24.2 | 311 | 12.1 | 292 | 11.4 | 18 | 0.7 |
| Neurosurgery | 54 | 37,312 | 2,534 | 6.8 | 377 | 14.9 | 196 | 7.7 | 151 | 6.0 | 30 | 1.2 |
| Ear, Nose and Throat clinic | 77 | 62,973 | 2,473 | 3.9 | 289 | 11.7 | 134 | 5.4 | 89 | 3.6 | 66 | 2.7 |
| Clinical geriatrics | 39 | 25,426 | 2,416 | 9.5 | 131 | 5.4 | 48 | 2.0 | 62 | 2.6 | 21 | 0.9 |
| Plastic surgery | 72 | 31,261 | 1,412 | 4.5 | 147 | 10.4 | 70 | 5.0 | 58 | 4.1 | 19 | 1.3 |
| Anaesthesiology | 70 | 9,231 | 1,094 | 11.9 | 140 | 12.8 | 48 | 4.4 | 61 | 5.6 | 31 | 2.8 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rheumatology | 57 | 4,386 | 741 | 16.9 | 42 | 5.7 | 21 | 2.8 | 13 | 1.8 | 8 | 1.1 |
| Ophthalmology | 69 | 5,872 | 414 | 7.1 | 69 | 16.7 | 28 | 6.8 | 30 | 7.2 | 11 | 2.7 |
| Dermatology | 63 | 2,127 | 394 | 18.5 | 30 | 7.6 | 11 | 2.8 | 14 | 3.6 | 5 | 1.3 |
| Oral and Maxillofacial Surgery | 71 | 11,835 | 347 | 2.9 | 57 | 16.4 | 31 | 8.9 | 12 | 3.5 | 14 | 4.0 |
| Psychiatry | 28 | 1,310 | 110 | 8.4 | 17 | 15.5 | 5 | 4.5 | 9 | 8.2 | 3 | 2.7 |
| Other medical specialty | 30 | 808 | 47 | 5.8 | 9 | 19.1 | 4 | 8.5 | 4 | 8.5 | 1 | 2.1 |
| *Total* | *77* | *2,333,173* | *240,122* | *10.3* | *21,440* | *8.9* | *7,076* | *2.9* | *9,037* | *3.8* | *5,327* | *2.2* |

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 to 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 paediatrics.

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

| **Discharge medical specialty index admission** | **C-statistic model any hospital** | **95% CI C-statistic model any hospital** | **C-statistic model same hospital** | **95% CI C-statistic model same hospital** | **Significance** | **R2 readmission ratios same versus any hospital** |
|---|---|---|---|---|---|---|
| General surgery | 0.627 | 0.624 - 0.629 | 0.627 | 0.624 - 0.630 | - | 0.948 |
| Cardiology | 0.610 | 0.607 - 0.613 | 0.623 | 0.620 - 0.627 | * | 0.787 |
| Internal medicine | 0.600 | 0.597 - 0.603 | 0.606 | 0.603 - 0.609 | * | 0.916 |
| Pulmonology | 0.625 | 0.621 - 0.628 | 0.630 | 0.626 - 0.633 | * | 0.930 |
| Paediatrics | 0.587 | 0.582 - 0.591 | 0.581 | 0.577 - 0.586 | * | 0.901 |
| Gastroenterology & Hepatology | 0.599 | 0.594 - 0.603 | 0.598 | 0.594 - 0.603 | - | 0.956 |
| Neurology | 0.613 | 0.608 - 0.618 | 0.616 | 0.611 - 0.621 | - | 0.820 |
| Urology | 0.624 | 0.619 - 0.629 | 0.624 | 0.619 - 0.629 | - | 0.944 |
| Orthopaedic surgery | 0.669 | 0.664 - 0.675 | 0.670 | 0.665 - 0.675 | - | 0.961 |
| Obstetrics and gynaecology | 0.620 | 0.610 - 0.630 | 0.619 | 0.608 - 0.629 | - | 0.957 |
| Cardiothoracic surgery | 0.633 | 0.623 - 0.644 | 0.665 | 0.653 - 0.677 | * | 0.802 |
| Neurosurgery | 0.629 | 0.617 - 0.641 | 0.630 | 0.617 - 0.643 | - | 0.994 |
| Ear, Nose and Throat clinic | 0.669 | 0.658 - 0.681 | 0.659 | 0.647 - 0.671 | - | 0.914 |
| Clinical geriatrics | 0.595 | 0.583 - 0.607 | 0.593 | 0.581 - 0.606 | - | 0.986 |
| Plastic surgery | 0.633 | 0.617 - 0.648 | 0.632 | 0.616 - 0.648 | - | 0.740 |
| Anaesthesiology | 0.600 | 0.582 - 0.617 | 0.621 | 0.603 - 0.639 | * | 0.955 |
| Rheumatology | 0.664 | 0.642 - 0.687 | 0.665 | 0.642 - 0.688 | - | 0.763 |
| Ophthalmology | 0.610 | 0.582 - 0.638 | 0.596 | 0.566 - 0.626 | - | 0.648 |
| Dermatology | 0.826 | 0.802 - 0.851 | 0.851 | 0.827 - 0.874 | * | 0.994 |
| Oral and Maxillofacial Surgery | 0.679 | 0.648 - 0.709 | 0.685 | 0.653 - 0.718 | - | 0.369 |
| Psychiatry | 0.670 | 0.613 - 0.728 | 0.700 | 0.642 - 0.757 | - | 0.920 |
| *Total* | 0.641 | 0.640 - 0.642 | 0.646 | 0.645 - 0.647 | * | 0.905 |

## Discussion

This study investigated the impact upon the readmission indicator of taking into account readmissions to other hospitals.

*Readmission rates for any hospital*

We found 10.3% of admissions resulted in readmissions to any hospital, which is comparable with a study of Davies (2013) which came up with a figure of 10.1% all-cause readmissions.[22] 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 to the 17-32% reported in other studies.[16-23] These studies, however, concerned only acute care and were mainly carried out in the US. 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 healthcare systems.

*The Dutch healthcare 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 US, 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.[32] 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

to the literature, could also apply to other countries with a comparable healthcare 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 Dutch National Basic Registration of Hospital Care, the LBZ, does not contain a variable that distinguishes between intended and unintended readmissions. In the LBZ, the variable 'urgency' (acute versus non-acute admission) 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. It appeared that a larger proportion of acute readmissions was classified as potentially preventable compared to elective readmissions (28.5% versus 5.0%). This finding implies that readmissions which are coded elective, as well as those which are coded as an emergency, may also be unintended. Therefore, we included both emergency and elective admissions and readmissions in our study.

*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 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.

Firstly, 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.

Secondly, 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.[14 33] 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.

**Conclusion**

Overall the impact on the readmission indicator 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 to the national average on the readmission indicator 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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**Conflicts of interest**

None declared

**Author's contribution**

All authors contributed to the study design. KH analysed the data and produced the figures and tables. GW, TK, IB and SC provided input to the analysis and the interpretation of the results. The initial draft of the manuscript was prepared by KH. GW, TK, IB and SC critically revised the manuscript. All authors approved the final version of the manuscript.

**Data sharing statement**

The data used in this study is fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands (CBS) (costs may apply).

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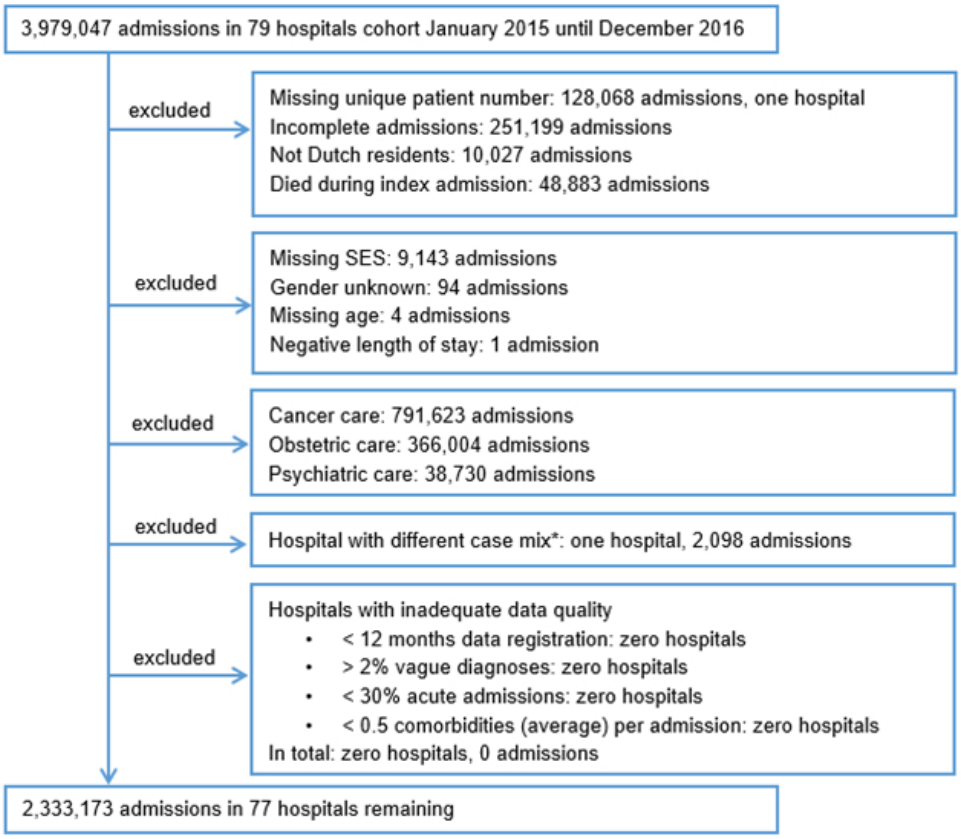
**Figure legends**

Figure 1. Flowchart admissions in the dataset

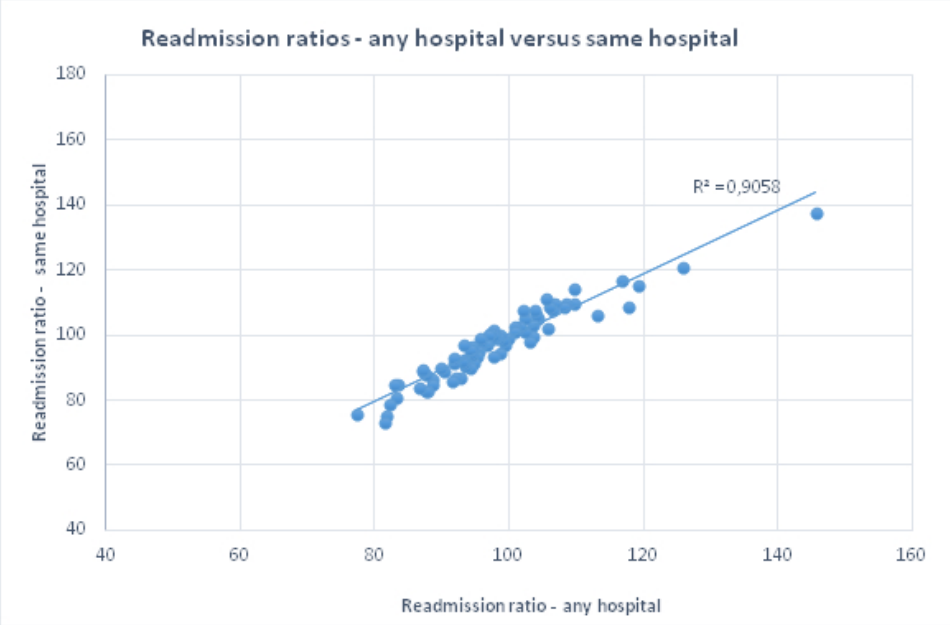
Figure 2. The plot readmission ratios for any hospital versus those readmissions for the same hospital, per hospital for all diagnosis groups.




* One hospital which had fewer than 100 readmissions per year, and treated only planned care and not emergency care, was, therefore, excluded from the analysis.

Flowchart admissions in the dataset

55x54mm (300 x 300 DPI)




The plot readmission ratios for any hospital versus those readmissions for the same hospital, per hospital for all diagnosis groups.

51x33mm (300 x 300 DPI)

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1, 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 4, 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 5, 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 5 |
| Bias | 9 | Describe any efforts to address potential sources of bias | - |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6, 7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 6, 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | - |
| | | (*c*) Explain how missing data were addressed | Figure 1 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | - |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 7, Figure 1 |
| | | (b) Give reasons for non-participation at each stage | Figure 1 |
| | | (c) Consider use of a flow diagram | Figure 1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Table 1 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Figure 1 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 9 - 13 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9, 11 - 13 |
| | | (*b*) Report category boundaries when continuous variables were categorized | - |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | - |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 14, 15 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 15, 16 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 14 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | - |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

# What is the impact on the readmission ratio of taking into account readmissions to other hospitals? A cross-sectional study.



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| | |

*Title page*

# What is the impact on the readmission ratio of taking into account readmissions to other hospitals? A cross-sectional study.

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**Abstract**

**Objectives:** There is widespread use made of readmissions 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 identify differences in the outcomes from a readmission ratio, with or without including readmission to other hospitals.

**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-days 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, per hospital and C-statistic of each model in order to determine the discriminative ability, per medical specialty.

**Results:** The percentage 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 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.

**Key words:** Quality in health care, Health & safety, Health policy

## Article summary

### Strengths and limitations of this study

- First study in the Netherlands that analyses the impact of taking into account readmissions to other hospitals.
- The database contains all hospital admissions of nearly all Dutch hospitals (97% of the general and university hospitals).
- Not all hospitals register the unique patient numbers completely, which could affect the readmission rate when including readmissions to other hospitals.
- The database does not contain a variable that distinguishes between intended and unintended readmissions.

## 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 healthcare 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% to 32% of the total number of readmissions.[16-23] Halfon [17] and Nasir [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 United States so it is not known if these results are also applicable for European countries with different healthcare systems, such as the Netherlands. The Dutch healthcare 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.[24] There are no financial penalties for hospitals with ratios higher than the national average (more than 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 Dutch National Basic Registration of Hospital Care (LBZ).[25] 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.[14 26] We calculated all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation.[26 27] 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.[28]

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 healthcare 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 one day[29], 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 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 was 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.[30]

Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data, we investigated the following criteria [31]: there should be at least twelve 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 [31] and are important in the calculation of readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of readmission.[1 13] 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. The following predicting covariates for the adjustment for case mix were used[32,33:] 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); socio-economic status (SES, 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% confidence intervals 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 to 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 standard errors 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 version 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.

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

| | All admissions | | | Only readmissions | | |
|---|---|---|---|---|---|---|
| **Variable** | **Median** | **5th percentile** | **95th percentile** | **Readmission same hospital (99,7% CI)** | **Readmission other hospitals (without transfer) (99,7% CI)** | **Significance** |
| mean age | 55.41 | 50.64 | 59.17 | 59.86 (59.70 - 60.01) | 56.09 (55.58 - 56.60) | * |
| % women | 50.59 | 47.49 | 53.60 | 46.72 (46.40 - 47.04) | 43.70 (42.69 - 44.72) | * |
| % admissions that was registered as acute* | 60.18 | 47.57 | 70.49 | 71.62 (71.33 - 71.91) | 68.48 (67.53 - 69.43) | * |
| % readmissions that was registered as acute* | 74.38 | 66.09 | 81.10 | 75.85 (75.57 - 76.12) | 59.97 (58.97 - 60.97) | * |
| mean number of comorbidities | 0.47 | 0.28 | 0.67 | 0.76 (0.76 - 0.77) | 0.64 (0.62 - 0.66) | * |

* 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

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%).

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

| | N | % |
|---|---|---|
| **All admissions** | | |
| Admissions total | 2,333,173 | |
| Readmissions < 30 days (% of admissions) * | 240,122 | 10.29% |
| Readmissions < 30 days of which in other hospital* (% of readmissions < 30 days) | 21,440 | 8.93% |
| **Acute admissions** | | |
| Acute admissions total | 1,370,628 | |
| Acute readmissions < 30 days (% of acute admissions) * | 128,439 | 9.37% |
| Acute readmissions < 30 days of which in other hospital* (% of acute readmissions < 30 days) | 8,604 | 5.20% |

* 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).

In total 14% (=11/77, marked grey in Table 3) of the hospitals changed their position of significance compared to the national average when taking into account readmissions to any hospital compared to the same hospital (Table 3).

Table 3. Change of position of hospitals when using the readmission ratio (the observed number of readmissions divided by the expected number of readmissions based on the case mix of the hospital, multiplied by 100) to same hospital versus that to any hospital

| | | **Readmission ratio - same hospital** | | |
|---|---|---|---|---|
| **Readmission ratio - any hospital** | Significantly lower (-1) | No significant difference (0) | Significantly higher (1) | Total |
| Significantly lower (-1) | 35 | 4 | 0 | 39 |
| No significant difference (0) | 2 | 14 | 2 | 18 |
| Significantly higher (1) | 0 | 3 | 17 | 20 |
| Total | 37 | 21 | 19 | 77 |

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 to 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 to 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.

257 Table 4. Readmission percentage and readmissions to other types of hospitals, per medical specialty

| Discharge medical specialty index admission | Hospitals (N) | Admissions (N) | Readmissions <30 days without transfer (N) | Readmissions (%) | Readmissions to other hospital <30 days (N) | Readmissions to other hospital <30 days (%) | Readmissions to other general hospitals <30 days (N) | Readmissions to other general hospitals <30 days (%) | Readmissions to other leading clinical hospitals <30 days (N) | Readmissions to other leading clinical hospitals <30 days (%) | Readmissions to other university hospitals <30 days (N) | Readmissions to other university hospitals <30 days (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General surgery | 77 | 403,806 | 43,003 | 10.6 | 2,686 | 6.2 | 1,022 | 2.4 | 1,172 | 2.7 | 492 | 1.1 |
| Cardiology | 77 | 345,162 | 38,878 | 11.3 | 5,739 | 14.8 | 1,915 | 4.9 | 2,674 | 6.9 | 1,150 | 3.0 |
| Internal medicine | 77 | 258,781 | 37,276 | 14.4 | 2,552 | 6.8 | 778 | 2.1 | 1,071 | 2.9 | 703 | 1.9 |
| Pulmonology | 77 | 186,936 | 25,830 | 13.8 | 1,479 | 5.7 | 476 | 1.8 | 599 | 2.3 | 404 | 1.6 |
| Paediatrics | 76 | 228,300 | 18,860 | 8.3 | 2,092 | 11.1 | 410 | 2.2 | 655 | 3.5 | 1,027 | 5.4 |
| Gastroenterology & Hepatology | 74 | 109,518 | 18,722 | 17.1 | 1,348 | 7.2 | 450 | 2.4 | 518 | 2.8 | 380 | 2.0 |
| Neurology | 77 | 193,469 | 15,224 | 7.9 | 2,076 | 13.6 | 522 | 3.4 | 920 | 6.0 | 634 | 4.2 |
| Urology | 77 | 100,582 | 13,350 | 13.3 | 664 | 5.0 | 276 | 2.1 | 255 | 1.9 | 133 | 1.0 |
| Orthopaedic surgery | 76 | 212,608 | 11,020 | 5.2 | 649 | 5.9 | 238 | 2.2 | 284 | 2.6 | 127 | 1.2 |
| Obstetrics and gynaecology | 77 | 74,150 | 3,413 | 4.6 | 226 | 6.6 | 82 | 2.4 | 94 | 2.8 | 50 | 1.5 |
| Cardiothoracic surgery | 15 | 27,320 | 2,564 | 9.4 | 621 | 24.2 | 311 | 12.1 | 292 | 11.4 | 18 | 0.7 |
| Neurosurgery | 54 | 37,312 | 2,534 | 6.8 | 377 | 14.9 | 196 | 7.7 | 151 | 6.0 | 30 | 1.2 |
| Ear, Nose and Throat clinic | 77 | 62,973 | 2,473 | 3.9 | 289 | 11.7 | 134 | 5.4 | 89 | 3.6 | 66 | 2.7 |
| Clinical geriatrics | 39 | 25,426 | 2,416 | 9.5 | 131 | 5.4 | 48 | 2.0 | 62 | 2.6 | 21 | 0.9 |
| Plastic surgery | 72 | 31,261 | 1,412 | 4.5 | 147 | 10.4 | 70 | 5.0 | 58 | 4.1 | 19 | 1.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaesthesiology | 70 | 9,231 | 1,094 | 11.9 | 140 | 12.8 | 48 | 4.4 | 61 | 5.6 | 31 | 2.8 |
| Rheumatology | 57 | 4,386 | 741 | 16.9 | 42 | 5.7 | 21 | 2.8 | 13 | 1.8 | 8 | 1.1 |
| Ophthalmology | 69 | 5,872 | 414 | 7.1 | 69 | 16.7 | 28 | 6.8 | 30 | 7.2 | 11 | 2.7 |
| Dermatology | 63 | 2,127 | 394 | 18.5 | 30 | 7.6 | 11 | 2.8 | 14 | 3.6 | 5 | 1.3 |
| Oral and Maxillofacial Surgery | 71 | 11,835 | 347 | 2.9 | 57 | 16.4 | 31 | 8.9 | 12 | 3.5 | 14 | 4.0 |
| Psychiatry | 28 | 1,310 | 110 | 8.4 | 17 | 15.5 | 5 | 4.5 | 9 | 8.2 | 3 | 2.7 |
| Other medical specialty | 30 | 808 | 47 | 5.8 | 9 | 19.1 | 4 | 8.5 | 4 | 8.5 | 1 | 2.1 |
| *Total* | *77* | *2,333,173* | *240,122* | *10.3* | *21,440* | *8.9* | *7,076* | *2.9* | *9,637* | *3.8* | *5,327* | *2.2* |

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 to 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 paediatrics.

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

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

## Discussion

This study investigated the impact upon 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 (2013) which came up with a figure of 10.1% all-cause readmissions.[22] 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 to the 17-32% reported in other studies.[16-23] These studies, however, concerned only acute care and were mainly carried out in the US. 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 healthcare 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 to the any hospital ratio. However, Gonzalez et al (2014) concluded that same hospital readmission rates provided unstable estimates of all-hospital readmission rates following coronary artery bypass grafting.[34]

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 to the same hospital ratio. A study by Kahn et al (2015) also concluded that different-hospital readmissions differentially affect hospitals' paediatric readmission rates.[35] Our study found that 14% of the hospitals changed their position of significance compared to the national average when taking into account readmissions to any hospital compared to 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. [35]

*The Dutch healthcare 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 US, 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.[36] 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 to the literature, could also apply to other countries with a comparable healthcare 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 Dutch National Basic Registration 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.[33] It appeared that a larger proportion of acute readmissions was classified as potentially preventable compared to 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 hours 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.

Firstly, 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.

Secondly, 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.[14,37] 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.

**Conclusion**

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 to 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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**Conflicts of interest**

None declared

**Author's contribution**

All authors contributed to the study design. KH analysed the data and produced the figures and tables. GW, TK, IB and SC provided input to the analysis and the interpretation of the results. The initial draft of the manuscript was prepared by KH. GW, TK, IB and SC critically revised the manuscript. All authors approved the final version of the manuscript.

**Data availability statement**

The data used in this study is fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands (CBS) (costs may apply).

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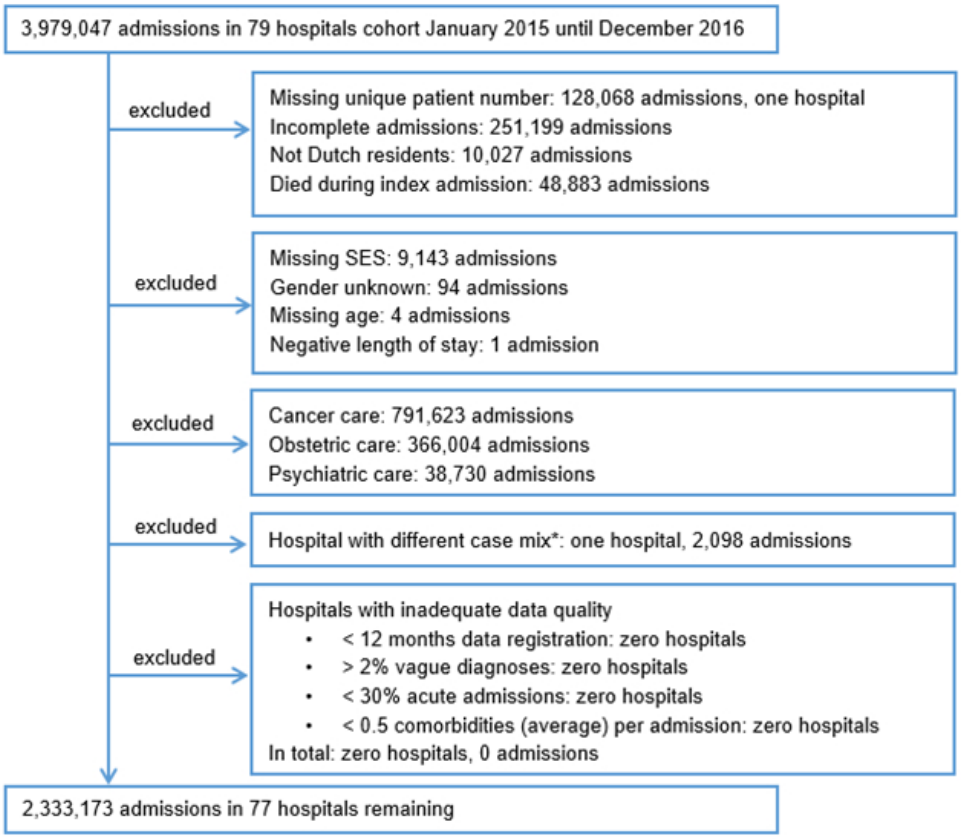
**Figure legends**

Figure 1. Flowchart admissions in the dataset

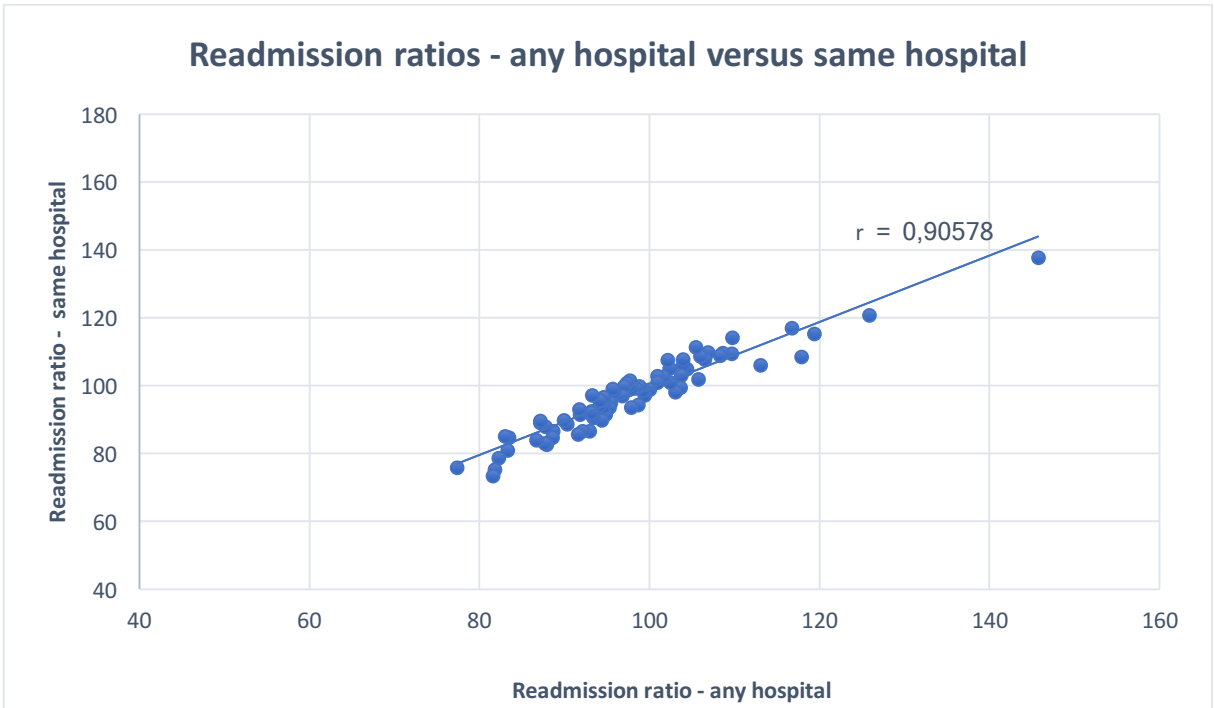
Figure 2. The plot readmission ratios for any hospital versus those readmissions for the same hospital, per hospital for all diagnosis groups.




* One hospital which had fewer than 100 readmissions per year, and treated only planned care and not emergency care, was, therefore, excluded from the analysis.

Flowchart admissions in the dataset

55x54mm (300 x 300 DPI)



**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1, 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 4, 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 5, 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 5 |
| Bias | 9 | Describe any efforts to address potential sources of bias | - |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6, 7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 6, 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | - |
| | | (*c*) Explain how missing data were addressed | Figure 1 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | - |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 7, Figure 1 |
| | | (b) Give reasons for non-participation at each stage | Figure 1 |
| | | (c) Consider use of a flow diagram | Figure 1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Table 1 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Figure 1 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 9 - 13 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9, 11 - 13 |
| | | (*b*) Report category boundaries when continuous variables were categorized | - |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | - |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 14, 15 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 15, 16 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 14 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | - |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

# What is the impact on the readmission ratio of taking into account readmissions to other hospitals? A cross-sectional study.



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| | |

*Title page*

# What is the impact on the readmission ratio of taking into account readmissions to other hospitals? A cross-sectional study.

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**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-days 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.

**Key words:** Quality in health care, Health & safety, Health policy

## Article summary

### Strengths and limitations of this study

- First study in the Netherlands that analyses the impact of taking into account readmissions to other hospitals.
- The database contains all hospital admissions of nearly all Dutch hospitals (97% of the general and university hospitals).
- Not all hospitals register the unique patient numbers completely, which could affect the readmission rate when including readmissions to other hospitals.
- The database does not contain a variable that distinguishes between intended and unintended readmissions.

## 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 healthcare 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% to 32% of the total number of readmissions.[16-23] Halfon [17] and Nasir [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 United States so it is not known if these results are also applicable for European countries with different healthcare systems, such as the Netherlands. The Dutch healthcare 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.[24] There are no financial penalties for hospitals with more readmissions than the national average (readmission ratio more than 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 Dutch National Basic Registration of Hospital Care (LBZ).[25] 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.[14 26] We calculated all-cause readmissions meaning that they do not need to be related to the cause of the initial hospitalisation.[26 27] 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.[28]

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 healthcare 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 one day[29], 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 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 was 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.[30]

Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data, we investigated the following criteria [31]: there should be at least twelve 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 [31] and are important in the calculation of readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of readmission.[1 13] 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.[32] The following predicting covariates for the adjustment for case mix were used:[33,34] 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); socio-economic status (SES, 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% confidence intervals 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 to 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 standard errors 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 version 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.

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

| | All admissions | | | Only readmissions | | |
|---|---|---|---|---|---|---|
| **Variable** | **Median** | **5th percentile** | **95th percentile** | **Readmission same hospital (99,7% CI)** | **Readmission other hospitals (without transfer) (99,7% CI)** | **Significance** |
| mean age | 55.41 | 50.64 | 59.17 | 59.86 (59.70 - 60.01) | 56.09 (55.58 - 56.60) | * |
| % women | 50.59 | 47.49 | 53.60 | 46.72 (46.40 - 47.04) | 43.70 (42.69 - 44.72) | * |
| % admissions that was registered as acute[1] | 60.18 | 47.57 | 70.49 | 71.62 (71.33 - 71.91) | 68.48 (67.53 - 69.43) | * |
| % readmissions that was registered as acute[1] | 74.38 | 66.09 | 81.10 | 75.85 (75.57 - 76.12) | 59.97 (58.97 - 60.97) | * |
| mean number of comorbidities | 0.47 | 0.28 | 0.67 | 0.76 (0.76 - 0.77) | 0.64 (0.62 - 0.66) | * |

[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

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%).

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

| | N | % |
|---|---|---|
| **All admissions** | | |
| Admissions total | 2,333,173 | |
| Readmissions < 30 days (% of admissions) [1] | 240,122 | 10.29% |
| Readmissions < 30 days of which in other hospital* (% of readmissions < 30 days) | 21,440 | 8.93% |
| **Acute admissions** | | |
| Acute admissions total | 1,370,628 | |
| Acute readmissions < 30 days (% of acute admissions) [1] | 128,439 | 9.37% |
| Acute readmissions < 30 days of which in other hospital[1] (% of acute readmissions < 30 days) | 8,604 | 5.20% |

[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).

In total 14% (=11/77, marked grey in Table 3) of the hospitals changed their position of significance compared to the national average when taking into account readmissions to any hospital compared to 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

| | Readmission ratio - same hospital | | | |
|---|---|---|---|---|
| **Readmission ratio - any hospital** | Significantly lower (-1) | No significant difference (0) | Significantly higher (1) | Total |
| Significantly lower (-1) [2] | 35 | 4 | 0 | 39 |
| No significant difference (0) | 2 | 14 | 2 | 18 |
| Significantly higher (1) [3] | 0 | 3 | 17 | 20 |
| Total | 37 | 21 | 19 | 77 |

[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 to the national average.

[3] Significantly higher readmission ratio means more readmissions compared to 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 to 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 to 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.

262 Table 4. Readmission percentage and readmissions to other types of hospitals, per medical specialty

| Discharge medical specialty index admission | Hospitals (N) | Admissions (N) | Readmissions <30 days without transfer (N) | Readmissions (%) | Readmissions to other hospital <30 days (N) | Readmissions to other hospital <30 days (%) | Readmissions to other general hospitals <30 days (N) | Readmissions to other general hospitals <30 days (%) | Readmissions to other leading clinical hospitals <30 days (N) | Readmissions to other leading clinical hospitals <30 days (%) | Readmissions to other university hospitals <30 days (N) | Readmissions to other university hospitals <30 days (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General surgery | 77 | 403,806 | 43,003 | 10.6 | 2,686 | 6.2 | 1,022 | 2.4 | 1,172 | 2.7 | 492 | 1.1 |
| Cardiology | 77 | 345,162 | 38,878 | 11.3 | 5,739 | 14.8 | 1,915 | 4.9 | 2,674 | 6.9 | 1,150 | 3.0 |
| Internal medicine | 77 | 258,781 | 37,276 | 14.4 | 2,552 | 6.8 | 778 | 2.1 | 1,071 | 2.9 | 703 | 1.9 |
| Pulmonology | 77 | 186,936 | 25,830 | 13.8 | 1,479 | 5.7 | 476 | 1.8 | 599 | 2.3 | 404 | 1.6 |
| Paediatrics | 76 | 228,300 | 18,860 | 8.3 | 2,092 | 11.1 | 410 | 2.2 | 655 | 3.5 | 1,027 | 5.4 |
| Gastroenterology & Hepatology | 74 | 109,518 | 18,722 | 17.1 | 1,348 | 7.2 | 450 | 2.4 | 518 | 2.8 | 380 | 2.0 |
| Neurology | 77 | 193,469 | 15,224 | 7.9 | 2,076 | 13.6 | 522 | 3.4 | 920 | 6.0 | 634 | 4.2 |
| Urology | 77 | 100,582 | 13,350 | 13.3 | 664 | 5.0 | 276 | 2.1 | 255 | 1.9 | 133 | 1.0 |
| Orthopaedic surgery | 76 | 212,608 | 11,020 | 5.2 | 649 | 5.9 | 238 | 2.2 | 284 | 2.6 | 127 | 1.2 |
| Obstetrics and gynaecology | 77 | 74,150 | 3,413 | 4.6 | 226 | 6.6 | 82 | 2.4 | 94 | 2.8 | 50 | 1.5 |
| Cardiothoracic surgery | 15 | 27,320 | 2,564 | 9.4 | 621 | 24.2 | 311 | 12.1 | 292 | 11.4 | 18 | 0.7 |
| Neurosurgery | 54 | 37,312 | 2,534 | 6.8 | 377 | 14.9 | 196 | 7.7 | 151 | 6.0 | 30 | 1.2 |
| Ear, Nose and Throat clinic | 77 | 62,973 | 2,473 | 3.9 | 289 | 11.7 | 134 | 5.4 | 89 | 3.6 | 66 | 2.7 |
| Clinical geriatrics | 39 | 25,426 | 2,416 | 9.5 | 131 | 5.4 | 48 | 2.0 | 62 | 2.6 | 21 | 0.9 |
| Plastic surgery | 72 | 31,261 | 1,412 | 4.5 | 147 | 10.4 | 70 | 5.0 | 58 | 4.1 | 19 | 1.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaesthesiology | 70 | 9,231 | 1,094 | 11.9 | 140 | 12.8 | 48 | 4.4 | 61 | 5.6 | 31 | 2.8 |
| Rheumatology | 57 | 4,386 | 741 | 16.9 | 42 | 5.7 | 21 | 2.8 | 13 | 1.8 | 8 | 1.1 |
| Ophthalmology | 69 | 5,872 | 414 | 7.1 | 69 | 16.7 | 28 | 6.8 | 30 | 7.2 | 11 | 2.7 |
| Dermatology | 63 | 2,127 | 394 | 18.5 | 30 | 7.6 | 11 | 2.8 | 14 | 3.6 | 5 | 1.3 |
| Oral and Maxillofacial Surgery | 71 | 11,835 | 347 | 2.9 | 57 | 16.4 | 31 | 8.9 | 12 | 3.5 | 14 | 4.0 |
| Psychiatry | 28 | 1,310 | 110 | 8.4 | 17 | 15.5 | 5 | 4.5 | 9 | 8.2 | 3 | 2.7 |
| Other medical specialty | 30 | 808 | 47 | 5.8 | 9 | 19.1 | 4 | 8.5 | 4 | 8.5 | 1 | 2.1 |
| *Total* | *77* | *2,333,173* | *240,122* | *10.3* | *21,440* | *8.9* | *7,076* | *2.9* | *9,637* | *3.8* | *5,327* | *2.2* |

264 The C-statistics differed between the medical specialties (Table 5). There were slight differences
265 between the C-statistics of the models with readmissions to any hospital compared to the models
266 with readmissions to the same hospital. For most medical specialties, the C-statistics of the models
267 with readmissions to the same hospital were higher. The largest significant difference was found for
268 cardiothoracic surgery. For some medical specialties, the C-statistics of the models with readmissions
269 to any hospital were higher. The largest significant difference for this group was found in paediatrics.
270

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

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

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## Discussion

This study investigated the impact upon 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 (2013) which came up with a figure of 10.1% all-cause readmissions.[22] 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 to the 17-32% reported in other studies.[16-23] These studies, however, concerned only acute care and were mainly carried out in the US. 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 healthcare 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 to the any hospital ratio. However, Gonzalez et al (2014) 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 to the same hospital ratio. A study by Kahn et al (2015) 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 to the national average when taking into account readmissions to any hospital compared to 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 healthcare 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 US, 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.[35] 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 to the literature, could also apply to other countries with a comparable healthcare 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 Dutch National Basic Registration 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.[36] It appeared that a larger proportion of acute readmissions was classified as potentially preventable compared to 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 hours 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.
Firstly, 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.
Secondly, 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.[14 36] 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.

**Conclusion**

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 to 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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**Conflicts of interest**

None declared

**Author's contribution**

All authors contributed to the study design. KH analysed the data and produced the figures and tables. GW, TK, IB and SC provided input to the analysis and the interpretation of the results. The initial draft of the manuscript was prepared by KH. GW, TK, IB and SC critically revised the manuscript. All authors approved the final version of the manuscript.

**Data sharing statement**

The data used in this study is fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands (CBS) (costs may apply).

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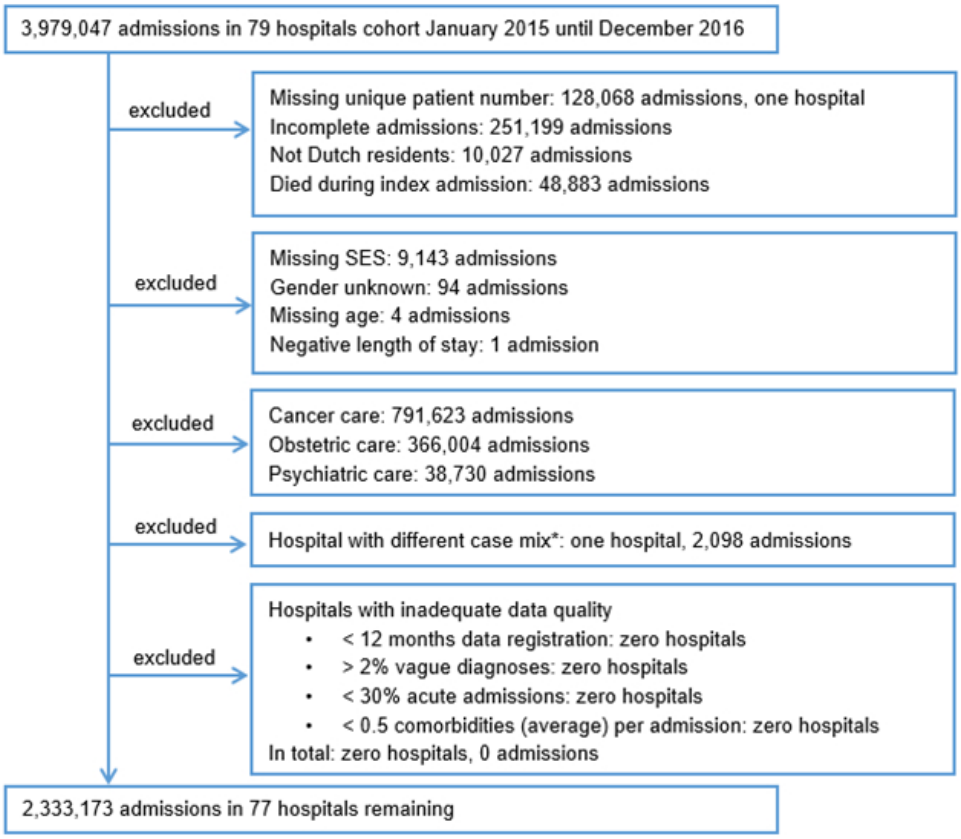
**Figure legends**

Figure 1. Flowchart admissions in the dataset

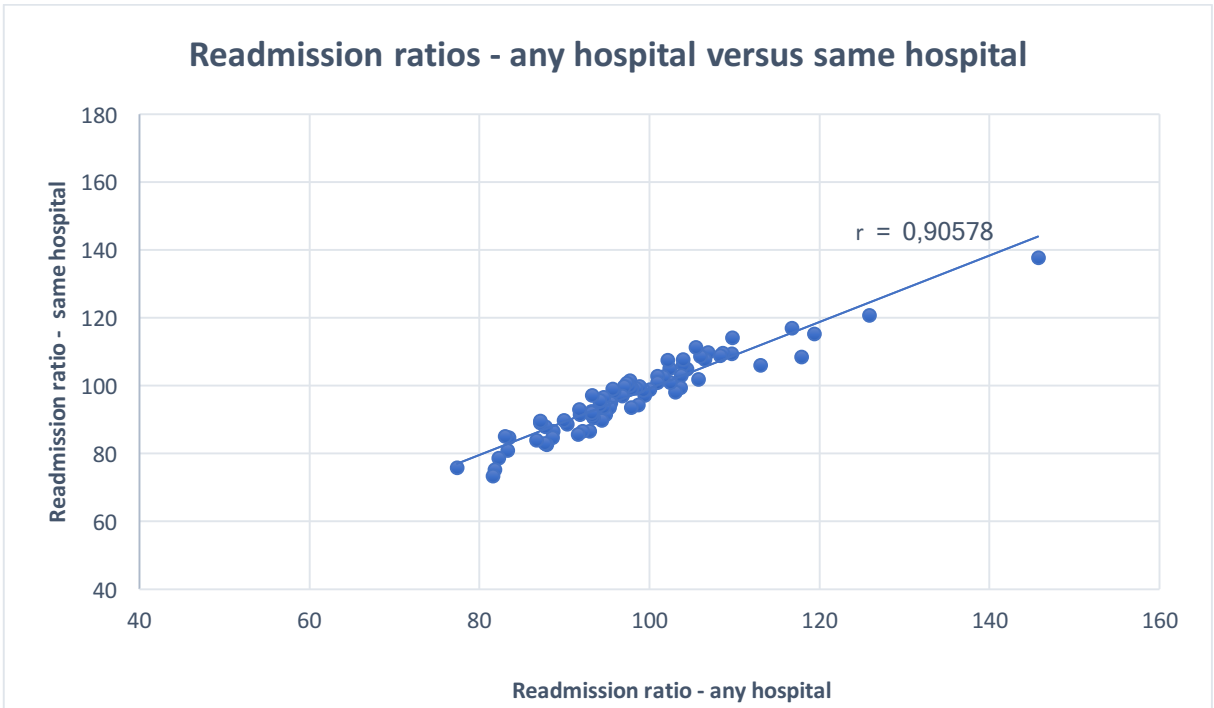
Figure 2. The plot readmission ratios for any hospital versus those readmissions for the same hospital, per hospital for all diagnosis groups.




* One hospital which had fewer than 100 readmissions per year, and treated only planned care and not emergency care, was, therefore, excluded from the analysis.

Flowchart admissions in the dataset

55x54mm (300 x 300 DPI)



**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| Section/Topic | Item # | Recommendation | Reported on page # |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1, 2 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 4, 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 6 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | 5, 6 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 5 |
| Bias | 9 | Describe any efforts to address potential sources of bias | - |
| Study size | 10 | Explain how the study size was arrived at | 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6, 7 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 6, 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | - |
| | | (*c*) Explain how missing data were addressed | Figure 1 |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | - |
| | | (*e*) Describe any sensitivity analyses | - |
| **Results** | | | |

| | | | |
|---|---|---|---|
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 7, Figure 1 |
| | | (b) Give reasons for non-participation at each stage | Figure 1 |
| | | (c) Consider use of a flow diagram | Figure 1 |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Table 1 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Figure 1 |
| Outcome data | 15* | Report numbers of outcome events or summary measures | 9 - 13 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 9, 11 - 13 |
| | | (*b*) Report category boundaries when continuous variables were categorized | - |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | - |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | - |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 14, 15 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 15, 16 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 14 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | - |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.