

Which factors are associated with unplanned hospital readmissions: a case-control study

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Introduction

Every year more than 10% of all people in the Netherlands are admitted to the hospital (1). In the majority of cases, this hospitalization is related to a new disease or trauma or involves planned surgery or treatment. The mean length of stay of these primary admissions is five days (1). Around 20% of the patients, who have been discharged from the hospital, have a readmission. A readmission is an admission of the same patient in the same hospital taking place within 30 days after discharge(2).

These readmissions are costly and potentially harmful. In the United States the cost to Medicare of readmissions in 2004 was \$17.4 billion(3) and currently in the United States under the affordable care act, these readmissions are not reimbursed if readmission is for the same cause. In the Netherlands there are no rates available about this subject.

Hospital readmissions are often associated with patient-related factors such as an older age, multimorbidity, lack of social support and higher number of previous readmissions(3)(4), process-related factors, such as lack of standardized discharge planning or poor communication between the hospital and primary care may also affect the rate of hospital readmissions(5) and medication-related factors such as changes in medication subscriptions during hospital admission and use of high risk medications(6, 7). When patients have one or more of these risk factors they are more likely to be readmitted.

Patients admitted to the department of internal medicine often have multiple chronic diseases, defined as multimorbidity(8). These patients are a vulnerable group for readmissions as they are already in need of care and are frequent visitors of the hospital, both for visits to the outpatient department, as well as hospital admissions(9). Internal medicine patients often use medication, have a higher age, have a lack of social support and have multimorbidity. All these factors ensure that they have an increased risk of getting a readmission. This patient group is also at increased risk for adverse events during and after hospital stay. Adverse events are unintended injuries or complications resulting in disability, death or prolonged hospital stay that arise from health care management(5). One of the adverse events is an unplanned hospital readmission(3). What should also take into consideration that internal medicine often is not planned care, this means that admissions are not prepared which can affect the planning of discharge.

In the literature, often patient-, process- or medication-related factors are considered. This study will look at all three: process, patient and medication. Medication use is also a topic in the literature showing that it can affect readmissions, for this reason this is included in the study(4).

Rationale

In several previous studies there were 30-day readmission rates of around 20%. It is not clear whether these readmissions are preventable and which factors contribute to it. Better understanding of patient, process and medication factors related to preventable readmissions would enable us to improve the discharge procedure and reorganize care pathways to prevent these readmissions. As internal medicine patients often have multiple morbidities(8) and have high rates of readmission, the population of this study focuses on patients hospitalized to general internal medicine ward in one university teaching hospital.

Aim and Research question

The aim of this study was to investigate which patient-, process- and medication-related factors are associated with unplanned hospital readmissions.

The research question of this study was: Which patient-, process- and medication-related factors are associated with unplanned hospital readmission in patients 18 years and older discharge from a general internal medicine ward?

Method

Study design and population

To see retrospective which factors lead to unplanned hospital readmissions two groups should be compared with each other. To compare these two groups as well as possible with each other there has been chosen for a case-control design. The two groups have gone through the same, namely a hospital admission, but one group received a readmission and another group not(10). This case-control study was conducted in the Academic Medical Center in Amsterdam, the Netherlands, a 1024-bed university teaching hospital. The patients for this study were derived from two prospective cohort studies of admitted patients, both aimed at studying the discharge process and the information needs at discharge. The studies ran in 2008 and 2010. For both studies the inclusion criteria were 1) age of 18 years or older, 2) admitted to one of four internal medicine wards and 3) a hospital stay of at least 48 hours. In both studies patients received questionnaires at discharge, one week and four weeks after hospital discharge.

Ethical aspects

All included patients provided written informed consent for participation in the prospective cohort study. Participants know that their data can be reused in the future for scientific

purposes within the same subject. The Institutional Review Board (IRB) approved both studies.

Screening for planned or unplanned readmission

From all readmissions it was necessary to know if they were planned or unplanned. When the discharge letter showed it was a planned readmission the patient was excluded, when it was not very obvious the readmissions were checked with the method of Haflon(11). This method contains a flowchart which can be followed. Several features as diagnose, reason for admission and complications must be discussed before to come out at one of three outcomes, foreseen readmission, unforeseen readmission for a new affection and unforeseen readmission for a previously known affection (see Appendix A).

Selection of cases and controls

Patients included in this case-control study were selected based on whether or not they were readmitted after the index hospital stay. Case patients in this study are patients who were unplanned readmitted within 30 days after the primary hospital admission. Control patients were not readmitted within 30 days after index hospital stay. Control patients were selected by matching. For every readmitted case patient one control patient was randomly selected by matching on age and gender with nQuery Advisor.

The sample size for a case control study is represented by a ratio. In the most case control studies the ratio 1:3 is used(12). Given the many factors that will be investigated is a 1:3 ratio of at least a desirable size. Given that this study is a small preliminary study of the final study a ratio 1:1 was used.

Data collection

From previous studies there were prospective data collected on satisfaction with the discharge process. These prospective data were included in this study. Demographic data, living situation, discharge care arrangements, social support, reason for admission, admission data and patient satisfaction on topics as information facility and usefulness of the patient letter were collected. Patients in both prospective cohort studies were interviewed at the time of hospital discharge and one week and four weeks after discharge. Four weeks after hospital discharge patients were interviewed on their health care consumption including readmission, emergency department visit and general practitioner visits.

Data collection from the medical record

Other factors were retrospectively collected from the medical record. We hypothesized that the medical record was the golden standard. A search in the literature was conducted to

discover on which level there are factors who lead to unplanned hospital readmissions. Literature showed that there were three types of factors. Patient-related factors, process-related factors and factors how are associated with medication. The investigated factors are all from the literature(4, 11, 13). For an overview which factor out which article is, see Appendix B.

Patient-related factors

Patient-related factors are directly linked to the patient. This factor include living situation, age, whether there is a chronic disease and demographic data. Determining whether there is a chronic disease is done through screening the medical history. There are standard disease states such as diabetes, Chronic Obstructive Pulmonary Disease (COPD), palliative cancer, heart failure, inflammatory bowel disease, chronic kidney problems, etc. which have been taken into consideration by the investigator for screening whether the diseases are chronic, there is further examined on the basis of the condition for a chronic disease(14). Patient-related factors include blood values, vital signs, health behavior, confusion and mean weight and length.

Previous research has shown that the following values affect the condition of a patient at discharge. The idea is that if a patient is unstable at discharge from the hospital that the risk for a readmission is greater. The values of the included factors are determined as:

Abnormal potassium (milliequivalents per liter) is defined as a value ≤ 2.9 , a value ≥ 6.0 , or a value between 5.5 and 5.9 but rising or 3.0 to 3.4 and falling.

Abnormal sodium (milliequivalents per liter) is defined as a value < 119 , a value ≥ 155 , or a value between 120 and 129 but falling or between 150 and 154 but rising.

Abnormal creatine is defined as a value > 6.0 , a rise in creatine > 0.5

Low hematocrit is defines as < 24.9 or between 25 and 34.9 with a drop ≥ 7.0

High leucocytes is defined as ≥ 12.0 and rising

High diastolic blood pressure is defined as ≥ 105 mm Hg

Low systolic blood pressure is defined as < 90 mm Hg

Low hartrithm is defined as < 50 beats/minute

Fever is defines as temperature ≥ 38.8 Celsius

(13)

Process-related factors

Process-related factors concerns the organization of discharge care such as transfer to home and information provision at discharge. Included factors are of there is a familiar caregiver available, if they give information at admission by them self, if they want receive

care after discharge, if they know which disease they have and treatment they get, if they are timely informed about their discharge and whether there is informed for help at home.

Medication-related factors

Medication use comprises whether patients know what medication they use and whether patient know how the medication works. There is also investigate which medication patients have at discharge and whether it deviate from the medication which they use at admission. There is also considering taking on a few specific medication because the literature showed that the use of this medication increases the risk of readmission.

Variables retrieved from the medical record were divided into patient, process and medication factors. The investigator had all these factors combined to a case report form (CRF). With this CRF all patient records are investigated by the researcher. The measuring instrument used is itself designed as a whole, and is not validated. The sources used to establish the instrument are well validity and reliability.

Screening of the readmission in cases

The case patients were again examined in order to obtain some additional information regarding the readmission. Length of hospital stay for the readmission, reason of the readmission and number of days between discharge en readmission were obtained from the medical record or discharge letter.

Statistical analysis

The analysis aimed to compare differences between cases and controls on patient-, process- and medication-related factors. Continuous and ranked variables were compared using the student's t-test or the wilcoxon rank-sum test in cases of non-normal distribution and expressed, respectively, as means with standard deviation or median and interquartile range. The Pearson Chi-Square was used to see if a statistical correlation between two variables is significant. All statistical analyses were done by using Statistical Package for the Social Sciences (SPSS) statistical software version 17.0.3. When there are too many missing values for statistical analyses the factor is not included.

Role of the Funding Source

None

Results

Baseline characteristics

In the cohort of 2008 195 patients were included. Of these patients 59 had a readmission. Looking at the in- and exclusion criteria and only at unplanned readmissions 18 patients remained to be enrolled. Many patients dropout because of the fact that the readmission take place in another hospital. In the cohort of 2010 172 patients were included. By 48 patients of this cohort a readmission or rehospitalization took place, 17 patients of this cohort were included in this study. Total 35 case patients are included. For controls are 35 patients included by matching ad random from the same cohorts by age and gender. The mean age of the case group was 53.9 years (SD+/- 19.8) in the control group this was 53.4 years (SD+/- 19.8). In the case group there were 18 males and in the control group 17 males. Demographic and clinical characteristics are reported in Table 1. The mean length of the index hospital stay in days was significantly higher for the cases (8.9 days) compared to 5.3 days for the controls ($p = 0.02$). In the group of case patients 33 had a chronic illness against 22 patients in the control group, ($p = 0.001$). There were no significant difference between cases and controls on medication use and previous hospital admissions. The reason for primary admission was quite diverse, both in case and control group.

Patient-related factors

The patient-related factors which are investigated show none significantly difference between case and control group. There is a small difference at smoking, chronic illness and weight. This difference was however not significant. Results of the patient-related factors are shown in table 2.

Process-related factors

Only a few patients have completed the questionnaires, where there was more response from the control group. A few results could be calculated. There is a significantly difference between the two groups about being timely informed about their discharge(p -value = 0.03). The case group did not feel that they are informed on time. There is a significant difference on the question if they wanted to receive care after discharge(p -value = 0.04). The response to this question was low. With a p -value of 0.07 there is just no significantly difference between the two groups about from who get the nurse information at admission. At the controls 29 give information by them self against 18 case patients. Other process-related factors were not significantly different between cases and controls. In table 3 all results from the process-related factors are report.

Medication related factors

From the medication related factors that were investigated in this study two variables were significantly different. Medication change during admission ($p = 0.05$) and using prednisone at discharge ($p = 0.04$). With a p -value of 0.09 is using opiates at discharge just not significant different. The other investigated medication-related factors did not differ between cases and controls. All the results from the medication related factors are reported at table 4.

Readmitted patients

From the patients who have been readmitted (cases) more data is collected. In 83 % of the cases the readmission is for a condition that the patient had previously been hospitalized for.. From the cases 18 patients were readmitted with a continuation, recurrence or complication of a known infection. The median time between discharge and readmission is 8 days (range 30). The median length of stay from the readmission was 8 days (range 68). Three patients died in the cases group within 30 days after discharge from the primary admission. In the control group no one died within 30 days. All results are shown in table 5.

Discussion

In this study on factors associated with unplanned 30-day readmissions we demonstrated that only a few factors were significantly different between the patients who were readmitted and those not readmitted within this time frame. All the differences between case and control were in disadvantage of the case group. The two groups were comparable when you regarding age and gender. From the patient-related factors only chronic illness is a factor that was associated with unplanned hospital readmissions. From the process-related factors length of hospital stay in days was longer for case patients, wanted to receive care after discharge was more for case patients and control patients were timely informed about discharge. This factors were related to readmissions significantly proven. On the medication level medication change during hospital stay and use of prednisolon were more often present in patients who were readmitted.

All the investigated factors have previously been found to be associated with unplanned hospital readmissions(4)(13). However this research shows that against all expectations, only a handful factors were found to be significant. Some of the literature we used to collect factors are outdated(13). This can be a reason, because the health care the last few years changed a lot. Some factors are from recently published studies and in this study the factors mentioned are not proven(4). A likely reason is the fact that the power in our study is too low, more controls should be included for more power. There are also a lot of missing values (more than 40%) on process-related factor which influence the analyze.

This study made use of factors, which earlier in the literature has shown that they affect unplanned readmissions. This allowed a focused look at what factors influence here in the Netherlands on unplanned readmissions. This case control study is the first in the Netherlands made with respect tot this subject. For the final study, some factors as chronicle disease, medication, and information about living situation should be considered and developed to be more exact of which factors lead to unplanned readmissions.

Another remarkable fact is that almost all unplanned readmissions occurred within one week after discharge. This is very fast and it could indicate that a slightly longer primary admission could have prevented a readmission. A readmission cost a lot of money while a longer admission is less costly(15). Whether a longer admission reduces the number of readmissions has to be further investigated.

This research, but also others(16), shows that there is much profit to be gained in terms of readmissions. In practice the transitional care have to be improved and there should pay more attention to the individual patient.

A limitation of this study is the ratio between cases and controls. For more power should be more controls enrolled. The desired ratio was 1:3, because this study is a small preliminary study of the final study a ratio 1:1 was used. This was not enough power to see the actual difference between cases and controls. Case control studies always have the disadvantage that they are sensitive to bias. In a case control study you are dependent on what is reported in the file, this may be that important information is missed. The investigator found that some records are not complete; this led to incomplete data collection.

Following this study it is a recommendation to extend this study with more controls and more depth in some factors, such as chronic illness, that are involved in unplanned readmissions. Now, it is still too wide examined. In the prospective data there were a lot of missing values, so many that analyzing was impossible. Next time this values are needed to say more about the factors who influence unplanned readmissions.

Conclusion

This case control study was done to find answers to the question: Which patient-, process- and medication-related factors are associated with unplanned hospital readmission in patients 18 years and older discharge from a general internal medicine ward? There are a lot factors investigated, but only a couple of them are significantly different between the case and control group. In the case group more patients have a chronic illness and they stay longer in the hospital for their primary admission. More cases as controls wanted receive care after discharge. More controls find that they are timely informed about discharge. From the medication level came that cases have more medication changes in their primary admission. Also uses the case patients more prednisone. All this factors can influence the risk for readmission and are associated with unplanned hospital readmission. Normally it is common to include more controls against the cases into such a ratio of 1:3. More research is necessary with more controls to give a solid answer to the research question. There were also a lot of missing data, in a next study this must be approved to find more significantly differences.

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Table 1

Table 1 Demographic and clinical characteristics of cases and controls

Variables	Cases (N=35)	Controls (N=35)	P-value
Mean age in years (+/- SD)	53.94 (+/- 19.80)	53.43 (+/- 19.80)	0.74
Males, N (%)	18 (51.40%)	17 (48.60%)	0.81
Mean length of stay in days (+/- SD)	8.9 (+/- 5.9)	5.3 (+/- 3.7)	0.02
Median length of stay in days (range)	8 (23)	4 (17)	0.02
Hospital admission in 6 months before	14	10	0.49
Chronic illness (N)	33	22	0.001
Medication use (N)	30	30	0.76

Continuous variables were calculated with Student's T-test and dichotomous variables with chi-square.

Table 2 patient related factors

Variable [^]	Cases (N=35)	Controls (N=35)	P-Value
Mean Weight(+/- SD)	91.57 (+/- 89.3)	73.95 (+/- 17.3)	0.28
Mean Length(+/- SD)	170.82 (+/- 12)	175.21 (+/- 8.9)	0.20
Abnormal Potassium*	0	0	0.21
Abnormal Sodium**	0	0	0.40
Abnormal Creatine***	9	4	0.17
Low Hematocrit****	1	0	0.59
High Leucocytes*****	4	3	0.84
High diastolic blood pressure#	1	1	0.29
Low systolic blood pressure##	1	0	0.16
Low Hartrithm###	0	0	0.19
Fever####	0	1	0.34
Shortness of Breath	1	0	0.28
Confused	1	0	0.28
Use alcohol	4	4	0.20
Smoking	0	5	0.20
Mental illness	2	0	0.14

Continuous variables were calculated with Student's T-test and dichotomous variables with chi-square.

[^]All these variables are measured at discharge or 1 day for discharge

* Abnormal potassium (milliequivalents per liter) is defined as a value ≤ 2.9 , a value ≥ 6.0 , or a value between 5.5 and 5.9 but rising or 3.0 to 3.4 and falling.

**Abnormal sodium (milliequivalents per liter) is defined as a value < 119 , a value ≥ 155 , or a value between 120 and 129 but falling or between 150 and 154 but rising.

***Abnormal creatine is defined as a value > 6.0 , a rise in creatine > 0.5

**** Low Hematocrit is defined as < 24.9 or between 25 and 34.9 with a drop ≥ 7.0

***** High leucocytes is defined as ≥ 12.0 and rising

High diastolic blood pressure is defined as ≥ 105 mm Hg

Low systolic blood pressure is defined as < 90 mm Hg

Low heart rate is defined as < 50 beats/minute

Fever is defined as temperature ≥ 38.8 celsius(13)

Table 3 Process related factors

Variable	Missings	Cases (%=yes by N=35)	Controls (%=yes by N=35)	P-Value
At admission information get from patient	Cases: 13 Controls: 5	81.8%	96.7%	0.07
Informed at admission for help at home	Cases: 23 Controls: 18	91.7%	88.2%	0.77
Familiar caregiver present at home	Cases: 24 Controls: 20	100%	93.3%	0.65
Did you want receive care after discharge	Cases: 30 Controls: 23	80%	25%	0.04
Did you know which disease you had	Cases: 22 Controls: 18	92.3%	82.4%	0.40
Did you know which treatment you get	Cases: 22 Controls: 18	100%	88.2%	0.58
Are you timely informed about your discharge	Cases: 23 Controls: 18	16.7%	64.7%	0.03

Dichotomous variables were calculated with Chi-square

Table 4 Medication related factors

Variable	Cases (N=yes)	Controls (N=yes)	P-Value
Use medication at admission	30	30	0.60
Use medication at discharge	34	32	0.28
Medication changed during admission	30	24	0.05
Use anti-coagulants at discharge	3	4	0.69
Use opiates at discharge	5	1	0.09
Use NSAID'S at discharge	2	3	0.64
Use prednisolon at discharge	8	2	0.04
Medication is not put back to their own specific name	3	0	0.12

Dichotomous variables were calculated with Chi-square

Table 5 information on readmitted patients

Variables	Yes (N=35)
Readmission for already known disease	82.9%
Readmission for a continuation, recurrence or complication of a known infection.	51.4% 11.4% continuation 34.3% recurrence 5.7% complication
Social readmission	0
Died within 30 days after primary admission	8.6%
Median time to readmission calculated from discharge (Range)	8 days (30)
Median length of stay (readmission) (range)	8 days (68)

Continuous variables were calculated with Student's T-test and dichotomous variables with chi-square

Dutch abstract

Titel: Welke factoren zijn geassocieerd met ongeplande ziekenhuis heropnames

Inleiding: In eerdere studies is gevonden dat 20% van de patiënten wordt heropgenomen binnen 30 dagen. Het is niet duidelijk of deze heropnames vermijdbaar zijn en welke factoren hier invloed op hebben. Door dit in kaart te brengen kan het helpen om ontslag procedure en zorgpaden te verbeteren, waarmee ongeplande heropnames hopelijk voorkomen kunnen worden.

Doel en onderzoeksvraag: Het vinden van patiënt, proces en medicatie gerelateerde factoren die leiden tot ongeplande heropnames. De onderzoeksvraag was: Welke patiënt, proces en medicatie gerelateerde factoren zijn geassocieerd met ongeplande heropnames bij patiënten van 18 jaar en ouder na ontslag van een interne afdeling van een ziekenhuis?

Methode: Deze case-control studie is uitgevoerd met 35 cases en 35 controls. Door middel van een zelf opgesteld case report formulier zijn de medische dossiers onderzocht. Al eerder verzamelde data is ook meegenomen in de studie. De factoren zijn opgedeeld in 3 niveaus. Patiënt, proces en medicatie.

Resultaten: Vanuit de patiënt gerelateerde factoren was alleen chronisch ziek zijn een factor die geassocieerd is met ongeplande heropnames. Vanuit het proces spelen duur van de opname, of patiënten zorg wilde ontvangen na ontslag en of ze op tijd geïnformeerd waren over het ontslag een rol. Bij medicatie waren een verandering van medicatie tijdens de opname en het gebruik van prednison significant bewezen factoren die kunnen leiden tot ongeplande heropnames.

Conclusie: Er zijn vele factoren onderzocht in de studie en maar een paar zijn significant bevonden. Normaal gesproken worden er meer controls geïnccludeerd waardoor de power hoger is en er meer verschil zal optreden.

Aanbevelingen: Het is een aanbeveling om deze studie uit te breiden met meer controls en meer diepgang in sommige factoren. In de prospectieve data waren een hoop missende waarden, dit moeten er volgende keer minder zijn.

Trefwoorden: Heropname, Factor, Ongepland, Gekoppeld en Ziekenhuis

English abstract

Title: Which factors are associated with unplanned hospital readmissions

Background: In previous studies there were 30-day readmission rates of around 20%. It is not clear whether these readmissions are preventable and which factors contribute to it. Better understanding of patient and process factors related to preventable readmissions would enable us to improve the discharge procedure and reorganize care pathways to prevent these readmissions.

Aim and research question: To find patient-, process-, and medication-related factors which lead to unplanned hospital readmissions. The research question of this study was: Which patient-, process- and medication-related factors are associated with unplanned hospital readmission in patients 18 years and older discharge from a general internal medicine ward?

Method: A case control study is done with 35 cases and 35 controls. Using a self made case report form all the medical records a searched. Also earlier collected prospective data is included in this study. The included factors are divided in three levels. Patient-, process- and medication-related factors.

Results: From the patient-related factors only chronic illness is a factor who can be associated with hospital readmissions. From the process-related factors mean length of stay in days, wanted to receive care after discharge and timely informed about discharge are significantly proven. The factors medication change and use prednisone are from the medication-related level and can be associated with unplanned hospital readmission.

Conclusion: There are a lot factors investigated, but only a couple of them are significantly different. Normally it is common to include more controls against the cases into such a ratio of 1:3.

Recommendations: It is a recommendation to extend this study with more controls and more depth in some factors. Now, it is still too wide examine. In the prospective data there were a lot of missing values, this should be less next time.

Keywords: Readmission, Factors, Unplanned, Associated and Hospital

Appendix

Appendix A

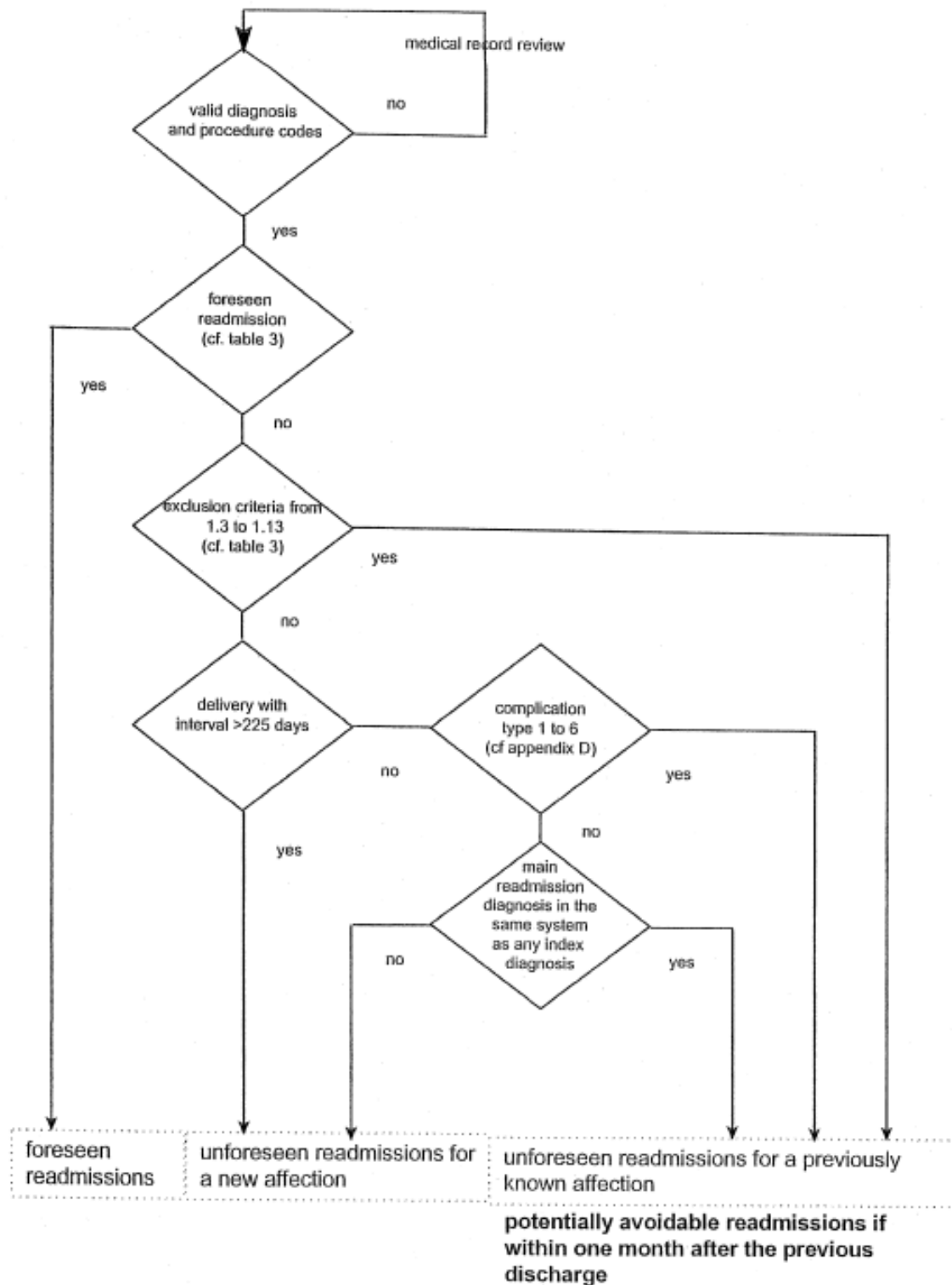


Fig. 2. Algorithm used to classify readmissions.

Table 3
Criteria used to classify readmissions^a

	Inclusion criteria	Exclusion criteria
Foreseen readmissions		
Deliveries (1.1)	$D^*_a = \{060-075.9; 080-084.9; 095\}$	Period from index discharge to readmission >225 ^a
Transplantations		
Organ transplants (1.2)	$I^*_a = \{33.5; 33.6; 37.5; 41.02-41.03; 50.51; 50.59; 52.80-52.83; 55.61; 55.69\}$	None
Leucopherese, autologous bone marrow grafts (1.3)	$I^*_a = \{41.00-41.01; 99.72; 99.73\}$	Unplanned readmission
Chemo- and radiotherapy (1.4)	$D^*_a = \{Z51.0-Z51.2\}$	Unplanned readmission or $D^*_p = \{D69.1; D69.5; D70\}$
Treatment follow-up (1.5)	$D^*_a = \{Z08.0-Z08.9; Z09.0-Z09.9\}$	Unplanned readmission
Rehabilitation (1.6)	$D^*_p = \{Z50.0-Z50.9\}$	Unplanned readmission
Procedure not carried out (1.7)	$D^*_p = \{Z53.0-Z53.9\}$	Unplanned readmission
Planned surgical interventions		
Material removal or replacement (1.8)	$I^*_a = \{02.07; 02.43; 02.95; 03.94; 03.97; 03.98; 37.85-37.89; 37.97-37.99; 78.60-78.69; 97.88\}$	Unplanned readmission or $D^*_a = \{\text{complication of categories 1 or 3 of Appendix C}\}$
Temporary stoma closure (1.9)	$I^*_a = \{31.72; 42.83; 44.62; 46.50-46.52; 55.82; 57.82\}$	Idem
Postoperative aftercare (1.10)	$D^*_a = \{Z42-Z48\}$	Idem
Other foreseen intervention following a surgical procedure, a delivery or an abortion during the index stay (1.11)	Surgical readmission AP-DRG and surgical or obstetrical index AP-DRG $S(D^*_p) = S(D^*_a)$	Unplanned readmission or $D^*_a = \{\text{complication of categories 1 to 3 of Appendix C}\}$ or a reopening of surgical site $I = \{01.23; 03.02; 06.02; 34.03; 35.95; 39.49; 54.12; 54.61\}$
Other foreseen intervention following a nonsurgical index hospitalization (1.12)	A surgical readmission AP-DRG and a nonsurgical and nonobstetrical index AP-DRG $S(D^*_p) = S(D^*_a)$	Unplanned readmission
Diagnostic or therapeutic nonsurgical intervention following a nonsurgical hospitalization (1.13)	$I^*_a = \{37.21-37.29; 42.33; 43.11; 43.41-43.42; 44.43; 45.30; 45.41-45.43; 50.11; 55.23; 88.40-88.49; 88.50-88-58; 99.62\}$ $S(D^*_p) = S(D^*_a)$	Unplanned readmission or procedure performed after the 2d following readmission or $D^*_a = \{\text{complication of categories 4 to 6 of Appendix C}\}$
Unforeseen readmissions for a new affection	$S(D^*_p) \neq S(D^*_a)$	$D^*_p = \{\text{complication of categories 1 to 6 of Appendix C}\}$
All other readmissions are unforeseen for a previously known affection		

D^*_a : any readmission diagnosis; I^*_a : any readmission intervention; D^*_p : readmission main diagnosis; AP-DRG All Patients Diagnosis Related Groups; $S(D^*_p)$: readmission damaged system (main diagnosis); $S(D^*_a)$: Index hospitalization damaged system (any diagnosis).

^a The algorithm follows the paragraph sequence

Appendix D

List of ICD-10 codes of complications

Type of complication	ICD-10 codes
1. Related to surgical care	E89.0–E89.9, H59.0–H59.9, G97.0–G97.2, G97.8–G97.9, H95.0–H95.1, H95.8–H95.9, I97.0–I97.2, I97.8–I97.9, J95.0–J95.9, K43.0–K43.9, K91.0–K91.5, K91.8–K91.9, M02.0, M80.3, M81.3, M84.0, M84.1, M96.0–M96.1, M96.3–M96.4, M96.6, M96.8–M96.9, N99.0–N99.5, N99.8–N99.9, O35.7, T81.0–T81.9, T82.0–T82.9, T83.0–T83.9, T84.0–T84.9, T85.0–T85.9, T86.0–T86.4, T86.8–T86.9, T87.0–T87.6, T88.0–T88.9, T89.0–T89.9, T90.0–T90.9, T91.0–T91.9, T92.0–T92.9, T93.0–T93.9, T94.0–T94.9, T95.0–T95.9, T96.0–T96.9, T97.0–T97.9, T98.0–T98.9, T99.0–T99.9, U00.0–U00.9, U01.0–U01.9, U02.0–U02.9, U03.0–U03.9, U04.0–U04.9, U05.0–U05.9, U06.0–U06.9, U07.0–U07.9, U08.0–U08.9, U09.0–U09.9, U10.0–U10.9, U11.0–U11.9, U12.0–U12.9, U13.0–U13.9, U14.0–U14.9, U15.0–U15.9, U16.0–U16.9, U17.0–U17.9, U18.0–U18.9, U19.0–U19.9, U20.0–U20.9, U21.0–U21.9, U22.0–U22.9, U23.0–U23.9, U24.0–U24.9, U25.0–U25.9, U26.0–U26.9, U27.0–U27.9, U28.0–U28.9, U29.0–U29.9, U30.0–U30.9, U31.0–U31.9, U32.0–U32.9, U33.0–U33.9, U34.0–U34.9, U35.0–U35.9, U36.0–U36.9, U37.0–U37.9, U38.0–U38.9, U39.0–U39.9, U40.0–U40.9, U41.0–U41.9, U42.0–U42.9, U43.0–U43.9, U44.0–U44.9, U45.0–U45.9, U46.0–U46.9, U47.0–U47.9, U48.0–U48.9, U49.0–U49.9, U50.0–U50.9, U51.0–U51.9, U52.0–U52.9, U53.0–U53.9, U54.0–U54.9, U55.0–U55.9, U56.0–U56.9, U57.0–U57.9, U58.0–U58.9, U59.0–U59.9, U60.0–U60.9, U61.0–U61.9, U62.0–U62.9, U63.0–U63.9, U64.0–U64.9, U65.0–U65.9, U66.0–U66.9, U67.0–U67.9, U68.0–U68.9, U69.0–U69.9, U70.0–U70.9, U71.0–U71.9, U72.0–U72.9, U73.0–U73.9, U74.0–U74.9, U75.0–U75.9, U76.0–U76.9, U77.0–U77.9, U78.0–U78.9, U79.0–U79.9, U80.0–U80.9, U81.0–U81.9, U82.0–U82.9, U83.0–U83.9, U84.0–U84.9, U85.0–U85.9, U86.0–U86.9, U87.0–U87.9, U88.0–U88.9, U89.0–U89.9, U90.0–U90.9, U91.0–U91.9, U92.0–U92.9, U93.0–U93.9, U94.0–U94.9, U95.0–U95.9, U96.0–U96.9, U97.0–U97.9, U98.0–U98.9, U99.0–U99.9, V00.0–V00.9, V01.0–V01.9, V02.0–V02.9, V03.0–V03.9, V04.0–V04.9, V05.0–V05.9, V06.0–V06.9, V07.0–V07.9, V08.0–V08.9, V09.0–V09.9, V10.0–V10.9, V11.0–V11.9, V12.0–V12.9, V13.0–V13.9, V14.0–V14.9, V15.0–V15.9, V16.0–V16.9, V17.0–V17.9, V18.0–V18.9, V19.0–V19.9, V20.0–V20.9, V21.0–V21.9, V22.0–V22.9, V23.0–V23.9, V24.0–V24.9, V25.0–V25.9, V26.0–V26.9, V27.0–V27.9, V28.0–V28.9, V29.0–V29.9, V30.0–V30.9, V31.0–V31.9, V32.0–V32.9, V33.0–V33.9, V34.0–V34.9, V35.0–V35.9, V36.0–V36.9, V37.0–V37.9, V38.0–V38.9, V39.0–V39.9, V40.0–V40.9, V41.0–V41.9, V42.0–V42.9, V43.0–V43.9, V44.0–V44.9, V45.0–V45.9, V46.0–V46.9, V47.0–V47.9, V48.0–V48.9, V49.0–V49.9, V50.0–V50.9, V51.0–V51.9, V52.0–V52.9, V53.0–V53.9, V54.0–V54.9, V55.0–V55.9, V56.0–V56.9, V57.0–V57.9, V58.0–V58.9, V59.0–V59.9, V60.0–V60.9, V61.0–V61.9, V62.0–V62.9, V63.0–V63.9, V64.0–V64.9, V65.0–V65.9, V66.0–V66.9, V67.0–V67.9, V68.0–V68.9, V69.0–V69.9, V70.0–V70.9, V71.0–V71.9, V72.0–V72.9, V73.0–V73.9, V74.0–V74.9, V75.0–V75.9, V76.0–V76.9, V77.0–V77.9, V78.0–V78.9, V79.0–V79.9, V80.0–V80.9, V81.0–V81.9, V82.0–V82.9, V83.0–V83.9, V84.0–V84.9, V85.0–V85.9, V86.0–V86.9, V87.0–V87.9, V88.0–V88.9, V89.0–V89.9, V90.0–V90.9, V91.0–V91.9, V92.0–V92.9, V93.0–V93.9, V94.0–V94.9, V95.0–V95.9, V96.0–V96.9, V97.0–V97.9, V98.0–V98.9, V99.0–V99.9, W00.0–W00.9, W01.0–W01.9, W02.0–W02.9, W03.0–W03.9, W04.0–W04.9, W05.0–W05.9, W06.0–W06.9, W07.0–W07.9, W08.0–W08.9, W09.0–W09.9, W10.0–W10.9, W11.0–W11.9, W12.0–W12.9, W13.0–W13.9, W14.0–W14.9, W15.0–W15.9, W16.0–W16.9, W17.0–W17.9, W18.0–W18.9, W19.0–W19.9, W20.0–W20.9, W21.0–W21.9, W22.0–W22.9, W23.0–W23.9, W24.0–W24.9, W25.0–W25.9, W26.0–W26.9, W27.0–W27.9, W28.0–W28.9, W29.0–W29.9, W30.0–W30.9, W31.0–W31.9, W32.0–W32.9, W33.0–W33.9, W34.0–W34.9, W35.0–W35.9, W36.0–W36.9, W37.0–W37.9, W38.0–W38.9, W39.0–W39.9, W40.0–W40.9, W41.0–W41.9, W42.0–W42.9, W43.0–W43.9, W44.0–W44.9, W45.0–W45.9, W46.0–W46.9, W47.0–W47.9, W48.0–W48.9, W49.0–W49.9, W50.0–W50.9, W51.0–W51.9, W52.0–W52.9, W53.0–W53.9, W54.0–W54.9, W55.0–W55.9, W56.0–W56.9, W57.0–W57.9, W58.0–W58.9, W59.0–W59.9, W60.0–W60.9, W61.0–W61.9, W62.0–W62.9, W63.0–W63.9, W64.0–W64.9, W65.0–W65.9, W66.0–W66.9, W67.0–W67.9, W68.0–W68.9, W69.0–W69.9, W70.0–W70.9, W71.0–W71.9, W72.0–W72.9, W73.0–W73.9, W74.0–W74.9, W75.0–W75.9, W76.0–W76.9, W77.0–W77.9, W78.0–W78.9, W79.0–W79.9, W80.0–W80.9, W81.0–W81.9, W82.0–W82.9, W83.0–W83.9, W84.0–W84.9, W85.0–W85.9, W86.0–W86.9, W87.0–W87.9, W88.0–W88.9, W89.0–W89.9, W90.0–W90.9, W91.0–W91.9, W92.0–W92.9, W93.0–W93.9, W94.0–W94.9, W95.0–W95.9, W96.0–W96.9, W97.0–W97.9, W98.0–W98.9, W99.0–W99.9, Y00.0–Y00.9, Y01.0–Y01.9, Y02.0–Y02.9, Y03.0–Y03.9, Y04.0–Y04.9, Y05.0–Y05.9, Y06.0–Y06.9, Y07.0–Y07.9, Y08.0–Y08.9, Y09.0–Y09.9, Y10.0–Y10.9, Y11.0–Y11.9, Y12.0–Y12.9, Y13.0–Y13.9, Y14.0–Y14.9, Y15.0–Y15.9, Y16.0–Y16.9, Y17.0–Y17.9, Y18.0–Y18.9, Y19.0–Y19.9, Y20.0–Y20.9, Y21.0–Y21.9, Y22.0–Y22.9, Y23.0–Y23.9, Y24.0–Y24.9, Y25.0–Y25.9, Y26.0–Y26.9, Y27.0–Y27.9, Y28.0–Y28.9, Y29.0–Y29.9, Y30.0–Y30.9, Y31.0–Y31.9, Y32.0–Y32.9, Y33.0–Y33.9, Y34.0–Y34.9, Y35.0–Y35.9, Y36.0–Y36.9, Y37.0–Y37.9, Y38.0–Y38.9, Y39.0–Y39.9, Y40.0–Y40.9, Y41.0–Y41.9, Y42.0–Y42.9, Y43.0–Y43.9, Y44.0–Y44.9, Y45.0–Y45.9, Y46.0–Y46.9, Y47.0–Y47.9, Y48.0–Y48.9, Y49.0–Y49.9, Y50.0–Y50.9, Y51.0–Y51.9, Y52.0–Y52.9, Y53.0–Y53.9, Y54.0–Y54.9, Y55.0–Y55.9, Y56.0–Y56.9, Y57.0–Y57.9, Y58.0–Y58.9, Y59.0–Y59.9, Y60.0–Y60.9, Y61.0–Y61.9, Y62.0–Y62.9, Y63.0–Y63.9, Y64.0–Y64.9, Y65.0–Y65.9, Y66.0–Y66.9, Y67.0–Y67.9, Y68.0–Y68.9, Y69.0–Y69.9, Y70.0–Y70.9, Y71.0–Y71.9, Y72.0–Y72.9, Y73.0–Y73.9, Y74.0–Y74.9, Y75.0–Y75.9, Y76.0–Y76.9, Y77.0–Y77.9, Y78.0–Y78.9, Y79.0–Y79.9, Y80.0–Y80.9, Y81.0–Y81.9, Y82.0–Y82.9, Y83.0–Y83.9, Y84.0–Y84.9, Y85.0–Y85.9, Y86.0–Y86.9, Y87.0–Y87.9, Y88.0–Y88.9, Y89.0–Y89.9, Y90.0–Y90.9, Y91.0–Y91.9, Y92.0–Y92.9, Y93.0–Y93.9, Y94.0–Y94.9, Y95.0–Y95.9, Y96.0–Y96.9, Y97.0–Y97.9, Y98.0–Y98.9, Y99.0–Y99.9, Z00.0–Z00.9, Z01.0–Z01.9, Z02.0–Z02.9, Z03.0–Z03.9, Z04.0–Z04.9, Z05.0–Z05.9, Z06.0–Z06.9, Z07.0–Z07.9, Z08.0–Z08.9, Z09.0–Z09.9, Z10.0–Z10.9, Z11.0–Z11.9, Z12.0–Z12.9, Z13.0–Z13.9, Z14.0–Z14.9, Z15.0–Z15.9, Z16.0–Z16.9, Z17.0–Z17.9, Z18.0–Z18.9, Z19.0–Z19.9, Z20.0–Z20.9, Z21.0–Z21.9, Z22.0–Z22.9, Z23.0–Z23.9, Z24.0–Z24.9, Z25.0–Z25.9, Z26.0–Z26.9, Z27.0–Z27.9, Z28.0–Z28.9, Z29.0–Z29.9, Z30.0–Z30.9, Z31.0–Z31.9, Z32.0–Z32.9, Z33.0–Z33.9, Z34.0–Z34.9, Z35.0–Z35.9, Z36.0–Z36.9, Z37.0–Z37.9, Z38.0–Z38.9, Z39.0–Z39.9, Z40.0–Z40.9, Z41.0–Z41.9, Z42.0–Z42.9, Z43.0–Z43.9, Z44.0–Z44.9, Z45.0–Z45.9, Z46.0–Z46.9, Z47.0–Z47.9, Z48.0–Z48.9, Z49.0–Z49.9, Z50.0–Z50.9, Z51.0–Z51.9, Z52.0–Z52.9, Z53.0–Z53.9, Z54.0–Z54.9, Z55.0–Z55.9, Z56.0–Z56.9, Z57.0–Z57.9, Z58.0–Z58.9, Z59.0–Z59.9, Z60.0–Z60.9, Z61.0–Z61.9, Z62.0–Z62.9, Z63.0–Z63.9, Z64.0–Z64.9, Z65.0–Z65.9, Z66.0–Z66.9, Z67.0–Z67.9, Z68.0–Z68.9, Z69.0–Z69.9, Z70.0–Z70.9, Z71.0–Z71.9, Z72.0–Z72.9, Z73.0–Z73.9, Z74.0–Z74.9, Z75.0–Z75.9, Z76.0–Z76.9, Z77.0–Z77.9, Z78.0–Z78.9, Z79.0–Z79.9, Z80.0–Z80.9, Z81.0–Z81.9, Z82.0–Z82.9, Z83.0–Z83.9, Z84.0–Z84.9, Z85.0–Z85.9, Z86.0–Z86.9, Z87.0–Z87.9, Z88.0–Z88.9, Z89.0–Z89.9, Z90.0–Z90.9, Z91.0–Z91.9, Z92.0–Z92.9, Z93.0–Z93.9, Z94.0–Z94.9, Z95.0–Z95.9, Z96.0–Z96.9, Z97.0–Z97.9, Z98.0–Z98.9, Z99.0–Z99.9
2. Related to a delivery or an abortion	O04.0–O04.8, O05.0–O05.8, O06.0–O06.8, O07.0–O07.3, O08.0–O08.9, O85, O86.0–O86.4, O86.8, O87.0–O87.3, O87.8–O87.9, O88.0–O88.3, O88.8, O90.0–O90.9, O91.0–O91.2, O92.0–O92.7, O96, O97
3. Some infections of a surgical site classified elsewhere	J85.0–J85.3, J86.0, J86.9, M00.0–M00.9, M46.2, M46.3, M86.2–M86.4, M86.6–M86.9, T79.3
4. Drug- or radiation-induced disorders	D61.1, D69.5, D70, E06.4, E13.–E13.9, E16.0, E23.1, E24.2, E27.3, E66.1, G21.0, G21.1, G25.1, G24.0, G25.4; G25.6, G44.4, G62.0, H26.3, H40.6, I95.2, K52.0, K62.7, K71.0–K71.9, L23.3, L24.4, L27.0–L27.1, L51.2, L53.0, L56.0–L56.1, L58.0–L58.1, L58.9, L59.0, L59.8, L59.9, M02.2, M10.2, M32.0, M80.4, M81.4, M83.5, M87.1, M96.5, N14.0–N14.2, N30.4, N98.0–N98.3, N98.8, N98.9, O29.0–O29.6, O29.8–O29.9, O35.5–O35.6, O89.0–O89.6, O89.8–O89.9, T80.0, T80.1–T80.6, T80.8–T80.9, T88.0–T88.9
5. Conditions generally resulting from a preexisting disease with multiple accompanying diseases	B20.0–B20.9, B21.0–B21.3, B21.7–B21.9, B22.0–B22.2, B22.7, B25.0–B25.2, B25.8–B25.9, C77.0–C77.9, C78.0–C78.8, C79.0–C79.8, C80., I46.0–I46.9, I85.0, J81, R40.0–R40.2, R55, R57.0–R57.1, R57.8–R57.9
6. Deep vein thrombosis, pulmonary embolism, and decubitus ulcer	I26.0, I26.9, I80.0–I80.3, I80.8–I80.9, I81, I82.0–I82.3, I82.8–I82.9, L89

Appendix B

Which factors are from which study.

<u>Factors article Kansegara</u>	<u>Factors article Haflon</u>	<u>Factors article Kosecoff</u>
<p>Medical comorbidities:</p> <ul style="list-style-type: none"> - Specific diagnoses or comorbidity index 	<p>Complication of surgical care:</p> <ul style="list-style-type: none"> - Hemorrhage - Disruption of wound - Infection - Obstruction or thrombosis of a surgical site - Fistulae - Pseudarthrosis - Surgical failure <p>Postoperative medical complication:</p> <ul style="list-style-type: none"> - Pulmonary embolism - Decubitus Ulcer - Other undesirable outcome 	<p>Instability at discharge*:</p> <ul style="list-style-type: none"> - Fever, temperature >38,3 - New incontinence - New chest pain - New shortness of breath - New confusion - New heart rate \geq 130 beats/min - New respiratory rate \geq 30/min - Diastolic blood pressure \geq 105 mm Hg - New systolic blood pressure < 90 mm Hg - New low heart rate < 50 beats/min - New premature ventricular contractions
<p>Mental health comorbidities:</p> <ul style="list-style-type: none"> - Mental illness - EtOH/substance use 	<p>Premature discharge <u>Clinical instability during last 2 days of the stay</u></p> <ul style="list-style-type: none"> - New clinical problem - Temperature > 38,3 - Diastolic blood pressure \geq100 mm HG - etc. <p><u>Abnormal last laboratory value</u></p> <ul style="list-style-type: none"> - Sodium - Potassium - Creatinine - Hematocrit 	<p>Sickness at discharge*:</p> <ul style="list-style-type: none"> - Fever, temperature > 38,3 - New incontinence - Chest pain - Shortness of breath - Confusion - Heart rate \geq 130 beats/min - Respiratory rate \geq 30/min - Diastolic blood pressure \geq 105 mm Hg

	<ul style="list-style-type: none"> - Leucocytes <u>Other criteria</u> - Modification of a treatment <p>Purulent drainage or purulent exudate on the day of discharge</p> <ul style="list-style-type: none"> - Unstable weight in patients with heart failure 	<ul style="list-style-type: none"> - Systolic blood pressure < 90 mm Hg - New decubitus - Low heart rate < 50 beats/min - Premature ventricular contractions - Parenteral antibiotics
<p>Illness severity:</p> <ul style="list-style-type: none"> - Illness severity index - Lab findings - Others 	<p>Complication of nonsurgical care:</p> <ul style="list-style-type: none"> - Urinary device infection or obstruction - Postlumbar puncture reaction - Dialysis or catheterism complication 	<p>Abnormal last laboratory values*:</p> <ul style="list-style-type: none"> - Potassium - Sodium - Renal distress - Low Hematocrit - High WBC - Weight increase > 1,35 KG - CHF by roentgenographic worsening
<p>Prior utilization:</p> <ul style="list-style-type: none"> - Hospitalizations - ER visits - Clinic visits/ <p>Missed clinic visits</p> <ul style="list-style-type: none"> - Index hospital length of stay 	<p>Drug-related adverse events:</p> <ul style="list-style-type: none"> - Agranulocystosis - Hemorrhage - Others... 	
<p>Overall health and function:</p> <ul style="list-style-type: none"> - Functional status; ADL dependence; mobility - Self-rated health, quality of life 	<p>Discharge with a missing or erroneous diagnosis or therapy:</p> <ul style="list-style-type: none"> - The cause of the readmission is a diagnosis that was ignored during index hospitalization in spite of existing symptoms or delayed or incorrect therapy. 	

<ul style="list-style-type: none"> - Cognitive impairment - Visual or hearing impairment 		
<p>Sociodemographic factors:</p> <ul style="list-style-type: none"> - Age - Gender - Race/ethnicity 	<p>Other inadequate discharge:</p> <ul style="list-style-type: none"> - Follow-up visit inappropriately scheduled in terms of patient's severity of illness, foreseen changes in therapy or regimen, or need for laboratory evaluation - Inappropriate planning of home or ambulatory health care or rehabilitation care - Insufficient educational support of the patient and/or his family 	
<p>Social determinants of health:</p> <ul style="list-style-type: none"> - SES/ income/ employment status - Insurance status‡ - Education - Marital status/# of people in home - Caregiver availability, other social support - Access to care/rurality - Discharge location (home, NH) 	<p>Failure of postdischarge follow-up care:</p> <ul style="list-style-type: none"> - Includes readmissions for problems that could have been managed in an ambulatory manner 	
	<p>Inadequate patient behavior:</p> <ul style="list-style-type: none"> - The patient didn't follow the prescribed treatment (drugs, diet, physiotherapy) or 	

	<p>abused alcohol or illicit drugs, refused home care or his transfer to another health service, or left hospital against medical advice</p>	
	<p>Relapse or aggravation of a previously known affection: - Recurrence, continuation, or complications of the index medical condition</p>	
	<p>Social readmission</p>	