



BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025740
Article Type:	Research
Date Submitted by the Author:	31-Jul-2018
Complete List of Authors:	Hekkert, Karin; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Borghans, Ine; Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection Cihangir, Sezgin; Dutch Hospital Data, Team Expertise and Support Westert, Gert; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Kool, Rudolf; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences
Keywords:	Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts

Title page

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

Names and affiliations of contributing authors:

Karin Hekkert¹, Ine Borghans², Sezgin Cihangir³, Gert Westert¹, Rudolf B Kool¹

¹ Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences, Radboud University Medical Center, Nijmegen, Netherlands

² Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection, The Netherlands

³ Dutch Hospital Data, Team Expertise and Support, Utrecht, The Netherlands

Correspondence details:

Karin Hekkert

karin.hekkert@radboudumc.nl

Phone: +31 (0)633318381

Fax: 024 3540166

Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences, Radboud University Medical Center, Nijmegen, Netherlands

P.O.Box 9101, 6500 HB Nijmegen (114), The Netherlands

Word count for the abstract: 286

Word count for the text of the manuscript: 3281

Number of tables and figures: 7

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

1

2

3 **Article summary**

4 **Strengths and limitations of this study**

- 5
- 6 - First study in the Netherlands that analyses the impact of taking into account readmissions to
- 7 other hospitals.
- 8
- 9 - The database contains all hospital admissions of nearly all Dutch hospitals (97% of the
- 10 general and university hospitals).
- 11
- 12 - Not all hospitals register the unique patient numbers completely, which could affect the
- 13 readmission rate when including readmissions to other hospitals.
- 14
- 15 - The database does not contain a variable that distinguishes between intended and
- 16 unintended readmissions.
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 32
- 33
- 34
- 35
- 36
- 37
- 38
- 39
- 40
- 41
- 42
- 43
- 44
- 45
- 46
- 47
- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60

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.¹⁹⁻¹² 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 them¹⁴ 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 Halfon¹⁷ and Nasir¹⁶ 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

1
2
3 impact, resulting from the inclusion of readmissions to other hospitals, is the same for other
4 countries. It is important to answer this question because, in the Netherlands, readmissions are an
5 indicator of the quality of care. The Dutch Health and Youth Care Inspectorate requires that hospitals
6 submit their overall number of readmissions each year.²⁴ At the moment, this concerns only
7 readmissions within the same hospital.
8
9

10
11
12 The aim of this study is to assess the difference between case mix adjusted readmission ratios for
13 each hospital including readmissions to other hospitals and those based solely on readmissions which
14 occur in the same hospital. The research question is: What is the impact on the readmission indicator
15 of taking into account readmissions to other hospitals?
16
17
18

19
20 **Methods**
21

22
23 *Database and study population*
24

25 We used data from the Dutch National Basic Registration of Hospital Care (LBZ).²⁵ This database
26 provides data from all 79 general and university hospitals in the Netherlands - at the time of the
27 study period - and contains all hospital admissions. Dutch Hospital Data, the national organisation
28 that administers the data from all the hospitals, gave permission to use the data anonymously. We
29 selected index admissions with a discharge date from 1 January 2015 to 31 October 2016, and all
30 subsequent readmissions until a discharge date of 31 December 2016. The data used in this study is
31 fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands
32 (CBS). We had permission of all hospitals to use the data anonymously.
33
34
35
36
37
38

39 The definition of a readmission was a clinical admission to the same hospital, within 30 days of
40 discharge, following the clinical index admission - that is the original hospital stay. We chose this time
41 frame in accordance with the international literature.^{14 26} We calculated all-cause readmissions
42 meaning that they do not need to be related to the cause of the initial hospitalisation.^{26 27} We used
43 the index admission as the unit of analysis. This means that each readmission of the same patient is
44 again an index admission for a subsequent readmission.²⁸
45
46
47
48
49

50 Index admissions and readmissions were linked with a unique patient number obtained by a Trusted
51 Third Party (Zorg TTP) which allows an individual's information in healthcare to be exchanged
52 without compromising their privacy. Readmissions were assigned to the hospital of the index
53 admission. Transfers, which are defined as readmissions to another hospital within one day, were not
54 counted as readmissions.²⁹
55
56
57

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 criteria³¹: 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 hospitals³¹ 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

Variable	Database all admissions			Subset only readmissions		
	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)	Readmission ns (%) hospital <30 days (N)	Readmissio ns to other hospital <30 days (%)	Readmissio ns to other hospital <30 days (N)	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
<i>Total</i>	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	C-statistic 95% CI		C-statistic 95% CI		Significance	R2	
admission	model	C-statistic model	model	C-statistic model			
	any	any hospital	same	same hospital			ratios
	hospital		hospital				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.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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).

References

1. Fischer C, Lingsma HF, Marang-van de Mheen PJ, et al. Is the readmission rate a valid quality indicator? A review of the evidence. *PloS one* 2014;9(11):e112282. doi: 10.1371/journal.pone.0112282 [published Online First: 2014/11/08]
2. van Walraven C, Bennett C, Jennings A, et al. Proportion of hospital readmissions deemed avoidable: a systematic review. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne* 2011;183(7):E391-402. doi: 10.1503/cmaj.101860 [published Online First: 2011/03/30]
3. Westert GP, Lagoe RJ, Keskimaki I, et al. An international study of hospital readmissions and related utilization in Europe and the USA. *Health policy (Amsterdam, Netherlands)* 2002;61(3):269-78. [published Online First: 2002/07/06]
4. Lagoe R, Nanno D, Luziani M. Quantitative tools for addressing hospital readmissions. *BMC Research Notes* 2012;5(1):620.
5. Bradley EH, Sipsma H, Horwitz LI, et al. Hospital Strategy Uptake and Reductions in Unplanned Readmission Rates for Patients with Heart Failure: A Prospective Study. *Journal of general internal medicine* 2014 doi: 10.1007/s11606-014-3105-5 [published Online First: 2014/12/20]
6. Hansen LO, Young RS, Hinami K, et al. Interventions to reduce 30-day rehospitalization: a systematic review. *Annals of internal medicine* 2011;155(8):520-8. doi: 10.7326/0003-4819-155-8-201110180-00008 [published Online First: 2011/10/19]
7. Laudicella M, Li Donni P, Smith PC. Hospital readmission rates: signal of failure or success? *Journal of health economics* 2013;32(5):909-21. doi: 10.1016/j.jhealeco.2013.06.004 [published Online First: 2013/08/14]
8. Kristensen SR, Bech M, Quentin W. A roadmap for comparing readmission policies with application to Denmark, England, Germany and the United States. *Health policy (Amsterdam, Netherlands)* 2015;119(3):264-73. doi: 10.1016/j.healthpol.2014.12.009 [published Online First: 2014/12/31]
9. Ashton CM, Kuykendall DH, Johnson ML, et al. The association between the quality of inpatient care and early readmission. *Annals of internal medicine* 1995;122(6):415-21. [published Online First: 1995/03/15]
10. Chung ES, Guo L, Casey Jr DE, et al. Relationship of a quality measure composite to clinical outcomes for patients with heart failure. *American journal of medical quality : the official journal of the American College of Medical Quality* 2008;23(3):168-75. doi: 10.1177/1062860608315337 [published Online First: 2008/06/10]
11. Encinosa WE, Hellinger FJ. The impact of medical errors on ninety-day costs and outcomes: an examination of surgical patients. *Health services research* 2008;43(6):2067-85. doi: 10.1111/j.1475-6773.2008.00882.x [published Online First: 2008/07/30]
12. Rosen AK, Loveland S, Shin M, et al. Examining the impact of the AHRQ Patient Safety Indicators (PSIs) on the Veterans Health Administration: the case of readmissions. *Medical care* 2013;51(1):37-44. doi: 10.1097/MLR.0b013e318270c0f7 [published Online First: 2012/10/04]
13. Halfon P, Eggli Y, van Melle G, et al. Measuring potentially avoidable hospital readmissions. *Journal of clinical epidemiology* 2002;55(6):573-87. [published Online First: 2002/06/14]
14. Blunt I, Bardsley M, Grove A, et al. Classifying emergency 30-day readmissions in England using routine hospital data 2004-2010: what is the scope for reduction? *Emergency medicine journal : EMJ* 2014 doi: 10.1136/emmered-2013-202531 [published Online First: 2014/03/29]
15. Hechenbleikner EM, Makary MA, Samarov DV, et al. Hospital readmission by method of data collection. *Journal of the American College of Surgeons* 2013;216(6):1150-8. doi: 10.1016/j.jamcollsurg.2013.01.057 [published Online First: 2013/04/16]
16. Nasir K, Lin Z, Bueno H, et al. Is same-hospital readmission rate a good surrogate for all-hospital readmission rate? *Medical care* 2010;48(5):477-81. doi: 10.1097/MLR.0b013e3181d5fb24 [published Online First: 2010/04/16]

17. Halfon P, Eggli Y, Pretre-Rohrbach I, et al. Validation of the potentially avoidable hospital readmission rate as a routine indicator of the quality of hospital care. *Medical care* 2006;44(11):972-81. doi: 10.1097/01.mlr.0000228002.43688.c2 [published Online First: 2006/10/26]

18. Metcalfe D, Olufajo OA, Zogg CK, et al. Unplanned 30-day readmissions in orthopaedic trauma. *Injury* 2016;47(8):1794-7. doi: 10.1016/j.injury.2016.05.007 [published Online First: 2016/06/06]

19. Moore L, Stelfox HT, Turgeon AF, et al. Rates, patterns, and determinants of unplanned readmission after traumatic injury: a multicenter cohort study. *Annals of surgery* 2014;259(2):374-80. doi: 10.1097/SLA.0b013e31828b0fae [published Online First: 2013/03/13]

20. Luu NP, Hussain T, Chang HY, et al. Readmissions After Colon Cancer Surgery: Does It Matter Where Patients Are Readmitted? *Journal of oncology practice* 2016;12(5):e502-12. doi: 10.1200/jop.2015.007757 [published Online First: 2016/04/07]

21. Kim H, Hung WW, Paik MC, et al. Predictors and outcomes of unplanned readmission to a different hospital. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2015;27(6):513-9. doi: 10.1093/intqhc/mzv082 [published Online First: 2015/10/17]

22. Davies SM, Saynina O, McDonald KM, et al. Limitations of using same-hospital readmission metrics. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2013;25(6):633-9. doi: 10.1093/intqhc/mzt068 [published Online First: 2013/10/30]

23. Parreco J, Buicko J, Cortolillo N, et al. Risk factors and costs associated with nationwide nonelective readmission after trauma. *The journal of trauma and acute care surgery* 2017;83(1):126-34. doi: 10.1097/ta.0000000000001505 [published Online First: 2017/04/20]

24. Kwaliteitsindicatoren Basisset ziekenhuizen 2016. In: Dutch Health Care Inspectorate MoH, Welfare and Sport, ed. Utrecht, , 09-2015:164 and 67.

25. DHD. Landelijke Basisregistratie Ziekenhuiszorg (LBZ) [Available from: <https://www.dhd.nl/producten-diensten/lbz/paginas/dataverzameling-lbz.aspx> accessed 18-12-2017.

26. Horwitz L, Partovian C, Lin Z, et al. Hospital-Wide All-Cause Unplanned Readmission Measure. Final Technical Report: Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHSC/CORE);, 2012.

27. Sacks GD, Dawes AJ, Russell MM, et al. Evaluation of Hospital Readmissions in Surgical Patients: Do Administrative Data Tell the Real Story? *JAMA surgery* 2014;149(8):759-64. doi: 10.1001/jamasurg.2014.18 [published Online First: 2014/06/13]

28. Yam CH, Wong EL, Chan FW, et al. Measuring and preventing potentially avoidable hospital readmissions: a review of the literature. *Hong Kong medical journal = Xianggang yi xue za zhi / Hong Kong Academy of Medicine* 2010;16(5):383-9. [published Online First: 2010/10/05]

29. Peng M, Li B, Southern DA, et al. Constructing Episodes of Inpatient Care: How to Define Hospital Transfer in Hospital Administrative Health Data? *Medical care* 2017;55(1):74-78. doi: 10.1097/mlr.0000000000000624 [published Online First: 2016/08/02]

30. Nolte E, Roland M, Guthrie S, et al. Preventing emergency readmissions to hospital. A scoping review. Santa Monica: RAND corporation, 2011.

31. CBS. HSMR 2016: Methodological report, 2017.

32. Eurostat Database OECD Health Statistics 2016. 2016 [published Online First: June 2016]

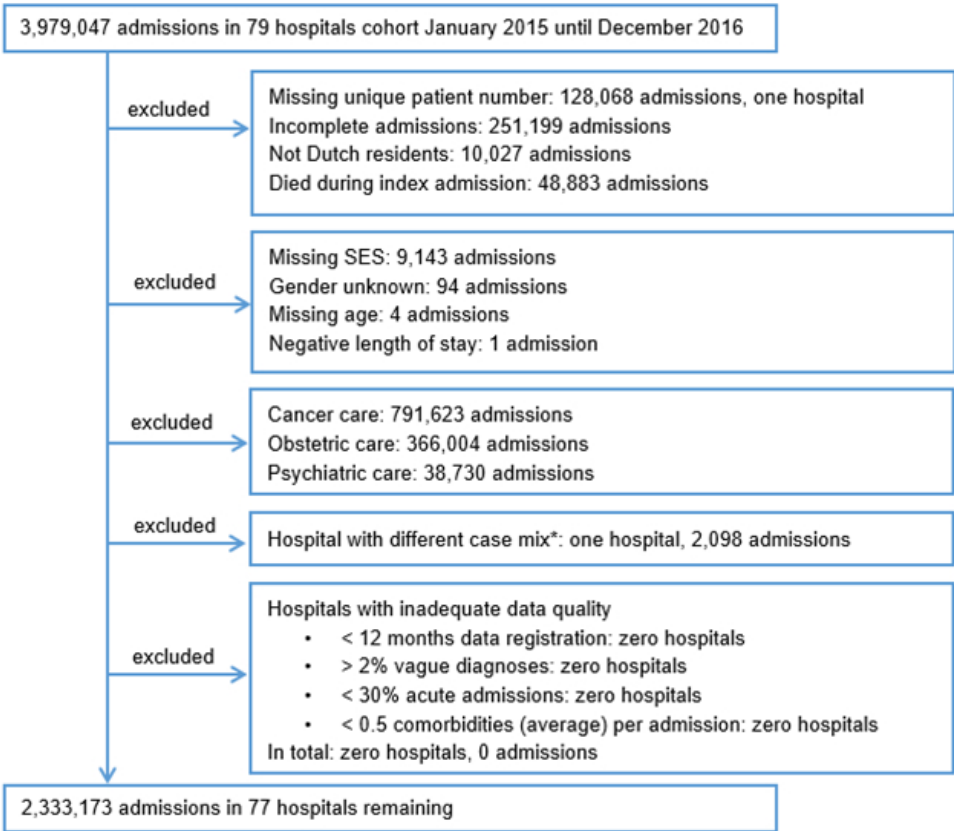
33. Hekkert K, van der Brug F, Borghans I, et al. How to identify potentially preventable readmissions by classifying them using a national administrative database. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2017;29(6):826-32. doi: 10.1093/intqhc/mxz110 [published Online First: 2017/10/13]

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.

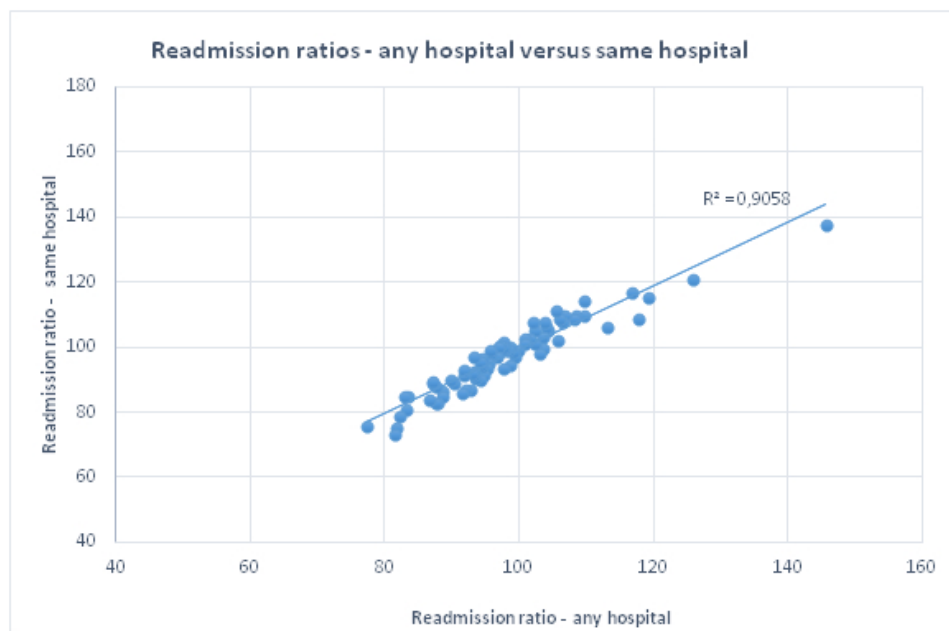
For peer review only



* 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.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025740.R1
Article Type:	Research
Date Submitted by the Author:	11-Dec-2018
Complete List of Authors:	Hekkert, Karin; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Borghans, Ine; Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection Cihangir, Sezgin; Dutch Hospital Data, Team Expertise and Support Westert, Gert; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Kool, Rudolf; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Health policy
Keywords:	Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts

1 Title page

2

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

5

6 **Names and affiliations of contributing authors:**

7 Karin Hekkert¹, Ine Borghans², Sezgin Cihangir³, Gert Westert¹, Rudolf B Kool¹

8 ¹ Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health
9 Sciences, Radboud University Medical Center, Nijmegen, Netherlands

10 ² Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection, The Netherlands

11 ³ Dutch Hospital Data, Team Expertise and Support, Utrecht, The Netherlands

12

13 **Correspondence details:**

14 Karin Hekkert

15 karin.hekkert@radboudumc.nl

16 Phone: +31 (0)633318381

17 Fax: 024 3540166

18 Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health
19 Sciences, Radboud University Medical Center, Nijmegen, Netherlands

20 P.O.Box 9101, 6500 HB Nijmegen (114), The Netherlands

21

22

23 **Word count for the abstract:** 310

24 **Word count for the text of the manuscript:** 3644

25 **Number of tables and figures:** 7

26

27

28 Abstract

29

30 **Objectives:** There is widespread use made of readmissions as an indicator of the quality of care
31 within hospitals. Including readmissions to other hospitals might have consequences for hospitals.
32 The aim of our study is to identify differences in the outcomes from a readmission ratio, with or
33 without including readmission to other hospitals.

34

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

43

44 **Main outcome measures:** percentage of readmissions to another hospital; readmission ratios same
45 hospital and any hospital, per hospital and C-statistic of each model in order to determine the
46 discriminative ability, per medical specialty.

47

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

53

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

58

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

60 Article summary

61 Strengths and limitations of this study

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

70 Introduction

71

72 Widespread use is made of readmissions as an indicator of the quality of care within hospitals.¹⁻⁴
73 Hospitals themselves use the indicator to measure and improve their quality of care,^{5,6} while
74 governments use readmissions for rankings and financial penalties.^{7,8} Because of their presumed
75 relationship to the quality of care, and the extra costs associated with them, hospitals should
76 monitor the number of readmissions carefully.¹⁹⁻¹² Monitoring readmissions can be done using
77 existing administrative data without an additional burden for healthcare professionals.¹³ However,
78 the interpretation of readmissions is complicated by the fact that there are many reasons for them
79 ¹⁴. Moreover, there are several ways of calculating readmission rates, depending on the objective of
80 the readmission measure and the data availability.^{2,15}

81

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

94

95 Several studies have shown a substantial impact when readmissions to other hospitals are included.
96 Depending on its definition, readmissions occurring in other hospitals can vary from between 17% to
97 32% of the total number of readmissions.¹⁶⁻²³ Halfon ¹⁷ and Nasir ¹⁶ specifically mentioned that the
98 part of the readmissions that occurred in another hospital varied substantially between hospitals.
99 This is an additional reason to take this mechanism into account. However, most of these studies are
100 performed in the United States so it is not known if these results are also applicable for European
101 countries with different healthcare systems, such as the Netherlands. The Dutch healthcare system is
102 based on mandatory private health insurance with an important role for the general practitioner (GP)
103 acting as the gatekeeper of secondary care. They play a crucial role in referrals to hospitals and can
104 be directive in their choice of hospitals. The question is therefore whether the abovementioned

1
2
3 105 impact, resulting from the inclusion of readmissions to other hospitals, is the same for other
4
5 106 countries. It is important to answer this question because, in the Netherlands, readmissions are an
6
7 107 indicator of the quality of care. The Dutch Health and Youth Care Inspectorate requires that hospitals
8
9 108 publicly submit their overall number of readmissions each year.²⁴ There are no financial penalties for
10
11 109 hospitals with ratios higher than the national average (more than 100). At the moment, this concerns
12
13 110 only readmissions within the same hospital.

14
15 111
16
17 112 The aim of this study is to assess the difference between case mix adjusted readmission ratios for
18
19 113 each hospital including readmissions to other hospitals and those based solely on readmissions which
20
21 114 occur in the same hospital. The research question is: What is the impact on the readmission ratio of
22
23 115 taking into account readmissions to other hospitals?

24
25 116
26
27 117 **Methods**

28
29 118
30
31 119 *Database and study population*

32
33 120 We used data from the Dutch National Basic Registration of Hospital Care (LBZ).²⁵ This database
34
35 121 provides data from all 79 general and university hospitals in the Netherlands - at the time of the
36
37 122 study period - and contains all hospital admissions. Dutch Hospital Data, the national organisation
38
39 123 that administers the data from all the hospitals, gave permission to use the data anonymously. We
40
41 124 selected index admissions with a discharge date from 1 January 2015 to 31 October 2016, and all
42
43 125 subsequent readmissions until a discharge date of 31 December 2016. The data used in this study is
44
45 126 fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands
46
47 127 (CBS). We had permission of all hospitals to use the data anonymously.

48
49 128
50
51 129 The definition of a readmission was a clinical admission to the same hospital, within 30 days of
52
53 130 discharge, following the clinical index admission - that is the original hospital stay. We chose this time
54
55 131 frame in accordance with the international literature.^{14 26} We calculated all-cause readmissions
56
57 132 meaning that they do not need to be related to the cause of the initial hospitalisation.^{26 27} We used
58
59 133 the index admission as the unit of analysis. This means that each readmission of the same patient is
60
134 again an index admission for a subsequent readmission.²⁸

135
136 Index admissions and readmissions were linked with a unique patient number obtained by a Trusted
137 Third Party (Zorg TTP) which allows an individual's information in healthcare to be exchanged
138 without compromising their privacy. Readmissions were assigned to the hospital of the index

139 admission. Transfers, which are defined as readmissions to another hospital within one day²⁹, were
140 not counted as readmissions but included as an index admission of the second hospital.

141

142 We excluded hospitals that did not register unique patient numbers. We also excluded admissions
143 that were not registered completely in the database (for example missing diagnosis). Patients not
144 living in the Netherlands were excluded as either their index admission, or their readmission, could
145 have taken place in their country of residence, and therefore readmissions could be underestimated.
146 Patients who died during their index admission were excluded from the population at risk.

147 Furthermore, we excluded admissions where data was missing on one of the variables that we used
148 in the analyses. Based on previous literature, we also excluded admissions in which the principal
149 diagnosis involved either cancer care, obstetrics or psychiatric care.³⁰

150 Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data,
151 we investigated the following criteria³¹: there should be at least twelve consecutive months of data
152 registration; not more than 2% of vague diagnoses; at least 30% acute admissions, and; at least 0.5
153 comorbidities, on average, per admission. We assessed these variables because they are subject to
154 variations in coding between different hospitals³¹ and are important in the calculation of
155 readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of
156 readmission.^{1 13} Hospitals that did not meet one or more criteria were excluded from the analyses.

157

158 *Design*

159 We performed logistic regression analyses to calculate readmission ratios for each hospital based on
160 the administrative data. The following predicting covariates for the adjustment for case mix were
161 used^{32,33}: severity of main diagnosis (a categorisation depending on the seriousness in terms of
162 mortality); gender; age category; urgency of the admission; Charlson comorbidities (17 groups of
163 comorbidity); socio-economic status (SES, based on the postal code of the patients' residence);
164 month of admission; and place of residence before admission. All variables concern the index
165 admission.

166

167 *Patient and Public Involvement*

168 Patients were not involved in the design of this study.

169

170 *Analysis*

171 We calculated the baseline characteristics of the subset of readmissions in the dataset, comparing
172 these characteristics for readmissions to the same hospital with readmissions to other hospitals. We
173 calculated readmission ratios for each hospital by dividing the observed number of readmissions by

174 the expected number of readmissions, multiplied by 100. The expected number of readmissions is
175 based on the case mix of the hospital. Two models were designed, one including only readmissions to
176 the same hospital, while the other included readmissions to any hospital. We compared the
177 readmission ratios of both models and calculated the correlation between both models with r .
178 We calculated 95% confidence intervals for the readmission ratio of each hospital to analyse if it
179 differed from the national average (readmission ratio of 100). Subsequently, we calculated the
180 number of hospitals whose position of significance compared with the national average changed
181 when taking into account readmissions to any hospital compared with to the same hospital. A change
182 in position of significance can be for example from significantly lower than the national average to no
183 significant difference from the national average.
184 The models were calculated on the hospital level for all in-patients and in more detail on the level of
185 medical specialties. The C-statistic of each model was calculated in order to determine the
186 discriminative ability. We analysed the difference in C-statistic between the models including only
187 readmissions to the same hospital, and the models with readmissions to any hospital, for each
188 medical specialty.
189 Variables with fewer than 50 admissions in a category were merged with the smallest nearby
190 category. This was done to prevent the standard errors of the regression coefficients becoming too
191 large. Comorbidities 9 and 17 (liver disease and severe liver disease), and 10 and 11 (diabetes and
192 diabetes complications), were merged into one when there were fewer than 50 admissions where
193 the comorbidity was present. Comorbidities with fewer than 50 admissions were not included in the
194 regression analysis. We calculated the part of the readmissions to other hospitals for each medical
195 specialty. Furthermore, we analysed which part of the readmissions to other hospitals concerned
196 readmissions to general hospitals, leading hospitals undertaking clinical research, and university
197 hospitals.
198 The data were analysed using R version 3.2.3. The package pROC was used to calculate the C-statistic.

200 **Results**

201
202 The database contained 2,333,173 admissions in 77 hospitals eligible for further analyses. See Figure
203 1 for all factors which resulted in hospitals or admissions being excluded from the study.
204
205 The mean age of the patients was 55 years and there were slightly more women. The admissions
206 were more often acute than non-acute. This was especially the case with readmissions (Table 1).
207
208

209 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

210

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

220

221 The percentage readmissions of all admissions was 10.3%, of which 91.1% was to the same hospital
 222 and 8.9% to another hospital (Table 2). When looking at acute admissions only, the percentage
 223 readmissions was lower (9.4%), of which a smaller percentage occurred in other hospitals (5.2%).

224

225

226 Table 2. Number of readmissions and percentage of admissions, which of these occurs in other
227 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%

228 * Transfers to another hospital were not counted as a readmission

229
230 The readmission ratios for any hospital versus the same hospital were strongly correlated (Figure 2).
231
232 In total 14% (=11/77, marked grey in Table 3) of the hospitals changed their position of significance
233 compared to the national average when taking into account readmissions to any hospital compared
234 to the same hospital (Table 3).

235
236 Table 3. Change of position of hospitals when using the readmission ratio (the observed number of
237 readmissions divided by the expected number of readmissions based on the case mix of the hospital,
238 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

239
240 When looking at the different types of hospital, such as university hospital, leading clinical hospital,
241 or general hospital, it is only the leading clinical hospitals that changed their position of significance

242 compared to the national average in a positive way, that is to say from significantly higher, to no
243 significant difference, or from no significant difference, to significantly lower. A change in position of
244 significance in a negative way, that is from significantly lower, to no significant difference, or from no
245 significant difference, to significantly higher, was seen, especially, in university hospitals. This
246 concerned 2 out of 7 university hospitals compared to 1 out of 42 for general hospitals and 2 out of
247 28 of teaching hospitals.

248 The percentage readmissions of all admissions differed between the medical specialities, from 2.9%
249 of readmissions for oral and maxillofacial surgery, to 18.5% readmissions for dermatology (Table 4).
250 The percentage of readmissions to other hospitals differed even more between the medical
251 specialties, from 5.0% of readmissions to other hospitals for urology, to 24.2% readmissions for
252 cardiothoracic surgery. The type of hospital into which the patient was readmitted also differed per
253 medical specialty. Patients discharged from cardiothoracic surgery were mainly readmitted to
254 general and leading clinical hospitals, whereas patients discharged from paediatrics were mainly
255 readmitted to university hospitals.

256

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)	Readmission ns (%)	Readmissio ns to other hospital <30 days (N)	Readmissio ns 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	1,472	2.7	492	1.1
Cardiology	77	345,162	38,878	11.3	5,739	14.8	1,915	4.9	2,074	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	1,099	2.3	404	1.6
Paediatrics	76	228,300	18,860	8.3	2,092	11.1	410	2.2	1,055	3.5	1,027	5.4
Gastroenterology & Hepatology	74	109,518	18,722	17.1	1,348	7.2	450	2.4	1,018	2.8	380	2.0
Neurology	77	193,469	15,224	7.9	2,076	13.6	522	3.4	1,020	6.0	634	4.2
Urology	77	100,582	13,350	13.3	664	5.0	276	2.1	1,055	1.9	133	1.0
Orthopaedic surgery	76	212,608	11,020	5.2	649	5.9	238	2.2	1,044	2.6	127	1.2
Obstetrics and gynaecology	77	74,150	3,413	4.6	226	6.6	82	2.4	1,044	2.8	50	1.5
Cardiothoracic surgery	15	27,320	2,564	9.4	621	24.2	311	12.1	1,092	11.4	18	0.7
Neurosurgery	54	37,312	2,534	6.8	377	14.9	196	7.7	1,051	6.0	30	1.2
Ear, Nose and Throat clinic	77	62,973	2,473	3.9	289	11.7	134	5.4	1,039	3.6	66	2.7
Clinical geriatrics	39	25,426	2,416	9.5	131	5.4	48	2.0	1,052	2.6	21	0.9
Plastic surgery	72	31,261	1,412	4.5	147	10.4	70	5.0	1,038	4.1	19	1.3

bmjopen-2018-025740 Open Access Article published on 9 April 2019. Downloaded from <http://bmjopen.bmj.com/> on March 20, 2024 by guest. Protected by copyright.

Anaesthesiology	70	9,231	1,094	11.9	140	12.8	48	4.4	51	5.6	31	2.8
Rheumatology	57	4,386	741	16.9	42	5.7	21	2.8	33	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	44	3.6	5	1.3
Oral and	71	11,835	347	2.9	57	16.4	31	8.9	22	3.5	14	4.0
Maxillofacial Surgery												
Psychiatry	28	1,310	110	8.4	17	15.5	5	4.5	9	8.2	3	2.7
Other medical	30	808	47	5.8	9	19.1	4	8.5	4	8.5	1	2.1
specialty												
Total	77	2,333,173	240,122	10.3	21,440	8.9	7,076	2.9	9,337	3.8	5,327	2.2

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

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

Discharge medical specialty index	C-statistic	95% CI	C-statistic	95% CI	Signifi	r
admission	model	C-statistic model	model	C-statistic model	cance	readmission
	any	any hospital	same	same hospital		ratios same
	hospital		hospital			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

267

268 Discussion

269

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

272

273 *Comparison with other studies*

274 We found 10.3% of admissions resulted in readmissions to any hospital, which is comparable with a
275 study of Davies (2013) which came up with a figure of 10.1% all-cause readmissions.²² However, the
276 Davies study was limited to acute care hospitals. In our analysis, we found fewer, 9.4% readmissions
277 when only looking at acute admissions and acute readmissions. Our analysis showed that 8.9% of the
278 readmissions, both acute and non-acute, were in another hospital. This is low compared to the 17-
279 32% reported in other studies.¹⁶⁻²³ These studies, however, concerned only acute care and were
280 mainly carried out in the US. When we limited our analysis to acute care, we found even fewer, 5.2%,
281 readmissions to other hospitals. This might indicate that the impact of taking into account
282 readmissions to other hospitals is not comparable across different countries with different
283 healthcare systems.

284

285 For most medical specialties, we found C-statistics of the models with readmissions to the same
286 hospital that were significantly higher. The largest significant difference was for cardiothoracic
287 surgery. This indicates better prediction of the same hospital ratio compared to the any hospital
288 ratio. However, Gonzalez et al (2014) concluded that same hospital readmission rates provided
289 unstable estimates of all-hospital readmission rates following coronary artery bypass grafting.³⁴

290 For some medical specialties, the C-statistics of the models with readmissions to any hospital we
291 found were higher, with the largest significant difference for paediatrics. This indicates better
292 prediction of the any hospital ratio compared to the same hospital ratio. A study by Kahn et al (2015)
293 also concluded that different-hospital readmissions differentially affect hospitals' paediatric
294 readmission rates.³⁵ Our study found that 14% of the hospitals changed their position of significance
295 compared to the national average when taking into account readmissions to any hospital compared
296 to the same hospital. This is quite comparable with the finding of Kahn et al (2015) that excluding
297 different-hospital readmissions incorrectly anticipated penalties for 11% of hospitals.³⁵

298

299

300 *The Dutch healthcare system*

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

308 The high level of patient satisfaction in the Netherlands can also be a reason for the low percentage
309 of readmissions to another hospital. In contrast to patients in the US, Canada, the UK or Switzerland,
310 in the Netherlands, more patients report that their regular doctor has spent enough time on their
311 consultation; has given explanations which are easy to understand, and has involved them in
312 decisions about care or treatment.³⁶ This high level of patient satisfaction could result in Dutch
313 patients usually going to the same hospital.

314

315 *Strengths and limitations*

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

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

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

333 It should also be mentioned that the Dutch National Basic Registration of Hospital Care, the LBZ, does
334 not contain a variable that distinguishes between intended and unintended readmissions. In the LBZ,
335 we do have the variable 'urgency' (acute versus non-acute admission) that indicates whether care

336 within 24 hours is needed.²⁵ A recent study reviewed medical records of readmissions to evaluate the
337 accuracy of a classification of potentially preventable readmissions with LBZ data.³³ It appeared that
338 a larger proportion of acute readmissions was classified as potentially preventable compared to non-
339 acute readmissions (28.5% versus 5.0%). Nevertheless, we included both acute and non-acute
340 admissions and readmissions in our study because complications might also result in readmissions
341 that do not have a real 24 hours urgency and to avoid hospitals considering not to code the
342 admission as acute in order to decrease their readmission ratio.

343

344 *Implications for practice*

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

354 Besides, there are two concerns when applying this in practice.

355 Firstly, hospitals cannot calculate their own readmission rate which includes readmissions to other
356 hospitals. Therefore, a national organisation is needed that monitors the data from all hospitals in a
357 specific country and which can apply case mix adjustment to readmission ratios, required if a fair
358 comparison between hospitals is to be achieved.

359 Secondly, it is illegal in the Netherlands to share information about the readmission to another
360 hospital with the hospital to which the patient was first admitted, without specific consent from the
361 patient. This means that learning from readmissions to other hospitals is complicated.

362 As a result of these concerns, we advise not to take into account readmissions to other hospitals in
363 the Dutch readmission indicator.

364

365 *Future research*

366 In order to identify areas for improvement it is necessary to assess unintended readmissions.

367 However, based on administrative data only, it is difficult to assess whether a readmission was
368 unintended. Previous research showed that about 30% of the readmissions are potentially
369 preventable.^{14,37} However, it is not known if this also applies to readmissions to other hospitals.

370 Therefore, reviewing the records of readmissions to other hospitals is needed in order to analyse

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

371 whether the readmission is a result of substandard care in the hospital where the original admission
372 took place.

373 The group of patients who most often switch hospital, young men with relatively few comorbidities,
374 may be interesting to explore further. For example, by using interviews to examine why they chose
375 another hospital for their subsequent admission, in order to learn where quality can be improved.
376

377 **Conclusion**

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

385

386 **Funding**

387 This research received no specific grant from any funding agency in the public, commercial or not-
388 for-profit sectors.

389

390 **Conflicts of interest**

391 None declared

392

393 **Author's contribution**

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

398

399 **Data availability statement**

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

402 References

- 404 1. Fischer C, Lingsma HF, Marang-van de Mheen PJ, et al. Is the readmission rate a valid quality
405 indicator? A review of the evidence. *PloS one* 2014;9(11):e112282. doi:
406 10.1371/journal.pone.0112282 [published Online First: 2014/11/08]
- 407 2. van Walraven C, Bennett C, Jennings A, et al. Proportion of hospital readmissions deemed
408 avoidable: a systematic review. *CMAJ : Canadian Medical Association journal = journal de*
409 *l'Association medicale canadienne* 2011;183(7):E391-402. doi: 10.1503/cmaj.101860
410 [published Online First: 2011/03/30]
- 411 3. Westert GP, Lagoe RJ, Keskimaki I, et al. An international study of hospital readmissions and
412 related utilization in Europe and the USA. *Health policy (Amsterdam, Netherlands)*
413 2002;61(3):269-78. [published Online First: 2002/07/06]
- 414 4. Lagoe R, Nanno D, Luziani M. Quantitative tools for addressing hospital readmissions. *BMC*
415 *Research Notes* 2012;5(1):620.
- 416 5. Bradley EH, Sipsma H, Horwitz LI, et al. Hospital Strategy Uptake and Reductions in Unplanned
417 Readmission Rates for Patients with Heart Failure: A Prospective Study. *Journal of general*
418 *internal medicine* 2014 doi: 10.1007/s11606-014-3105-5 [published Online First: 2014/12/20]
- 419 6. Hansen LO, Young RS, Hinami K, et al. Interventions to reduce 30-day rehospitalization: a
420 systematic review. *Annals of internal medicine* 2011;155(8):520-8. doi: 10.7326/0003-4819-
421 155-8-201110180-00008 [published Online First: 2011/10/19]
- 422 7. Laudicella M, Li Donni P, Smith PC. Hospital readmission rates: signal of failure or success? *Journal*
423 *of health economics* 2013;32(5):909-21. doi: 10.1016/j.jhealeco.2013.06.004 [published
424 Online First: 2013/08/14]
- 425 8. Kristensen SR, Bech M, Quentin W. A roadmap for comparing readmission policies with application
426 to Denmark, England, Germany and the United States. *Health policy (Amsterdam,*
427 *Netherlands)* 2015;119(3):264-73. doi: 10.1016/j.healthpol.2014.12.009 [published Online
428 First: 2014/12/31]
- 429 9. Ashton CM, Kuykendall DH, Johnson ML, et al. The association between the quality of inpatient
430 care and early readmission. *Annals of internal medicine* 1995;122(6):415-21. [published
431 Online First: 1995/03/15]
- 432 10. Chung ES, Guo L, Casey Jr DE, et al. Relationship of a quality measure composite to clinical
433 outcomes for patients with heart failure. *American journal of medical quality : the official*
434 *journal of the American College of Medical Quality* 2008;23(3):168-75. doi:
435 10.1177/1062860608315337 [published Online First: 2008/06/10]
- 436 11. Encinosa WE, Hellinger FJ. The impact of medical errors on ninety-day costs and outcomes: an
437 examination of surgical patients. *Health services research* 2008;43(6):2067-85. doi:
438 10.1111/j.1475-6773.2008.00882.x [published Online First: 2008/07/30]
- 439 12. Rosen AK, Loveland S, Shin M, et al. Examining the impact of the AHRQ Patient Safety Indicators
440 (PSIs) on the Veterans Health Administration: the case of readmissions. *Medical care*
441 2013;51(1):37-44. doi: 10.1097/MLR.0b013e318270c0f7 [published Online First: 2012/10/04]
- 442 13. Halfon P, Eggli Y, van Melle G, et al. Measuring potentially avoidable hospital readmissions.
443 *Journal of clinical epidemiology* 2002;55(6):573-87. [published Online First: 2002/06/14]
- 444 14. Blunt I, Bardsley M, Grove A, et al. Classifying emergency 30-day readmissions in England using
445 routine hospital data 2004-2010: what is the scope for reduction? *Emergency medicine*
446 *journal : EMJ* 2014 doi: 10.1136/emered-2013-202531 [published Online First: 2014/03/29]
- 447 15. Hechenbleikner EM, Makary MA, Samarov DV, et al. Hospital readmission by method of data
448 collection. *Journal of the American College of Surgeons* 2013;216(6):1150-8. doi:
449 10.1016/j.jamcollsurg.2013.01.057 [published Online First: 2013/04/16]
- 450 16. Nasir K, Lin Z, Bueno H, et al. Is same-hospital readmission rate a good surrogate for all-hospital
451 readmission rate? *Medical care* 2010;48(5):477-81. doi: 10.1097/MLR.0b013e3181d5fb24
452 [published Online First: 2010/04/16]

17. Halfon P, Eggli Y, Pretre-Rohrbach I, et al. Validation of the potentially avoidable hospital readmission rate as a routine indicator of the quality of hospital care. *Medical care* 2006;44(11):972-81. doi: 10.1097/01.mlr.0000228002.43688.c2 [published Online First: 2006/10/26]
18. Metcalfe D, Olufajo OA, Zogg CK, et al. Unplanned 30-day readmissions in orthopaedic trauma. *Injury* 2016;47(8):1794-7. doi: 10.1016/j.injury.2016.05.007 [published Online First: 2016/06/06]
19. Moore L, Stelfox HT, Turgeon AF, et al. Rates, patterns, and determinants of unplanned readmission after traumatic injury: a multicenter cohort study. *Annals of surgery* 2014;259(2):374-80. doi: 10.1097/SLA.0b013e31828b0fae [published Online First: 2013/03/13]
20. Luu NP, Hussain T, Chang HY, et al. Readmissions After Colon Cancer Surgery: Does It Matter Where Patients Are Readmitted? *Journal of oncology practice* 2016;12(5):e502-12. doi: 10.1200/jop.2015.007757 [published Online First: 2016/04/07]
21. Kim H, Hung WW, Paik MC, et al. Predictors and outcomes of unplanned readmission to a different hospital. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2015;27(6):513-9. doi: 10.1093/intqhc/mzv082 [published Online First: 2015/10/17]
22. Davies SM, Saynina O, McDonald KM, et al. Limitations of using same-hospital readmission metrics. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2013;25(6):633-9. doi: 10.1093/intqhc/mzt068 [published Online First: 2013/10/30]
23. Parreco J, Buicko J, Cortolillo N, et al. Risk factors and costs associated with nationwide nonelective readmission after trauma. *The journal of trauma and acute care surgery* 2017;83(1):126-34. doi: 10.1097/ta.0000000000001505 [published Online First: 2017/04/20]
24. Kwaliteitsindicatoren Basisset ziekenhuizen 2016. In: Dutch Health Care Inspectorate MoH, Welfare and Sport, ed. Utrecht, , 09-2015:164 and 67.
25. DHD. Landelijke Basisregistratie Ziekenhuiszorg (LBZ) [Available from: <https://www.dhd.nl/producten-diensten/lbz/paginas/dataverzameling-lbz.aspx> accessed 18-12-2017.
26. Horwitz L, Partovian C, Lin Z, et al. Hospital-Wide All-Cause Unplanned Readmission Measure. Final Technical Report: Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE);, 2012.
27. Sacks GD, Dawes AJ, Russell MM, et al. Evaluation of Hospital Readmissions in Surgical Patients: Do Administrative Data Tell the Real Story? *JAMA surgery* 2014;149(8):759-64. doi: 10.1001/jamasurg.2014.18 [published Online First: 2014/06/13]
28. Yam CH, Wong EL, Chan FW, et al. Measuring and preventing potentially avoidable hospital readmissions: a review of the literature. *Hong Kong medical journal = Xianggang yi xue za zhi / Hong Kong Academy of Medicine* 2010;16(5):383-9. [published Online First: 2010/10/05]
29. Peng M, Li B, Southern DA, et al. Constructing Episodes of Inpatient Care: How to Define Hospital Transfer in Hospital Administrative Health Data? *Medical care* 2017;55(1):74-78. doi: 10.1097/mlr.0000000000000624 [published Online First: 2016/08/02]
30. Nolte E, Roland M, Guthrie S, et al. Preventing emergency readmissions to hospital. A scoping review. Santa Monica: RAND corporation, 2011.
31. CBS. HSMR 2016: Methodological report, 2017.
32. Kansagara D, Englander H, Salanitro A, Kagen D, Theobald C, Freeman M, Kripalani S: Risk prediction models for hospital readmission: a systematic review. *JAMA : the journal of the American Medical Association* 2011, 306(15):1688-1698.
33. Vest JR, Gamm LD, Oxford BA, Gonzalez MI, Slawson KM: Determinants of preventable readmissions in the United States: a systematic review. *Implementation science : IS* 2010, 5:88.

- 504 34. Gonzalez AA, Shih T, Dimick JB, et al. Using Same-Hospital Readmission Rates to Estimate All-
505 Hospital Readmission Rates. *J Am Coll Surg*. 2014 Oct; 219(4): 656–663.
- 506 35. Khan A, Nakamura MM, Zaslavsky AM, et al. Same-Hospital Readmission Rates as a Measure of
507 Pediatric Quality of Care. *JAMA Pediatr*. 2015 Oct; 169(10): 905–912.
- 508 36. Eurostat Database OECD Health Statistics 2016. 2016 [published Online First: June 2016]
- 509 37. Hekkert K, van der Brug F, Borghans I, et al. How to identify potentially preventable readmissions
510 by classifying them using a national administrative database. *International journal for quality*
511 *in health care : journal of the International Society for Quality in Health Care / ISQua*
512 2017;29(6):826-32. doi: 10.1093/intqhc/mzx110 [published Online First: 2017/10/13]
513

514

515 Figure legends

516

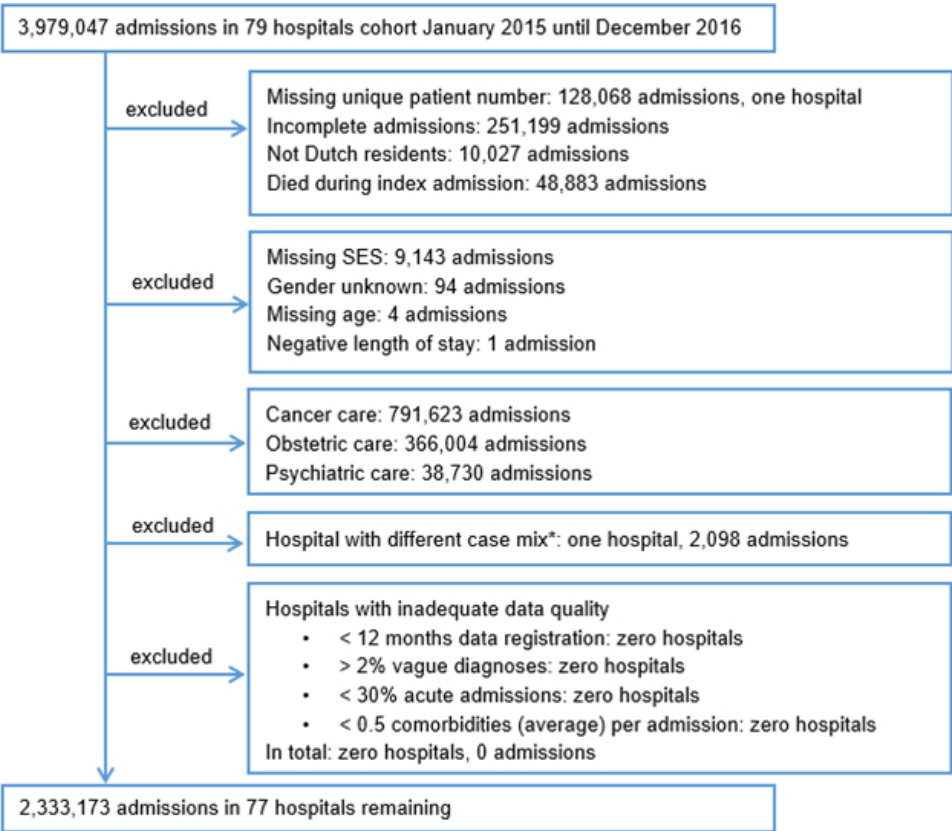
517 Figure 1. Flowchart admissions in the dataset

518

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

521

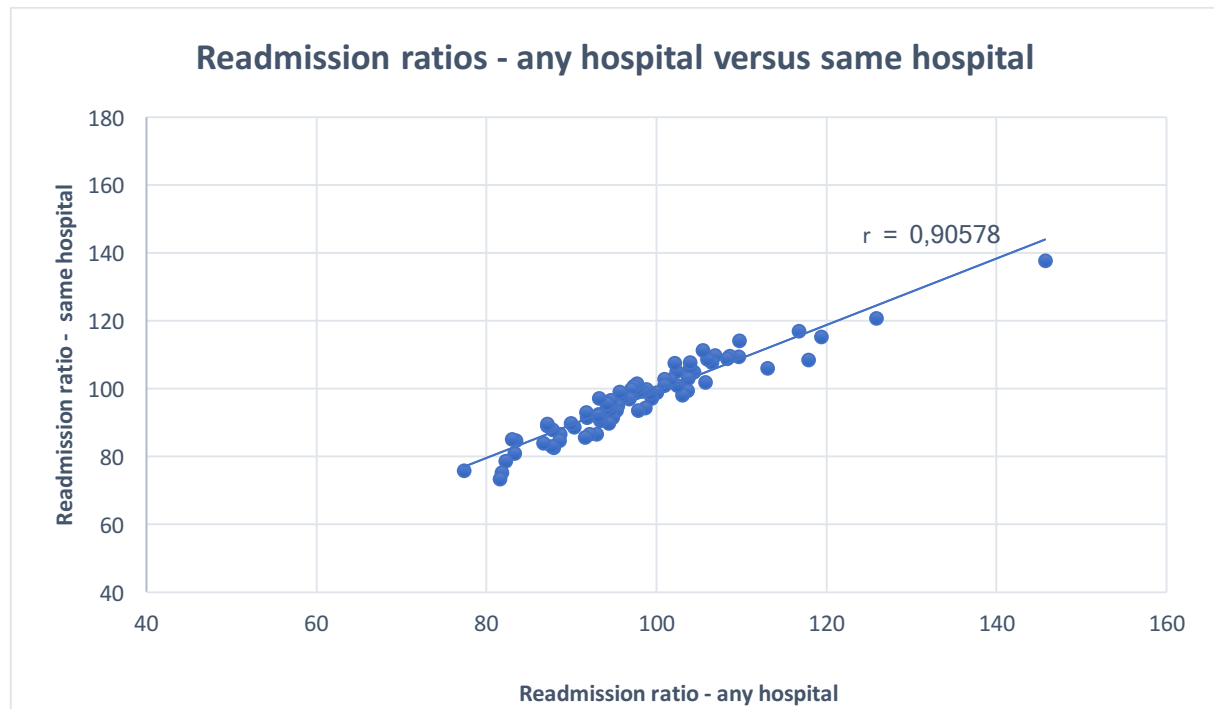
522



* 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.

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-025740.R2
Article Type:	Research
Date Submitted by the Author:	21-Feb-2019
Complete List of Authors:	Hekkert, Karin; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Borghans, Ine; Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection Cihangir, Sezgin; Dutch Hospital Data, Team Expertise and Support Westert, Gert; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences Kool, Rudolf; Radboud University Medical Center, Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health Sciences
Primary Subject Heading:	Health policy
Secondary Subject Heading:	Health policy, Health services research
Keywords:	Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts

1 Title page

2

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

5

6 **Names and affiliations of contributing authors:**

7 Karin Hekkert¹, Ine Borghans², Sezgin Cihangir³, Gert Westert¹, Rudolf B Kool¹

8 ¹ Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health
9 Sciences, Radboud University Medical Center, Nijmegen, Netherlands

10 ² Dutch Health and Youth Care Inspectorate (IGJ), Team Risk Detection, The Netherlands

11 ³ Dutch Hospital Data, Team Expertise and Support, Utrecht, The Netherlands

12

13 **Correspondence details:**

14 Karin Hekkert

15 karin.hekkert@radboudumc.nl

16 Phone: +31 (0)633318381

17 Fax: 024 3540166

18 Scientific Center for Quality of Healthcare (IQ healthcare), Radboud Institute for Health
19 Sciences, Radboud University Medical Center, Nijmegen, Netherlands

20 P.O.Box 9101, 6500 HB Nijmegen (114), The Netherlands

21

22

23 **Word count for the abstract:** 299

24 **Word count for the text of the manuscript:** 3594

25 **Number of tables and figures:** 7

26

27

28 Abstract

29

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

34

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

43

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

47

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

53

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

58

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

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

60 Article summary

61 Strengths and limitations of this study

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

70 Introduction

71

72 Widespread use is made of readmissions as an indicator of the quality of care within hospitals.¹⁻⁴
73 Hospitals themselves use the indicator to measure and improve their quality of care,^{5,6} while
74 governments use readmissions for rankings and financial penalties.^{7,8} Because of their presumed
75 relationship to the quality of care, and the extra costs associated with them, hospitals should
76 monitor the number of readmissions carefully.¹⁹⁻¹² Monitoring readmissions can be done using
77 existing administrative data without an additional burden for healthcare professionals.¹³ However,
78 the interpretation of readmissions is complicated by the fact that there are many reasons for them
79 ¹⁴. Moreover, there are several ways of calculating readmission rates, depending on the objective of
80 the readmission measure and the data availability.^{2,15}

81

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

94

95 Several studies have shown a substantial impact when readmissions to other hospitals are included.
96 Depending on its definition, readmissions occurring in other hospitals can vary from between 17% to
97 32% of the total number of readmissions.¹⁶⁻²³ Halfon ¹⁷ and Nasir ¹⁶ specifically mentioned that the
98 part of the readmissions that occurred in another hospital varied substantially between hospitals.
99 This is an additional reason to take this mechanism into account. However, most of these studies are
100 performed in the United States so it is not known if these results are also applicable for European
101 countries with different healthcare systems, such as the Netherlands. The Dutch healthcare system is
102 based on mandatory private health insurance with an important role for the general practitioner (GP)
103 acting as the gatekeeper of secondary care. They play a crucial role in referrals to hospitals and can
104 be directive in their choice of hospitals. The question is therefore whether the abovementioned

1
2
3 105 impact, resulting from the inclusion of readmissions to other hospitals, is the same for other
4
5 106 countries. It is important to answer this question because, in the Netherlands, readmissions are an
6
7 107 indicator of the quality of care. The Dutch Health and Youth Care Inspectorate requires that hospitals
8
9 108 publicly submit their overall number of readmissions each year.²⁴ There are no financial penalties for
10
11 109 hospitals with more readmissions than the national average (readmission ratio more than 100). At
12
13 110 the moment, this concerns only readmissions within the same hospital.

14
15 111
16
17 112 The aim of this study is to assess the difference between case mix adjusted readmission ratios for
18
19 113 each hospital including readmissions to other hospitals and those based solely on readmissions which
20
21 114 occur in the same hospital. The research question is: What is the impact on the readmission ratio of
22
23 115 taking into account readmissions to other hospitals?

24
25 116
26
27 117 **Methods**

28
29 118
30
31 119 *Database and study population*

32
33 120 We used data from the Dutch National Basic Registration of Hospital Care (LBZ).²⁵ This database
34
35 121 provides data from all 79 general and university hospitals in the Netherlands - at the time of the
36
37 122 study period - and contains all hospital admissions. Dutch Hospital Data, the national organisation
38
39 123 that administers the data from all the hospitals, gave permission to use the data anonymously. We
40
41 124 selected index admissions with a discharge date from 1 January 2015 to 31 October 2016, and all
42
43 125 subsequent readmissions until a discharge date of 31 December 2016. The data used in this study is
44
45 126 fully anonymised and publicly available for researchers via Remote Access to Statistics Netherlands
46
47 127 (CBS). We had permission of all hospitals to use the data anonymously.

48
49 128
50
51 129 The definition of a readmission was a clinical admission to the same hospital, within 30 days of
52
53 130 discharge, following the clinical index admission - that is the original hospital stay. We chose this time
54
55 131 frame in accordance with the international literature.^{14 26} We calculated all-cause readmissions
56
57 132 meaning that they do not need to be related to the cause of the initial hospitalisation.^{26 27} We used
58
59 133 the index admission as the unit of analysis. This means that each readmission of the same patient is
60
134 again an index admission for a subsequent readmission.²⁸

135
136 Index admissions and readmissions were linked with a unique patient number obtained by a Trusted
137 Third Party (Zorg TTP) which allows an individual's information in healthcare to be exchanged
138 without compromising their privacy. Readmissions were assigned to the hospital of the index

139 admission. Transfers, which are defined as readmissions to another hospital within one day²⁹, were
140 not counted as readmissions but included as an index admission of the second hospital.

141

142 We excluded hospitals that did not register unique patient numbers. We also excluded admissions
143 that were not registered completely in the database (for example missing diagnosis). Patients not
144 living in the Netherlands were excluded as either their index admission, or their readmission, could
145 have taken place in their country of residence, and therefore readmissions could be underestimated.
146 Patients who died during their index admission were excluded from the population at risk.

147 Furthermore, we excluded admissions where data was missing on one of the variables that we used
148 in the analyses. Based on previous literature, we also excluded admissions in which the principal
149 diagnosis involved either cancer care, obstetrics or psychiatric care.³⁰

150 Hospitals with inadequate quality of data were also excluded. In order to assess the quality of data,
151 we investigated the following criteria³¹: there should be at least twelve consecutive months of data
152 registration; not more than 2% of vague diagnoses; at least 30% acute admissions, and; at least 0.5
153 comorbidities, on average, per admission. We assessed these variables because they are subject to
154 variations in coding between different hospitals³¹ and are important in the calculation of
155 readmissions. Acute admissions and admissions with multiple comorbidities have a higher risk of
156 readmission.^{1 13} Hospitals that did not meet one or more criteria were excluded from the analyses.

157

158 *Design*

159 We performed logistic regression analyses to calculate readmission ratios for each hospital based on
160 the administrative data. We did not perform hierarchical modelling, as a recent study showed that
161 adding a hospital level had only a very small impact on the results.³² The following predicting
162 covariates for the adjustment for case mix were used:^{33,34} severity of main diagnosis (a categorisation
163 depending on the seriousness in terms of mortality); gender; age category; urgency of the admission;
164 Charlson comorbidities (17 groups of comorbidity); socio-economic status (SES, based on the postal
165 code of the patients' residence); month of admission; and place of residence before admission. All
166 variables concern the index admission.

167

168 *Patient and Public Involvement*

169 Patients were not involved in the design of this study.

170

171 *Analysis*

172 We calculated the baseline characteristics of the subset of readmissions in the dataset, comparing
173 these characteristics for readmissions to the same hospital with readmissions to other hospitals. We

1
2
3 174 calculated readmission ratios for each hospital by dividing the observed number of readmissions by
4
5 175 the expected number of readmissions, multiplied by 100. The expected number of readmissions is
6
7 176 based on the case mix of the hospital. Two models were designed, one including only readmissions to
8
9 177 the same hospital, while the other included readmissions to any hospital. We compared the
10
11 178 readmission ratios of both models and calculated the correlation between both models with r .
12
13 179 We calculated 95% confidence intervals for the readmission ratio of each hospital to analyse if it
14
15 180 differed from the national average (readmission ratio of 100). Subsequently, we calculated the
16
17 181 number of hospitals whose position of significance compared with the national average changed
18
19 182 when taking into account readmissions to any hospital compared with to the same hospital. A change
20
21 183 in position of significance can be for example from significantly lower than the national average to no
22
23 184 significant difference from the national average.
24
25 185 The models were calculated on the hospital level for all in-patients and in more detail on the level of
26
27 186 medical specialties. The C-statistic of each model was calculated in order to determine the
28
29 187 discriminative ability. We analysed the difference in C-statistic between the models including only
30
31 188 readmissions to the same hospital, and the models with readmissions to any hospital, for each
32
33 189 medical specialty.
34
35 190 Variables with fewer than 50 admissions in a category were merged with the smallest nearby
36
37 191 category. This was done to prevent the standard errors of the regression coefficients becoming too
38
39 192 large. Comorbidities 9 and 17 (liver disease and severe liver disease), and 10 and 11 (diabetes and
40
41 193 diabetes complications), were merged into one when there were fewer than 50 admissions where
42
43 194 the comorbidity was present. Comorbidities with fewer than 50 admissions were not included in the
44
45 195 regression analysis. We calculated the part of the readmissions to other hospitals for each medical
46
47 196 specialty. Furthermore, we analysed which part of the readmissions to other hospitals concerned
48
49 197 readmissions to general hospitals, leading hospitals undertaking clinical research, and university
50
51 198 hospitals.
52
53 199 The data were analysed using R version 3.2.3. The package pROC was used to calculate the C-statistic.
54
55 200
56
57 201
58
59 202

201 **Results**

202
203 The database contained 2,333,173 admissions in 77 hospitals eligible for further analyses. See Figure
204 1 for all factors which resulted in hospitals or admissions being excluded from the study.
205
206 The mean age of the patients was 55 years and there were slightly more women. The admissions
207 were more often acute than non-acute. This was especially the case with readmissions (Table 1).

208 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)	*

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

211

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

221

222 The percentage readmissions of all admissions was 10.3%, of which 91.1% was to the same hospital
223 and 8.9% to another hospital (Table 2). When looking at acute admissions only, the percentage
224 readmissions was lower (9.4%), of which a smaller percentage occurred in other hospitals (5.2%).

225

226

227 Table 2. Number of readmissions and percentage of admissions, which of these occurs in other
228 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%

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

230

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

232

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

236

237 Table 3. Change of position of hospitals when using the readmission ratio¹ to same hospital versus
238 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

239

240 ¹ Readmission ratio is the observed number of readmissions divided by the expected number of readmissions
241 based on the case mix of the hospital, multiplied by 100.

242 ² Significantly lower readmission ratio means less readmissions compared to the national average.

243 ³ Significantly higher readmission ratio means more readmissions compared to the national average.

244

245 When looking at the different types of hospital, such as university hospital, leading clinical hospital,
246 or general hospital, it is only the leading clinical hospitals that changed their position of significance
247 compared to the national average in a positive way, that is to say from significantly higher, to no
248 significant difference, or from no significant difference, to significantly lower. A change in position of
249 significance in a negative way, that is from significantly lower, to no significant difference, or from no
250 significant difference, to significantly higher, was seen, especially, in university hospitals. This
251 concerned 2 out of 7 university hospitals compared to 1 out of 42 for general hospitals and 2 out of
252 28 of teaching hospitals.

253 The percentage readmissions of all admissions differed between the medical specialties, from 2.9%
254 of readmissions for oral and maxillofacial surgery, to 18.5% readmissions for dermatology (Table 4).

255 The percentage of readmissions to other hospitals differed even more between the medical
256 specialties, from 5.0% of readmissions to other hospitals for urology, to 24.2% readmissions for
257 cardiothoracic surgery. The type of hospital into which the patient was readmitted also differed per
258 medical specialty. Patients discharged from cardiothoracic surgery were mainly readmitted to
259 general and leading clinical hospitals, whereas patients discharged from paediatrics were mainly
260 readmitted to university hospitals.

261

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)	Readmission ns (%)	Readmissio ns to other hospital <30 days (N)	Readmissio ns 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	1,472	2.7	492	1.1
Cardiology	77	345,162	38,878	11.3	5,739	14.8	1,915	4.9	2,074	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	1,099	2.3	404	1.6
Paediatrics	76	228,300	18,860	8.3	2,092	11.1	410	2.2	1,055	3.5	1,027	5.4
Gastroenterology & Hepatology	74	109,518	18,722	17.1	1,348	7.2	450	2.4	1,018	2.8	380	2.0
Neurology	77	193,469	15,224	7.9	2,076	13.6	522	3.4	1,020	6.0	634	4.2
Urology	77	100,582	13,350	13.3	664	5.0	276	2.1	1,055	1.9	133	1.0
Orthopaedic surgery	76	212,608	11,020	5.2	649	5.9	238	2.2	1,044	2.6	127	1.2
Obstetrics and gynaecology	77	74,150	3,413	4.6	226	6.6	82	2.4	1,044	2.8	50	1.5
Cardiothoracic surgery	15	27,320	2,564	9.4	621	24.2	311	12.1	1,092	11.4	18	0.7
Neurosurgery	54	37,312	2,534	6.8	377	14.9	196	7.7	1,051	6.0	30	1.2
Ear, Nose and Throat clinic	77	62,973	2,473	3.9	289	11.7	134	5.4	1,039	3.6	66	2.7
Clinical geriatrics	39	25,426	2,416	9.5	131	5.4	48	2.0	1,052	2.6	21	0.9
Plastic surgery	72	31,261	1,412	4.5	147	10.4	70	5.0	1,038	4.1	19	1.3

bmjopen-2018-025740 Open Access Article published on 9 April 2019. Downloaded from <http://bmjopen.bmj.com/> on March 20, 2024 by guest. Protected by copyright.

Anaesthesiology	70	9,231	1,094	11.9	140	12.8	48	4.4	51	5.6	31	2.8
Rheumatology	57	4,386	741	16.9	42	5.7	21	2.8	33	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	34	3.6	5	1.3
Oral and	71	11,835	347	2.9	57	16.4	31	8.9	22	3.5	14	4.0
Maxillofacial Surgery												
Psychiatry	28	1,310	110	8.4	17	15.5	5	4.5	9	8.2	3	2.7
Other medical	30	808	47	5.8	9	19.1	4	8.5	4	8.5	1	2.1
specialty												
Total	77	2,333,173	240,122	10.3	21,440	8.9	7,076	2.9	9,337	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 95% CI		C-statistic 95% CI		Significance	readmission ratios same versus any hospital
	model	C-statistic model	model	C-statistic model		
	any	any hospital	same	same hospital		
	hospital		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

273 Discussion

274

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

277

278 *Comparison with other studies*

279 We found 10.3% of admissions resulted in readmissions to any hospital, which is comparable with a
280 study of Davies (2013) which came up with a figure of 10.1% all-cause readmissions.²² However, the
281 Davies study was limited to acute care hospitals. In our analysis, we found fewer, 9.4% readmissions
282 when only looking at acute admissions and acute readmissions. Our analysis showed that 8.9% of the
283 readmissions, both acute and non-acute, were in another hospital. This is low compared to the 17-
284 32% reported in other studies.¹⁶⁻²³ These studies, however, concerned only acute care and were
285 mainly carried out in the US. When we limited our analysis to acute care, we found even fewer, 5.2%,
286 readmissions to other hospitals. This might indicate that the impact of taking into account
287 readmissions to other hospitals is not comparable across different countries with different
288 healthcare systems.

289

290 For most medical specialties, we found C-statistics of the models with readmissions to the same
291 hospital that were significantly higher. The largest significant difference was for cardiothoracic
292 surgery. This indicates better prediction of the same hospital ratio compared to the any hospital
293 ratio. However, Gonzalez et al (2014) concluded that same hospital readmission rates provided
294 unstable estimates of all-hospital readmission rates following coronary artery bypass grafting.

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

303

304

305 *The Dutch healthcare system*

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

313 The high level of patient satisfaction in the Netherlands can also be a reason for the low percentage
314 of readmissions to another hospital. In contrast to patients in the US, Canada, the UK or Switzerland,
315 in the Netherlands, more patients report that their regular doctor has spent enough time on their
316 consultation; has given explanations which are easy to understand, and has involved them in
317 decisions about care or treatment.³⁵ This high level of patient satisfaction could result in Dutch
318 patients usually going to the same hospital.

319

320 *Strengths and limitations*

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

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

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

338 It should also be mentioned that the Dutch National Basic Registration of Hospital Care, the LBZ, does
339 not contain a variable that distinguishes between intended and unintended readmissions. In the LBZ,
340 we do have the variable 'urgency' (acute versus non-acute admission) that indicates whether care

341 within 24 hours is needed.²⁵ A recent study reviewed medical records of readmissions to evaluate the
342 accuracy of a classification of potentially preventable readmissions with LBZ data.³⁶ It appeared that
343 a larger proportion of acute readmissions was classified as potentially preventable compared to non-
344 acute readmissions (28.5% versus 5.0%). Nevertheless, we included both acute and non-acute
345 admissions and readmissions in our study because complications might also result in readmissions
346 that do not have a real 24 hours urgency and to avoid hospitals considering not to code the
347 admission as acute in order to decrease their readmission ratio.

348

349 *Implications for practice*

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

360 Firstly, hospitals cannot calculate their own readmission rate which includes readmissions to other
361 hospitals. Therefore, a national organisation is needed that monitors the data from all hospitals in a
362 specific country and which can apply case mix adjustment to readmission ratios, required if a fair
363 comparison between hospitals is to be achieved.

364 Secondly, it is illegal in the Netherlands to share information about the readmission to another
365 hospital with the hospital to which the patient was first admitted, without specific consent from the
366 patient. This means that learning from readmissions to other hospitals is complicated.

367 As a result of these concerns, we advise not to take into account readmissions to other hospitals in
368 the Dutch readmission indicator.

369

370 *Future research*

371 In order to identify areas for improvement it is necessary to assess unintended readmissions.
372 However, based on administrative data only, it is difficult to assess whether a readmission was
373 unintended. Previous research showed that about 30% of the readmissions are potentially
374 preventable.^{14 36} However, it is not known if this also applies to readmissions to other hospitals.
375 Therefore, reviewing the records of readmissions to other hospitals is needed in order to analyse

1
2
3 376 whether the readmission is a result of substandard care in the hospital where the original admission
4
5 377 took place.
6
7 378 The group of patients who most often switch hospital, young men with relatively few comorbidities,
8
9 379 may be interesting to explore further. For example, by using interviews to examine why they chose
10
11 380 another hospital for their subsequent admission, in order to learn where quality can be improved.
12
13 381

14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29 382 **Conclusion**

30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
383 Overall the impact on the readmission ratio of taking into account readmissions to other hospitals
384 seems to be limited. We found 8.9% of the readmissions occur in another hospital, while 91.1% of
385 the readmissions occur in the same hospital. However, for some hospitals, it does have
386 consequences as 14% of the hospitals change their position of significance compared to the national
387 average on the readmission ratio when taking into account readmissions to other hospitals. For these
388 hospitals, it is interesting to explore what causes this difference and if it is related to the quality of
389 care.

390

391 **Funding**

392 This research received no specific grant from any funding agency in the public, commercial or not-
393 for-profit sectors.

394

395 **Conflicts of interest**

396 None declared

397

398 **Author's contribution**

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

403

404 **Data sharing statement**

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

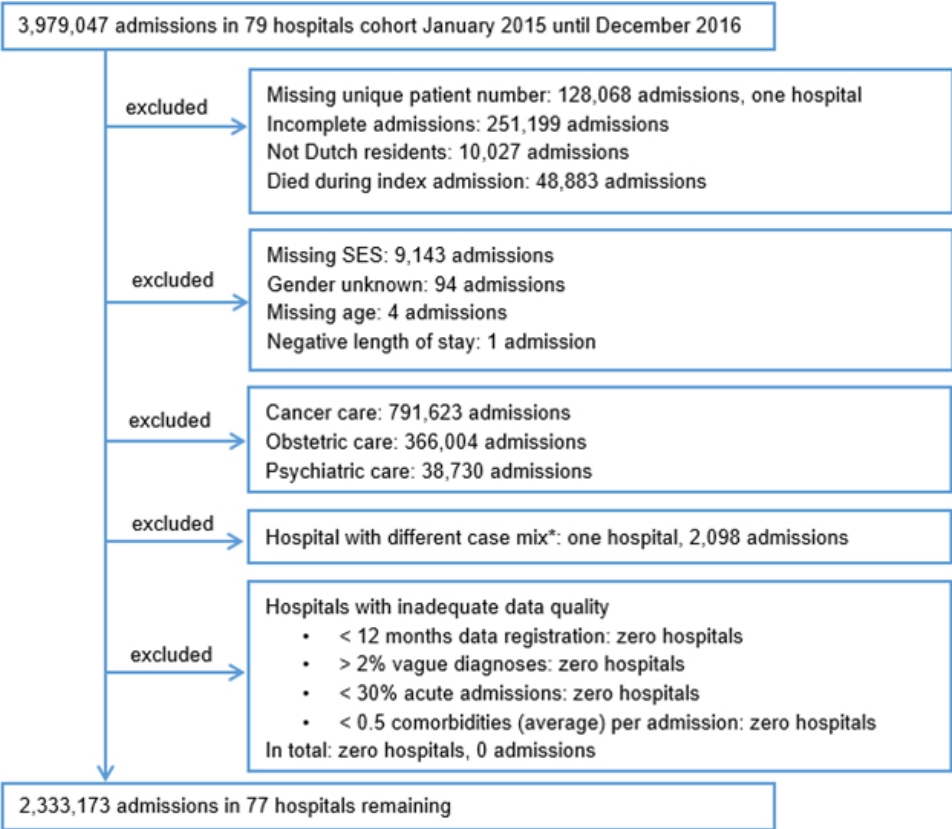
407 References

408

- 409 1. Fischer C, Lingsma HF, Marang-van de Mheen PJ, et al. Is the readmission rate a valid quality
410 indicator? A review of the evidence. *PloS one* 2014;9(11):e112282. doi:
411 10.1371/journal.pone.0112282 [published Online First: 2014/11/08]
- 412 2. van Walraven C, Bennett C, Jennings A, et al. Proportion of hospital readmissions deemed
413 avoidable: a systematic review. *CMAJ : Canadian Medical Association journal = journal de*
414 *l'Association medicale canadienne* 2011;183(7):E391-402. doi: 10.1503/cmaj.101860
415 [published Online First: 2011/03/30]
- 416 3. Westert GP, Lagoe RJ, Keskimaki I, et al. An international study of hospital readmissions and
417 related utilization in Europe and the USA. *Health policy (Amsterdam, Netherlands)*
418 2002;61(3):269-78. [published Online First: 2002/07/06]
- 419 4. Lagoe R, Nanno D, Luziani M. Quantitative tools for addressing hospital readmissions. *BMC*
420 *Research Notes* 2012;5(1):620.
- 421 5. Bradley EH, Sipsma H, Horwitz LI, et al. Hospital Strategy Uptake and Reductions in Unplanned
422 Readmission Rates for Patients with Heart Failure: A Prospective Study. *Journal of general*
423 *internal medicine* 2014 doi: 10.1007/s11606-014-3105-5 [published Online First:
424 2014/12/20]
- 425 6. Hansen LO, Young RS, Hinami K, et al. Interventions to reduce 30-day rehospitalization: a
426 systematic review. *Annals of internal medicine* 2011;155(8):520-8. doi: 10.7326/0003-4819-
427 155-8-201110180-00008 [published Online First: 2011/10/19]
- 428 7. Laudicella M, Li Donni P, Smith PC. Hospital readmission rates: signal of failure or success? *Journal*
429 *of health economics* 2013;32(5):909-21. doi: 10.1016/j.jhealeco.2013.06.004 [published
430 Online First: 2013/08/14]
- 431 8. Kristensen SR, Bech M, Quentin W. A roadmap for comparing readmission policies with application
432 to Denmark, England, Germany and the United States. *Health policy (Amsterdam,*
433 *Netherlands)* 2015;119(3):264-73. doi: 10.1016/j.healthpol.2014.12.009 [published Online
434 First: 2014/12/31]
- 435 9. Ashton CM, Kuykendall DH, Johnson ML, et al. The association between the quality of inpatient
436 care and early readmission. *Annals of internal medicine* 1995;122(6):415-21. [published
437 Online First: 1995/03/15]
- 438 10. Chung ES, Guo L, Casey Jr DE, et al. Relationship of a quality measure composite to clinical
439 outcomes for patients with heart failure. *American journal of medical quality : the official*
440 *journal of the American College of Medical Quality* 2008;23(3):168-75. doi:
441 10.1177/1062860608315337 [published Online First: 2008/06/10]
- 442 11. Encinosa WE, Hellinger FJ. The impact of medical errors on ninety-day costs and outcomes: an
443 examination of surgical patients. *Health services research* 2008;43(6):2067-85. doi:
444 10.1111/j.1475-6773.2008.00882.x [published Online First: 2008/07/30]
- 445 12. Rosen AK, Loveland S, Shin M, et al. Examining the impact of the AHRQ Patient Safety Indicators
446 (PSIs) on the Veterans Health Administration: the case of readmissions. *Medical care*
447 2013;51(1):37-44. doi: 10.1097/MLR.0b013e318270c0f7 [published Online First: 2012/10/04]
- 448 13. Halfon P, Egli Y, van Melle G, et al. Measuring potentially avoidable hospital readmissions.
449 *Journal of clinical epidemiology* 2002;55(6):573-87. [published Online First: 2002/06/14]
- 450 14. Blunt I, Bardsley M, Grove A, et al. Classifying emergency 30-day readmissions in England using
451 routine hospital data 2004-2010: what is the scope for reduction? *Emergency medicine*
452 *journal : EMJ* 2014 doi: 10.1136/emered-2013-202531 [published Online First: 2014/03/29]
- 453 15. Hechenbleikner EM, Makary MA, Samarov DV, et al. Hospital readmission by method of data
454 collection. *Journal of the American College of Surgeons* 2013;216(6):1150-8. doi:
455 10.1016/j.jamcollsurg.2013.01.057 [published Online First: 2013/04/16]

16. Nasir K, Lin Z, Bueno H, et al. Is same-hospital readmission rate a good surrogate for all-hospital readmission rate? *Medical care* 2010;48(5):477-81. doi: 10.1097/MLR.0b013e3181d5fb24 [published Online First: 2010/04/16]
17. Halfon P, Egli Y, Pretre-Rohrbach I, et al. Validation of the potentially avoidable hospital readmission rate as a routine indicator of the quality of hospital care. *Medical care* 2006;44(11):972-81. doi: 10.1097/01.mlr.0000228002.43688.c2 [published Online First: 2006/10/26]
18. Metcalfe D, Olufajo OA, Zogg CK, et al. Unplanned 30-day readmissions in orthopaedic trauma. *Injury* 2016;47(8):1794-7. doi: 10.1016/j.injury.2016.05.007 [published Online First: 2016/06/06]
19. Moore L, Stelfox HT, Turgeon AF, et al. Rates, patterns, and determinants of unplanned readmission after traumatic injury: a multicenter cohort study. *Annals of surgery* 2014;259(2):374-80. doi: 10.1097/SLA.0b013e31828b0fae [published Online First: 2013/03/13]
20. Luu NP, Hussain T, Chang HY, et al. Readmissions After Colon Cancer Surgery: Does It Matter Where Patients Are Readmitted? *Journal of oncology practice* 2016;12(5):e502-12. doi: 10.1200/jop.2015.007757 [published Online First: 2016/04/07]
21. Kim H, Hung WW, Paik MC, et al. Predictors and outcomes of unplanned readmission to a different hospital. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2015;27(6):513-9. doi: 10.1093/intqhc/mzv082 [published Online First: 2015/10/17]
22. Davies SM, Saynina O, McDonald KM, et al. Limitations of using same-hospital readmission metrics. *International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua* 2013;25(6):633-9. doi: 10.1093/intqhc/mzt068 [published Online First: 2013/10/30]
23. Parreco J, Buicko J, Cortolillo N, et al. Risk factors and costs associated with nationwide nonelective readmission after trauma. *The journal of trauma and acute care surgery* 2017;83(1):126-34. doi: 10.1097/ta.0000000000001505 [published Online First: 2017/04/20]
24. Kwaliteitsindicatoren Basisset ziekenhuizen 2016. In: Dutch Health Care Inspectorate MoH, Welfare and Sport, ed. Utrecht, , 09-2015:164 and 67.
25. DHD. Landelijke Basisregistratie Ziekenhuiszorg (LBZ) [Available from: <https://www.dhd.nl/producten-diensten/lbz/paginas/dataverzameling-lbz.aspx> accessed 18-12-2017.
26. Horwitz L, Partovian C, Lin Z, et al. Hospital-Wide All-Cause Unplanned Readmission Measure. Final Technical Report: Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHC/CORE);, 2012.
27. Sacks GD, Dawes AJ, Russell MM, et al. Evaluation of Hospital Readmissions in Surgical Patients: Do Administrative Data Tell the Real Story? *JAMA surgery* 2014;149(8):759-64. doi: 10.1001/jamasurg.2014.18 [published Online First: 2014/06/13]
28. Yam CH, Wong EL, Chan FW, et al. Measuring and preventing potentially avoidable hospital readmissions: a review of the literature. *Hong Kong medical journal = Xianggang yi xue za zhi / Hong Kong Academy of Medicine* 2010;16(5):383-9. [published Online First: 2010/10/05]
29. Peng M, Li B, Southern DA, et al. Constructing Episodes of Inpatient Care: How to Define Hospital Transfer in Hospital Administrative Health Data? *Medical care* 2017;55(1):74-78. doi: 10.1097/mlr.0000000000000624 [published Online First: 2016/08/02]
30. Nolte E, Roland M, Guthrie S, et al. Preventing emergency readmissions to hospital. A scoping review. Santa Monica: RAND corporation, 2011.
31. CBS. HSMR 2016: Methodological report, 2017.
32. Hekkert K, Kool RB, Rake E, et al. To what degree can variations in readmission rates be explained on the level of the hospital? a multilevel study using a large Dutch database. *BMC Health Services Research* (2018) 18:999 <https://doi.org/10.1186/s12913-018-3761-y>33. Kansagara D, Englander H, Salanitro A, et al. Risk prediction models for hospital readmission: a

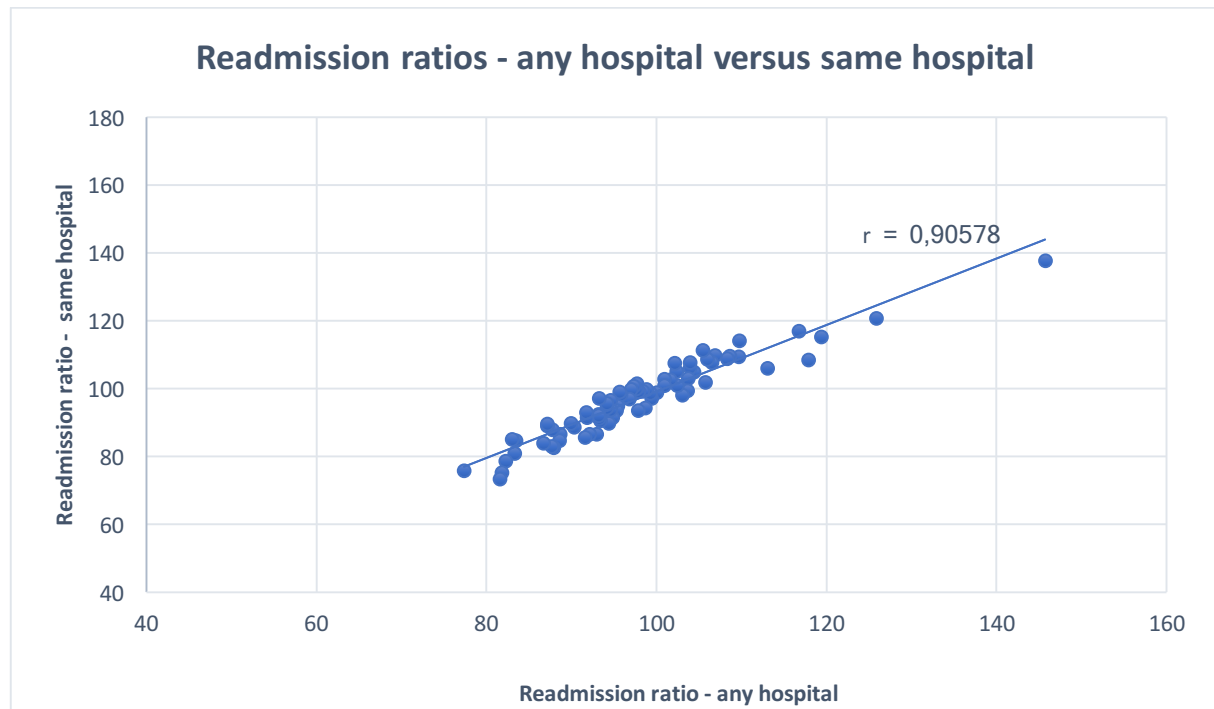
1
2
3 508 systematic review. JAMA : the journal of the American Medical Association 2011,
4 509 306(15):1688-1698.
5 510 34. Vest JR, Gamm LD, Oxford BA, et al. Determinants of preventable readmissions in the United
6 511 States: a systematic review. Implementation science : IS 2010, 5:88.
7 512 35. Eurostat Database OECD Health Statistics 2016. 2016 [published Online First: June 2016]
8 513 36. Hekkert K, van der Brug F, Borghans I, et al. How to identify potentially preventable readmissions
9 514 by classifying them using a national administrative database. International journal for quality
10 515 in health care : journal of the International Society for Quality in Health Care / ISQua
11 516 2017;29(6):826-32. doi: 10.1093/intqhc/mzx110 [published Online First: 2017/10/13]
12 517
13
14
15 518
16
17 519 **Figure legends**
18
19 520
20 521 Figure 1. Flowchart admissions in the dataset
21
22 522
23 523 Figure 2. The plot readmission ratios for any hospital versus those readmissions for the same
24 524 hospital, per hospital for all diagnosis groups.
25
26
27 525
28 526
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



* 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.