Methodological paper

HSMR 2015: Methodological report

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1. Introduction

This report presents the methods Statistics Netherlands (CBS) has used to calculate the Hospital Standardised Mortality Ratios (HSMRs) for Dutch hospitals. HSMRs are ratios of observed and expected number of deaths and aim to present comparable hospital mortality figures. This chapter gives a general overview of the HSMR. Chapter 2 presents the changes introduced in the method of calculating the HSMR. The methodological aspects of the model used to calculate the HSMRs are described in chapter 3. The model outcomes are evaluated in chapter 4.

1.1 What is the (H)SMR?

Hospital mortality can be measured as the ratio of the number of hospital deaths to the number of hospital admissions (hospital stays) in the same period. This is generally referred to as the "gross mortality rate". Judging hospital performance on the basis of gross mortality rates is unfair, since one hospital may have had more life-threatening cases than another. For this purpose, it is more appropriate to adjust (i.e. standardise) mortality rates across hospitals as much as possible for differences in characteristics of the patients admitted to these hospitals ("case mix"). To this end, the *SMR* (Standardised Mortality Ratio) of a hospital *h* for diagnosis *d* is defined as

$$SMR_{dh} = 100 \times \frac{\text{Observed mortality}_{dh}}{\text{Expected mortality}_{dh}}.$$

The numerator is the *observed* number of deaths with main diagnosis *d* in hospital *h*. The denominator is the *expected* number of deaths for this type of admission under the assumption that individual mortality probabilities (per admission) do *not* depend on the hospital, i.e. are equal to mortality probabilities of identical cases in other hospitals. The denominator is therefore founded on a model based on data from all hospitals, in which the mortality of an admission is explained by characteristics of the patient, such as age, and characteristics of the admission, such as diagnosis and whether the admission is acute and unplanned versus planned. Characteristics of the hospital, such as the number of doctors per bed, are generally not incorporated in the model, since these can be related to the quality of care in the hospitals, which is the intended outcome of the indicator. The model thus produces an expected (estimated) mortality probability for each admission. Adding up these probabilities per hospital gives the total expected mortality over all admissions of that hospital. For each diagnosis *d*, the average SMR_d across the hospitals equals 100 when each hospital is weighted with its (relative) expected mortality.

The *HSMR* of hospital *h* is defined as

$$HSMR_h = 100 \times \frac{\text{Observed mortality in } h}{\text{Expected mortality in } h}.$$

in which both the numerator and denominator are sums across all admissions for all considered diagnoses. The HSMR thus also has a weighted average of 100. As HSMRs may also deviate from 100 only by chance, confidence intervals of the SMRs and HSMRs are calculated so that hospitals can see whether they have a (statistically) significantly high or low adjusted mortality rate compared with the average of 100.

1.2 Purpose of the HSMR

As in many other countries, there is much interest in measuring the quality of health care in the Netherlands. Hospitals can be assessed using various quality indicators, such as the number of medical staff per bed or the availability of certain facilities. However, these indicators do not measure the outcomes of medical performance. A good indicator for the performance of a hospital is the extent to which its patients recover, given the diagnoses and other important characteristics, such as age, sex and comorbidity, of the patients. Unfortunately, recovery is hard to measure and mostly takes place after patients have been discharged from the hospital. Although hospital mortality is a much more limited quality indicator, it can be measured accurately. That is why this indicator is now used in several countries, using the HSMR and SMRs as defined in section 1.1. If these instruments were totally valid, i.e. the calculations could adjust perfectly for everything that cannot be influenced by the hospital, a value above 100 would always point to inferior care quality, and the difference between numerator and denominator could be considered an estimate of "avoidable mortality". This would only be possible if the measurement was perfect and mortality by unforeseen complications, after adjustment for differences in case mix, was equally distributed across hospitals. However, it is impossible to construct a perfect instrument to measure the quality of health care. A significantly high (H)SMR will at most be an indication of possible shortcomings in hospital care. But the high value may also be caused by coding errors in the data or the lack of essential covariates in the model related to mortality. Still, a significantly high (H)SMR is often seen as a warning sign, a reason for further investigation into the causes.

1.3 History of the HSMR

In 1999 Jarman initiated the calculation of the (H)SMR for hospitals in England (Jarman et al., 1999). In the following years the model for estimating mortality probabilities was improved by incorporating additional covariates into the model. Analogous models were adopted by some other countries.

In 2005, Jarman started to calculate the (H)SMR for the Netherlands. Later on, these Dutch (H)SMRs were calculated by Kiwa Prismant, in collaboration with Jarman and his colleagues of Imperial College London, Dr Foster Intelligence in London and De Praktijk Index in the Netherlands. Their method is described in Jarman et al. (2010) and was slightly adapted by Kiwa Prismant (Prismant, 2008) up to reporting year 2009. In 2010 Dutch Hospital Data (DHD, Utrecht), the holder of the national hospital discharge data, asked CBS to calculate the (H)SMRs for the period 2008-2010 and for subsequent years. CBS is an independent public body and familiar with the input data for the HSMR, i.e. the hospital discharge register (LMR: Landelijke Medische Registratie, and its successor LBZ: Landelijke Basisregistratie Ziekenhuiszorg), as it uses this data source for a number of health statistics (see www.statline.cbs.nl).

The starting point for CBS was the HSMR methods previously used by Kiwa Prismant. As a result of progressive insight CBS has introduced changes in the model for the HSMR 2008-2010 and later years, which are described in the yearly methodological reports (CBS, 2011, 2012, 2013, etc.)

1.4 Confidentiality

Under the Statistics Netherlands Act, CBS is required to keep all data about individuals, households, companies or institutions confidential. Therefore it normally does not deliver recognisable data from institutions to third parties, unless the institutions concerned have stated that they do not have any objections to this. For this reason, CBS needs written

permission from all hospitals to deliver their hospital specific (H)SMR figures to DHD. CBS only supplies DHD with (H)SMR outcomes of hospitals that have granted authorisation to do so. In turn DHD sends each hospital its individual outcome report. Publication of (H)SMR data, which has become mandatory in the Netherlands since 2014 by a regulation of the Dutch Healthcare Authority (NZa), is the responsibility of the hospitals themselves. CBS does not publish data on identifiable hospitals.

1.5 CBS output

CBS estimated the models for expected mortality per diagnosis for the most recent three year period. It calculated the HSMRs and SMRs for all hospitals that (1) had authorised CBS, (2) had registered all or a sufficient part of its admissions in the LBZ/LMR in the relevant period, and (3) were not excluded on the grounds of criteria for quality and comparability, which means that the hospital's LBZ/LMR data were not too deviant in some respects (see section 3.5).

CBS produces the following output:

1. A hospital-specific report for each hospital, sent via DHD, containing the HSMR and the diagnosis-specific SMR figures for the three year period and the individual years. SMRs are also presented for different patient groups (by age, sex and urgency of admission) and diagnosis clusters. Hospitals can see how they compare with the national average, overall, and per diagnosis and patient group. CBS only made reports for hospitals not excluded under the exclusion criteria and that signed the authorisation request.
2. Each hospital not excluded on the grounds of the exclusion criteria and that signed the authorisation request is provided with a dataset with the mortality probabilities for all its admissions. Besides the probability, each record contains the observed mortality (0 or 1) and the scores on the covariates of the HSMR model. The hospital can use these data for internal investigation.
3. A report on the methods used for calculating the HSMR including the model results and parameters (this document; see www.cbs.nl).

1.6 Limitations of the HSMR

In section 1.2 we argued that the HSMR is not the only indicator to measure hospital care quality. Furthermore, the quality and limitations of the HSMR (and the SMR) instrument are under debate. After all it is based on a statistical model (i.e. the denominator), and a model is always a simplification of reality.

Since the very first publication of the HSMR in England, there has been an on-going debate about the quality of the HSMR as an instrument. Supporters and opponents agree that the HSMR is not a unique, ideal measure, but at most a possible indicator for the quality of health care, alongside other possible indicators. But even if HSMR were to be used for a more limited purpose, i.e. standardising hospital mortality rates for unwanted side-effects, the interpretation of HSMRs would present various problems, some of which are described briefly below. See also Van Gestel et al. (2012) for an overview.

- Section 3.4 contains the list of covariates included in the regression model. Hospitals do not always code these variables in the same way. Variables such as Age and Sex do not give any problems, but how aspects like acute admissions, main diagnosis and comorbidity are coded may depend on individual physicians and coders. Lilford and Pronovost (2010) argue that if the quality of the source data is insufficient, the regression model should not adjust for such erroneously coded covariates. Our own

investigation (Van der Laan, 2013) shows that comorbidities in particular present a problem, as there is not much uniformity in coding this covariate (see also section 4.3). Van den Bosch et al. (2010) refer extensively to the influence of coding errors. Exclusion criteria for outliers may solve this problem in part but not completely.

- Some hospitals may have on average more seriously ill patients than others, even if they have the same set of scores on the covariates. University hospitals may, for example, have more serious cases than other hospitals. It is questionable whether the model adjusts satisfactorily for this phenomenon (also see section 4.6). Some essential covariates related to mortality are then missing. This may be caused by some of the desired covariates not being measured in the LBZ/LMR. Some factors will actually even be hard to measure in this type of routinely collected datasets of all hospital discharges.

- The same problem occurs when certain high risk surgical procedures are only performed in certain hospitals. For instance, open heart surgery only occurs in authorised cardiac centres, and these hospitals may have higher SMRs for heart disease because of the more dangerous interventions. This could be solved by including a covariate in the model that indicates whether such a procedure was performed. This has the disadvantage that a method of treatment is used as a covariate, while ideally it should not be part of the model as it is a component of hospital care.

- Hospital admission and discharge policies may differ. For instance, one hospital may admit the same patient more frequently but for shorter stays than another. Or it may discharge a patient earlier than another because there are adequate external terminal care facilities in the neighbourhood. Also, patients may be referred from one hospital to another for further treatment. Obviously, all these situations influence the outcome of the HSMR, as they influence the observed mortality numbers, but these differences in HSMR cannot be translated in terms of quality of care.

- Hospitals can compare their HSMR and SMRs with the national average of 100. The comparison between (H)SMRs of two or more hospitals with each other is more complicated. There is no complete adjustment for differences in case mix between pairs of hospitals. Theoretically, it is even possible that hospital A has higher SMRs than hospital B for all diagnosis groups, but a lower HSMR. Although this is rather theoretical, bilateral comparison of HSMRs should be undertaken with caution (Heijink et al., 2008).

Some issues in the incomplete correction for differences in the case mix between hospitals may be partly addressed by peer group comparison of (H)SMRs. The calculation of H(SMR)s is still based on the model for all hospitals (without correcting for the type of hospital), but a specialised hospital can then also compare its results with the average for similar hospitals (peer group). For instance, the average HSMR of university hospitals is >100 in the Netherlands, due to insufficient case mix correction, but this still allows these hospitals (and for specific diagnoses also other specialised hospitals) to compare their results with the peer group average.

An indicator including early post-discharge mortality alongside in-hospital mortality could be introduced to tackle the problem of differences in discharge policies (e.g. the availability of terminal care outside hospital), and to some extent referrals between hospitals. Ploemacher *et al*. (2013) saw a decrease in standardised in-hospital mortality in the Netherlands in 2005-2010, which may have been caused by an overall improvement in care quality, but may also be partly explained by substitution of in-hospital mortality by outside-hospital mortality, possibly caused by changes in hospital admission and discharge policies. In cooperation with CBS, Pouw *et al*. (2013) did a retrospective analysis on Dutch hospital data linked to mortality data, and concluded that including early post-discharge mortality is advisable to diminish the effect of discharge bias on the HSMR. In the UK, the SHMI (Summary Hospital-level Mortality Indicator) has been adopted, which includes mortality up to 30 days after discharge (Campbell *et al*., 2011). In 2014, CBS studied the optimal time frame and definition of an indicator including early post-discharge mortality (Van der Laan *et al*., 2015). A fixed period of 45 days after admission in which all mortality is included in the mortality indicator would make the indicator less dependent on hospital discharge policies. A recent French study also recommends fixed post-admission periods of more than 30 days (Lamarche-Vadel et al., 2015).

Although including post-discharge mortality in the indicator would reduce the effect of differences in hospital discharge policies, it would not reduce the effect of differences in admission policies for terminally ill patients. Some hospitals may admit more patients specifically (and sometimes only) for palliative care than other hospitals. As such patients are admitted to die in hospital, not to receive curative care, these admissions may distort HSMR outcomes. Palliative care can be measured in ICD10 (code Z51.5), but this variable should be used with caution, as differences between hospitals in coding practices have been shown in UK and Canada, and adjusting for palliative care may increase the risk of gaming (NHS, 2013; Chong et al., 2012; Bottle et al., 2011). Because of this, and because the LBZ/LMR registration does not allow for distinguishing between admissions of terminally ill patients for palliative care only and admissions for curative treatment ending in palliative care, palliative care admissions have not yet been excluded from the calculation of the HSMR in the Netherlands. However, the HSMR reports sent to the hospitals include information on the percentage of the hospital's admissions and deaths related to palliative care as registered in the LBZ/LMR compared to the overall average. This may indicate to some extent whether or not palliative care could have biased a hospital's HSMR. However, since the Netherlands also shows a large variation between hospitals in the coding of palliative care, this information should be used with caution.

2. Method changes

This chapter summarizes the changes in the HSMR method (HSMR 2015) compared to the method used last year (HSMR 2014). For previous changes see the respective methodological reports (CBS, 2011, 2012, 2013, 2014, 2015).

In 2015, a major change in the calculation of the HSMR was implemented. In the years before, the HSMR was only calculated for the 50 diagnoses groups with the highest mortality. Together these covered approximately 80 percent of the total mortality in hospitals and approximately 37 percent of the total number of inpatient admissions. However, for individual hospitals the mortality covered by the HSMR can also be lower than 70 percent. Furthermore, the percentage of mortality covered by these 50 diagnoses groups has decreased in recent years. And because it would also be attractive on principal grounds to include all inpatient mortality in the HSMR, the extension of the HSMR to all diagnosis groups was investigated in 2015 (see section 4.6). Based on the results of this study and discussions with an advisory committee organized by Dutch Hospital Data, it was decided to base the HSMR of 2015 on all inpatient mortality. The HSMR is therefore no longer calculated for 50 diagnosis groups but for 157 groups, covering all diagnoses.

Although the HSMR based on the 157 diagnoses groups is strongly correlated with the HSMR based on the 50 diagnoses groups, it is no longer comparable to that of previous years. For 2015 the HSMRs of the original 50 diagnosis groups are also included in the reports sent to the hospitals, in order to allow them to see the effect of this method change.

There are also some smaller changes:

- Since the number of SMRs by diagnosis group went from 50 to 157, the likelihood of falsely significant SMRs has increased. Therefore, the significance level for these SMRs was raised from 95 to 98 percent.

- From 2015 onwards, the HSMR also includes the new case type ‘prolonged observations, unplanned, without overnight stay’. This case-type was introduced by the Dutch Healthcare Authority, and it replaces the majority of one-day inpatient admissions that were formerly registered. This case type also involves more mortality than in day cases, so it is relevant to include it in the HSMR.

- Some ICD10 codes (I42.1-I42.4) have been added to the Charlson comorbidity ‘heart failure’.

- The severity of main diagnosis classification is now based on data from 2006-2011. In the coming years, the period on which the severity classification is based will shift by one year every year (using the most recent 6 years before the period on which the model is based)

- Now that all mortality is included in the calculation of the HSMR, some of the previous exclusion criteria are no longer relevant.

3. (H)SMR model

Expected hospital mortality - i.e. the denominator of the SMR - has to be determined for each diagnosis group. To this end we use logistic regression models, with mortality as the target (dependent) variable and various variables available in the LBZ/LMR as covariates. The regression models for the (H)SMR of a three year period (year t-2 up to year t), and the (H)SMRs of the individual years t-2, t-1 and t, use LBZ/LMR data of four years: year t-3 up to year t. The addition an additional year increases the stability and accuracy of the estimates, while keeping the model up to date.

3.1 Target population and dataset

3.1.1 Hospitals

"Hospital" is the primary observation unit. Hospitals report admission data (hospital stay data) in the LBZ/LMR. However, not all hospitals participate in the LBZ/LMR. In principle, the HSMR model includes all short-stay hospitals with inpatient admissions participating in the LBZ/LMR in the relevant years. The target population of hospitals that qualify for entry in the HSMR-model thus includes all general hospitals, all university hospitals, and short-stay specialised hospitals with inpatient admissions. For a number of partially non-responding hospitals only the fully registered months were included in the model, as in the other months there were indications that fatal cases were registered completely and non-fatal cases partially. The partially registered months of these hospitals were removed from the model as these would otherwise unjustly influence the estimates.

All the above-mentioned hospitals were included in the model, but (H)SMRs were only calculated for hospitals that met the criteria for LBZ/LMR participation, data quality and case mix (see section 3.5).

3.1.2 Admissions

We consider both the population of hospitals and the population of admissions. Our target population of admissions consists of "all hospital stays (inpatient admissions) of Dutch residents in Dutch short-stay hospitals in a certain period". The date of discharge, and not the day of admission, determines the year a record is assigned to. So the population of hospital stays of year *t* comprises all inpatient admissions that ended in year *t*. For the sake of convenience, mostly we call these hospital stays "admissions", thus meaning the hospital stay instead of only its beginning. Day admissions are excluded as these are in principle non-life-threatening cases with hardly any mortality. However, from 2015 onwards the new case type 'prolonged observations, unplanned, without overnight stay' is included in the HSMR. This case-type was introduced by the Dutch Healthcare Authority, and it replaces the majority of one-day inpatient admissions that were formerly registered. This case type involves more mortality than day cases, and it is therefore relevant to include this in the HSMR.

Lastly, admissions of foreigners are excluded from the HSMR model, partly in the context of possible future modifications of the model, when other data can be linked to admissions of Dutch residents. The number of admissions of foreigners is relatively small..

3.2 Target variable (dependent variable)

The target variable for the regression analysis is the "in-hospital mortality". As this variable is binary, logistic regressions were performed.

3.3 Stratification

Instead of performing one logistic regression for all admissions, we performed a separate logistic regression for each of the diagnosis groups *d*. These sub-populations of admissions are more homogeneous than the entire population. Hence, this stratification may improve the precision of the estimated mortality probabilities. As a result of the stratification, covariates are allowed to have different regression coefficients across diagnosis groups.
The diagnosis groups are clusters of ICD codes registered in the LBZ/LMR. Here the main diagnosis of the admission is used, i.e. the main reason for the hospital stay, which is determined at discharge. The basis for the clustering is the CCS *(Clinical Classifications Software*[1]), which clusters ICD diagnoses into 259 clinically meaningful categories. For the HSMR, we further clustered these into 157 diagnosis groups, which are partly the same clusters used for the SHMI (Summary Hospital-level Mortality Indicator) in the UK (HSCIC, 2016).

Therefore, the model includes 157 separate logistic regressions, one for each diagnosis group *d* selected.

The ICD9-CM definitions of the CCS groups are used for the data up to 2012, and the ICD10 definitions are used from 2013 onwards. Dutch hospitals transferred to ICD10 coding in the period 2011-2013. In 2012, less than half of the hospitals coded all or part of their diagnoses in ICD10. In 2013 almost all hospitals coded in ICD10, and in 2014 all hospitals did. When a hospital coded in another ICD version than the definitions used for the CCS groups in a particular year, the registered codes were converted from ICD10 to ICD9-CM using conversion table 'ICD10 – CvZ80', and from ICD9-CM to ICD10 using conversion table 'CvZ80 – ICD-10', see http://www.rivm.nl/who-fic/ICD.htm. These conversion tables were also used for the covariates severity of main diagnosis and the comorbidities (see section 3.4).

In the file 'Classification of variables', published together with this report, for each of the 157 diagnosis groups the corresponding CCS group(s) are given, as well as the ICD10 codes of each CCS group.

Apart from the SMRs for each of the 157 diagnosis groups, hospitals also receive SMRs for 17 aggregates of diagnosis groups. This makes it possible to evaluate the SMR outcomes at both the detailed and the aggregated diagnosis level. The 17 main clusters are also given in the 'Classification of variables' file. These were derived from the main clusters in the CCS classification of HCUP (see Appendix C1 in http://www.hcup-us.ahrq.gov/toolssoftware/ccs/CCSUsersGuide.pdf), with the following adaptations:

- HCUP main clusters 17 ("Symptoms; signs; and ill-defined conditions and factors influencing health status") and 18 ("Residual codes; unclassified") were merged into one cluster.
- CCS group 54 ("Gout and other crystal arthropathies") is classified in main cluster "Diseases of the musculoskeletal system and connective tissue", and CCS group 57 ("Immunity

[1] *See http://www.hcup-us.ahrq.gov/toolssoftware/icd_10/ccs_icd_10.jsp*

disorders") is classified in main cluster "Diseases of the blood and blood-forming organs", whereas in the HCUP classification these groups fall in main cluster "Endocrine, nutritional and metabolic diseases, and immunity disorders".
- CCS group 113 ("Late effects of cerebrovascular disease") is classified in main cluster "Diseases of the nervous system and sense organs", whereas in the HCUP classification this group falls in main cluster "Diseases of the circulatory system".
- CCS group 218 ("Liveborn") is classified in main cluster "Complications of pregnancy, childbirth, and the puerperium; liveborn", whereas in the HCUP classification this group falls in main cluster "Certain conditions originating in the perinatal period".

These adaptations are in accordance with the diagnosis groups used for the SHMI (Summary Hospital-level Mortality Indicator) in the United Kingdom (HSCIC, 2016).

Although the names of the main clusters have much similarity with the names of the chapters of the ICD10, there is no one-to-one relation between the two. Although most ICD10 codes of a CCS group do fall within one ICD10 chapter, there often are also codes that fall in other chapters. Especially codes from the R chapter of ICD10 are scattered over several HCUP main clusters.

3.4 Covariates (explanatory variables or predictors of in-hospital mortality)

By including covariates of patient and admission characteristics in the model, the in-hospital mortality is adjusted for these characteristics. As a result, the (H)SMRs are adjusted for these covariates as well. Thus, variables (available in the LBZ/LMR) associated with patient in-hospital mortality are chosen as covariates. The more the covariates discriminate between hospitals, the larger the effect on the (H)SMR.

The LBZ/LMR variables that are included in the model as covariates are age, sex, socio-economic status, severity of main diagnoses, urgency of admission, Charlson comorbidities, source of admission, year of discharge and month of admission. These variables are described below. For the variables socio-economic status, severity of main diagnosis and source of admission the detailed classifications are presented in the file 'Classification of variables', published together with this report.

For the regressions, all categorical covariates are transformed into dummy variables (indicator variables), having scores 0 and 1. A patient scores 1 on a dummy variable if he/she belongs to the corresponding category, and 0 otherwise. As the dummy variables for a covariate are linearly dependent, one dummy variable is left out for each categorical covariate. The corresponding category is the so-called *reference category*. We took the *first* category of each covariate as the reference category.

The general procedure for collapsing categories is described in section 3.6.2. Special (deviant) cases of collapsing are mentioned below.

Age at admission (in years): *0, 1-4, 5-9, 10-14, …, 90-94, 95+*.

Sex of the patient: *male, female.*

If Sex is unknown, “female” was imputed. This is a rare occurrence.

SES (socio-economic status) of the postal area of patient’s address: *lowest, below average, average, above average, highest, unknown.*

The SES variable was added to the LBZ/LMR dataset on the basis of the postal code of the patient’s residence. SES was derived from the Netherlands Institute for Social Research (SCP)[2], which had collected SES data and performed principal component analyses on variables concerning Income, Employment and Education level. Each four-letter postal area was thus assigned a component score. Population-weighted quintiles were calculated from these scores, resulting in the six SES categories mentioned above. Patients for whom the postal area does not exist in the dataset of the SCP (category “unknown”), were added to the category “average” if collapsing was necessary. For 2011-2013, admissions followed the SES classification of 2010, whereas admissions of 2014 and 2015 followed the SES classification of 2014.

Severity of main diagnosis groups: *[0-0.01), [0.01-0.02), [0.02-0.05), [0.05-0.1), [0.1-0.2), [0.2-0.3), [0.3-0.4), [0.4-1], Other*.

This is a categorisation of main diagnoses into mortality rates. Each ICD9-CM main diagnosis code is classified in one of these groups, as explained below.

A separate model was estimated for each of the 157 diagnosis groups. Most groups have many sub-diagnoses (individual ICD codes), which may differ in seriousness (mortality risk). To classify the severity of the sub-diagnosis, we used the method suggested by Van den Bosch et al. (2011), who suggested categorising the ICD codes into mortality rate categories. To this end, we computed inpatient mortality rates for all ICD9-CM sub-diagnoses for six historical LMR years, and chose the following boundaries for the mortality rate intervals: 0, .01, .02, .05, .1, .2, .3, .4 and 1. (‘0’ means 0 percent mortality; ‘1’ means 100 percent mortality). These boundaries are used for all CCS diagnosis groups. The higher severity categories only occur for a few diagnosis groups.

Six historical LMR years are used to determine the classification, preferably not overlapping with the years of the HSMR model as otherwise both are using the same mortality data. For the present HSMR model of 2012-2015, the severity classification was based on the LMR of 2006-2011. Because the diagnoses were still coded in ICD9-CM in these years, the severities were also determined for ICD9-CM codes. Main diagnoses registered in ICD10 are therefore converted to ICD9-CM to determine the severity covariate. Because the conversion table used has not been updated for recent years, new ICD codes added to the ICD10 in recent years did not have a converted ICD9-CM code. Furthermore, some converted ICD9-CM codes did not occur in the dataset of the historical LMR years. In these cases a severity ” other” was assigned in the calculation of the (H)SMR. ICD9-CM codes that are used by less than four hospitals and/or have less than 20 admissions also receive a severity of ”other”. The category ”other” contains diagnoses for which it is not possible to accurately determine the severity. If this category “other” needs to be collapsed however, it does not have a natural nearby category. We decided to collapse “other” with the category with the highest frequency (i.e. the mode), if necessary. In the file with regression coefficients (see section 4.5) this will result in a coefficient for “other” equal to that of the category with which “other” is collapsed.

[2] http://www.scp.nl/Onderzoek/Lopend_onderzoek/A_Z_alle_lopende_onderzoeken/Statusscores

In the coming years, the period on which the severity classification is based will shift by one year every year (using the most recent 6 years before the period on which the model is based).

The individual ICD9-CM codes with the corresponding severity category are available in the separate file 'Classification of variables', published together with this report.

Urgency of the admission: elective, acute.
The definition of an acute admission is: an admission that cannot be postponed as immediate treatment or aid within 24 hours is necessary. Within 24 hours means 24 hours from the moment the specialist decides an acute admission is necessary.

3.4.1 Comorbidity groups of Charlson index and the corresponding ICD9-CM and ICD10 codes

No.	Comorbidity groups	ICD9-CM codes	ICD10 codes
1	Acute myocardial infarction	410, 412	I21, I22, I252
2	Congestive heart failure	428	I50, I110, I130, I132, I255, I42, I43, P290
3	Peripheral vascular disease	441, 4439, 7854, V434	I70, I71, I731, I738, I739, I771, I790, I792, K551, K558, K559, Z958, Z959, R02
4	Cerebrovascular disease	430-438	G450-G452, G454, G458, G459, G46, I60-I69
5	Dementia	290	F00-F03, F051, G30, G311
6	Pulmonary disease	490-496, 500-505	J40-J47, J60-J67
7	Connective tissue disorder	7100, 7101, 7104, 7140-7142, 71481, 5171, 725	M05, M060, M063, M069, M32, M332, M34, M353
8	Peptic ulcer	531-534	K25-K28
9	Liver disease	5712, 5714-5716	B18, K700-K703, K709, K713-K715, K717, K73, K74, K760, K762-K764, K768, K769, Z944
10	Diabetes	2500-2503, 2507	E109, E119, E129, E139, E149
11	Diabetes complications	2504-2506	E100-E108, E110-E118, E120-E128, E130-E138, E140-E148
12	Hemiplegia or paraplegia	342, 3441	G041, G114, G801, G802, G81, G82, G830-G834, G838, G839
13	Renal disease	582, 5830-5832, 5834, 5836, 5837, 585, 586, 588	I120, I131, N01, N03, N052-N057, N18, N19, N25, Z490-Z492, Z940, Z992
14	Cancer	14-16, 18, 170-172, 174-176, 179, 190-194, 1950-1955, 1958, 200-208	C00-C26, C30-C34, C37-C41, C43, C45-C58, C60-C76, C81-C85, C88, C90-C97
15	HIV	042-044	B20-B24
16	Metastatic cancer	196-198, 1990, 1991	C77-C80
17	Severe liver disease	5722-5724, 5728	I850, I859, I864, I982, K704, K711, K721, K729, K765, K766, K767

Comorbidity_1 – Comorbidity_17. All these 17 covariates are dummy variables, having categories: *0* (*no*) and *1* (*yes*).

The 17 comorbidity groups are listed in table 3.4.1, with their corresponding ICD9-CM and ICD10 codes. These are the same comorbidity groups as in the Charlson index. However, separate dummy variable are used for each of the 17 comorbidity groups.
Up to 2012 the ICD9-CM definitions of the Charlson comorbidities are used, and from 2013 onwards the ICD10 definitions are used. For the data for 2012 and earlier, the minority of diagnoses registered in ICD10 were first converted to ICD9-CM and then classified in the ICD9-CM Charlson comorbidity groups. For 2012, however, it was decided not to include ICD10 code Z95.5 in comorbidity group 3 (peripheral vascular disease), as after converting to ICD9-CM this code would end up in this comorbidity group, while this (coronary) diagnosis does not belong there. For the few hospitals that still registered in ICD9-CM in 2013 the diagnoses are converted to ICD10 and then classified according to the ICD10 definitions of the Charlson comorbidities.

All secondary diagnoses registered in the LBZ/LMR and belonging to the 17 comorbidity groups are used, but if a secondary diagnosis is identical to the main diagnosis, it is not considered a comorbidity. Secondary diagnoses registered as a complication arising during the hospital stay are not counted as a comorbidity either.

In conformity with the collapsing procedure for other covariates, comorbidity groups registered in fewer than 50 admissions or that have no deaths are left out, as the two categories of the dummy variable are then collapsed. An exception was made for Comorbidity_17 (Severe liver disease) and Comorbidity_11 (Diabetes complications). Instead of leaving out these covariates in the case of fewer than 50 admissions or no deaths, they are first added to the less severe analogues Comorbidity_9 (Liver diseases) and Comorbidity_10 (Diabetes), respectively. If the combined comorbidities still have fewer than 50 admissions or no deaths, then these are dropped after all.

The ICD9-CM definitions of the Charlson comorbidities in table 3.4.1 follow the definitions of Deyo et al. (1992). The ICD10 definitions used are mostly identical or nearly identical to those of Quan et al. (2005), with some adaptations, which are described in CBS (2014).
In the present HSMR model of 2012-2015 some ICD10 codes (I42.1-I42.4) were added to Comorbidity_2 (Congestive heart failure), from 2013 onwards. All sub-diagnoses of I42 are now included in this group.

Source of admission: *home, nursing home or other institution, hospital.*
This variable indicates the patient's location before admission.

Year of discharge: *2012, 2013, 2014. 2015*.
Inclusion of the year guarantees the number of observed and expected (predicted) deaths to be equal for that year. As a result the yearly (H)SMRs have an average of 100 when weighting the hospitals proportional to their expected mortality.

Month of admission: *January/February, …, November/December*.
The months of admission are combined into 2-month periods.

3.5 Exclusion criteria

Although all hospitals mentioned in section 3.1.1 are included in the model, HSMR outcome data were not produced for all hospitals. HSMRs were only calculated for hospitals that met the criteria for LBZ/LMR participation, data quality and case mix. In addition to this, only HSMRs were calculated for hospitals that had authorised CBS to supply their HSMR figures to DHD. Criteria used for excluding a hospital from calculating HSMRs were:

No inpatient admissions

0. Hospitals treating only day cases or outpatients are excluded, as calculation of the HSMR is not relevant for them. In fact, these hospitals do not belong to the HSMR population. Therefore, a code "0" was assigned to this criterion.

Insufficient participation in the LBZ/LMR

1. From 2014 onwards, hospitals are required to register all inpatient admissions to get HSMR outcomes. From 2011 up until 2013 hospitals were excluded when they had fewer than six completely registered months in a year (for inpatient admissions).

Data quality

Hospitals are excluded if*:*

2. ≥2% of inpatient admissions have a vague diagnosis code (ICD10 code R69).
3. ≤30% of inpatient admissions are coded as acute.
4. ≤0.5 secondary diagnoses are registered per inpatient admission, on average per hospital.[3]

Case mix

Hospitals are excluded if:

5. Observed mortality is less than 60 in all registered inpatient admissions (criterion from 2013 onwards). Up to 2012 the criterion used was an expected mortality of 50 or less in the 50 CCS groups, i.e. $E_{dk} \leq 50$.

Previously there was also a case mix criterion of a minimum percentage of all inpatient hospital deaths that fall within the previously selected 50 CCS diagnosis groups. As in the present model all diagnosis groups are included, this criterion is not relevant anymore.

In addition to the above-mentioned criteria, hospitals are also excluded if they had not authorised CBS to supply their HSMR figures.

3.6 Computation of the model and the (H)SMR

3.6.1 SMR and HSMR

According to the first formula in section 1.1, the SMR of hospital *h* for diagnosis *d* is written as

$$SMR_{dh} = 100\frac{O_{dh}}{E_{dh}} \tag{3.6.1}$$

with O_{dh} the observed number of deaths with diagnosis *d* in hospital *h*, and E_{dh} the expected number of deaths in a certain period. We can denote these respectively as

[3] For this criterion, all secondary diagnoses are considered, even if they do not belong to the 17 comorbidity groups used as covariates. If identical secondary diagnoses (identical ICD10 codes) are registered within one admission, only one is counted. If a secondary diagnosis is identical to the main diagnosis of the admission, it is not counted as a secondary diagnosis.

$$O_{dh} = \sum_i D_{dhi}, \tag{3.6.2}$$

and

$$E_{dh} = \sum_i \hat{p}_{dhi}, \tag{3.6.3}$$

where D_{dhi} denotes the observed mortality for the i^{th} admission of the combination (*d*,*h*), with scores 1 (death) and 0 (survival), and $\hat{p}_{dhi}$ the mortality probability for this admission, as estimated by the logistic regression of "mortality diagnosis *d*" on the set of covariates mentioned in section 3.4 This gives

$$\hat{p}_{dhi} = \text{Prob}(D_{dhi} = 1|X_{dhi}) = \frac{1}{1 + \exp(-\hat{\beta}_d' X_{dhi})}, \tag{3.6.4}$$

with X_{dhi} the scores of admission *i* of hospital *h* on the set of covariates, and $\hat{\beta}_d$ the maximum likelihood estimates of the corresponding regression coefficients, i.e. the so-called log-odds. For the HSMR of hospital *h*, we have accordingly

$$\text{HSMR}_h = 100\frac{O_h}{E_h} = 100\frac{\sum_d O_{dh}}{\sum_d E_{dh}} = 100\frac{\sum_d \sum_i D_{dhi}}{\sum_d \sum_i \hat{p}_{dhi}}. \tag{3.6.5}$$

It follows from the above formulae that:

$$\text{HSMR}_h = 100\frac{\sum_d E_{dh}\frac{O_{dh}}{E_{dh}}}{E_h} = \sum_d \frac{E_{dh}}{E_h}\text{SMR}_{dh}. \tag{3.6.6}$$

Hence, an HSMR is a weighted mean of the SMRs, with the expected mortalities across diagnoses as the weights.

3.6.2 Modelling and model-diagnostics

We estimated a logistic regression model for each of the 157 CCS diagnosis groups, using the categorical covariates mentioned in section 3.4. Computations were performed using the lrm procedure of the R-package rms. Categories, including the reference category, are collapsed if the number of admissions is smaller than 50 or when there are no deaths in the category, to prevent standard errors of the regression coefficients becoming too large. This collapsing is performed starting with the smallest category, which is combined with the smallest nearby category, etc. For variables with only two categories collapsing results in dropping the covariate out of the model (except for comorbidities 17 (Severe liver disease) and 11 (Diabetes complications) which are first combined with comorbidity 9 (Liver disease), and comorbidity 10 (Diabetes), respectively; see section 3.4). Non-significant covariates are preserved in the model, unless the number of admissions is smaller than 50 (or if there are no deaths) for all but one category of a covariate. All regression coefficients are presented in a file published together with this report.

The following statistics are presented to evaluate the models:

- *standard errors* for all regression coefficients (published with the regression coefficients);

- *statistical significance* of the covariates with significance level α=.05, i.e. confidence level .95 (see Appendix);
- *Wald statistics* for the overall effect and the significance testing of categorical variables;
- *C-statistics* for the overall fit. The C-statistic is a measure for the predictive validity of, in our case, a logistic regression. Its maximum value of 1 indicates perfect discriminating power and 0.5 discriminating power not better than expected by chance, which will be the case if no appropriate covariates are found. We present the C-statistics as an evaluation criterion for the logistic regressions.

In addition to these diagnostic measures for the regressions, we present the *average shift in HSMR* by inclusion/deletion of the covariate in/from the model (table 4.4.1). This average absolute difference in HSMR is defined as

$$\frac{1}{N}\sum_{h=1}^{N}\left|\mathrm{HSMR}_h - \mathrm{HSMR}_h^{-x_j}\right|, \tag{3.6.7}$$

where $\mathrm{HSMR}_h^{-x_j}$ is the HSMR that would result from deletion of covariate x_j, and N=81 the total number of hospitals for which an HSMR was calculated..

The Wald statistic is used to test whether the covariates have a significant impact on mortality. But it can also be used as a measure of association. A large value of a Wald statistic points to a strong impact of that covariate on mortality, adjusted for the impact of the other covariates. It is a kind of “explained chi-square”. As the number of categories may “benefit” covariates with many categories, it is necessary to also take into account the corresponding numbers of degrees of freedom (df), where the df is the number of categories minus 1. As a result of collapsing the categories, the degrees of freedom can be smaller than the original number of categories minus 1.

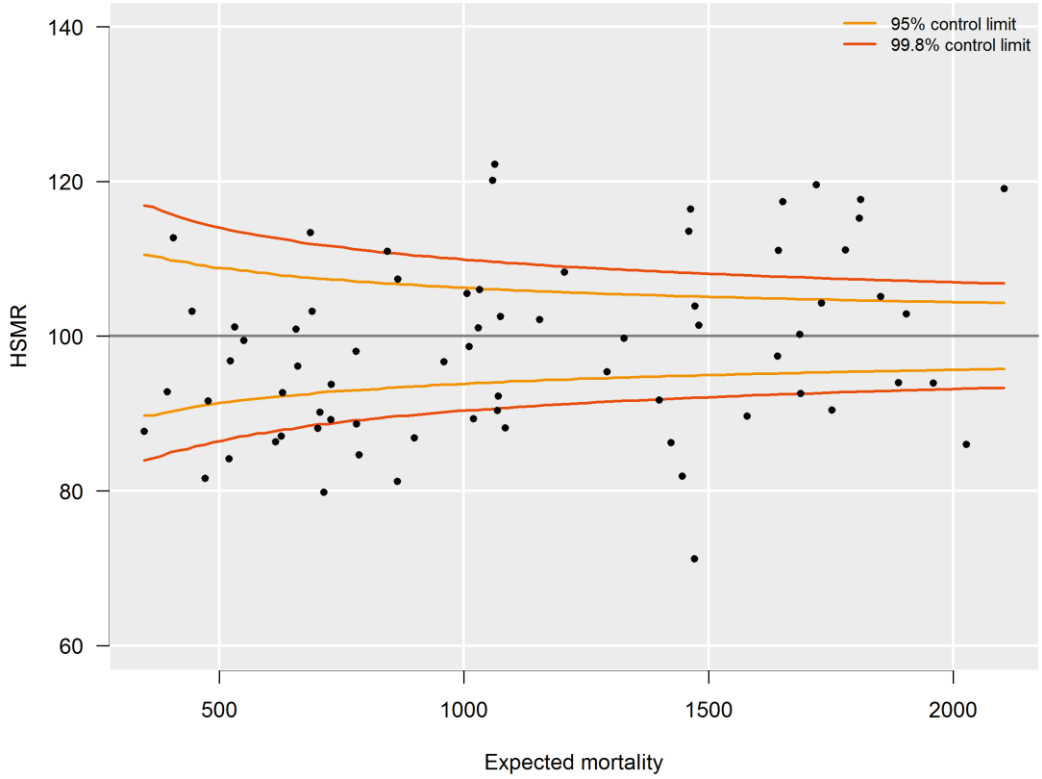
A high Wald statistic implies that the covariate’s categories discriminate in mortality rates. But if the frequency distribution of the covariate is equal for all hospitals, the covariate would not have any impact on the (H)SMRs. Therefore we also present the change in HSMRs resulting from deleting the covariate. Of course, a covariate that only has low Wald statistics has little impact on the (H)SMRs.

3.6.3 Confidence intervals and control limits

A confidence interval is calculated for each SMR and HSMR, i.e. an upper and lower confidence limit. For the HSMR and most SMRs a confidence level of 95 percent is used, for the SMRs of the 157 diagnosis groups a confidence level of 98 percent is used. These limits are mentioned in the specific reports for the hospitals. A lower limit above 100 indicates a statistically significant high (H)SMR, and an upper limit below 100 a statistically significant low (H)SMR. In the calculation of these confidence intervals, a Poisson distribution is assumed for the numerator of the (H)SMR, while the denominator is assumed to have no variation. This is a good approximation, since the variance of the denominator is small. As a result of these assumptions, we were able to compute exact confidence limits.

HSMRs can be presented in a funnel plot (see figure 3.6.4): a plot of hospitals, where the vertical axis represents the HSMRs and the horizontal axis the expected mortalities. Hospitals located above the horizontal axis (HSMR=100) have a higher than expected mortality. As this might be a non-significant feature, based on chance, control limits are shown in the plot for each possible expected mortality. HSMRs within these control limits do not deviate significantly from 100. In the case of 95 percent control limits, about 2.5 percent of the points would lie above the upper limit if there is no reason for differences between HSMRs, and about 2.5 percent of the points below the lower limit. The same holds, mutatis mutandis, for the 99.8 percent control limits. Here about 0.1 percent of the points would be located above the upper line if there is no reason for differences in standardised mortality rates. Most attention will be paid to this line, as points above this line have a high HSMR that is statistically very significant, which can hardly be the result of chance alone. These hospitals would be advised to investigate the possible reasons for the significantly high values: coding errors, unmeasured case mix variables and/or suboptimal quality of care.

3.6.4 Funnel plot HSMR (example)



The precision of the HSMR is much greater for a three-year period than for a single year, which is reflected by a smaller range between the control limits. The confidence intervals of the HSMR are also smaller. Of course, drawbacks are that two consecutive three-year figures (e.g. 2011-2013 and 2012-2014) overlap, and that the three-year figure is less up-to-date than the figure of the last year. Therefore we also calculated the figures for the last available year. Observed mortality (numerator) and expected mortality (denominator) are then calculated for this year's admissions, whereas the expected mortality model of the HSMR still uses the four year data. If a hospital has a significantly high HSMR in the last year , but not in the three year period, this is a signal for further investigation, as the quality of care may have deteriorated. On the other hand, if a hospital has a significantly high HSMR for the three year period, but not in the last year, this does not necessarily mean that the situation has improved in the last year, as the one-year

figures are less often significant because of the larger margins. In such cases, not only the significance should be taken into account, but also the HSMR levels over the years.

4. Evaluation of the HSMR of 2015

This chapter presents and evaluates the model results. Some summary measures of the 157 logistic regressions are presented, with inpatient mortality as the dependent variable and the variables mentioned in section 3.4 as explanatory variables. More detailed results are presented in the Appendix, and the regression coefficients and their standard errors are presented in the file "Coefficients HSMR 2015.xls", published together with this report.

4.1 Target population and data set

Table 4.1.1 shows the number of hospitals that were included in the HMSR model. The total number of general hospitals decreased in the period 2012-2015 due to mergers. Some of the merged hospitals requested separate HSMR reports for their pre-merge locations instead of one report for the merger hospital. For these hospitals we have counted the pre-merge locations as separate hospitals in table 4.1.1.

Hospitals that did not register any (complete) inpatient records in the LMR/LBZ were not included in the HSMR model.

In 2015 all general and university hospitals could be included in the model. As the HSMR now includes all diagnosis groups, all specialised hospitals that registered complete inpatient records in the HSMR were also included.

4.1.1 Number of hospitals in HSMR model 2012-2015

		General hospitals[a)]	University hospitals	Short stay specialised hospitals[b)]	Total hospitals
2012	Total number	82	8	4	94
	Used in model	74	8	2	84
2013	Total number	82	8	4	94
	Used in model	77	8	2	87
2014	Total number	80	8	4	92
	Used in model	78	8	2	88
2015	Total number	75	8	4	87
	Used in model	75	8	3	86

a) Excluding military hospital
b) Included are one clinic for lung diseases, one cancer hospital, one clinic for orthopaedics, rheumatic diseases and rehabilitation, and one eye hospital

For hospitals that did not register all its inpatient records (and the 'prolonged observation without overnight stay' records in 2015) completely, only the completely registered records were included in the model. For some of these hospitals only the fully registered months were included, as in the other months there were indications that fatal cases were registered completely and non-fatal cases partially. The partially registered months of these hospitals were removed from the model as these would otherwise unjustly influence the estimates. For the years 2012 to 2014 this was done for 4, 6 and 1 hospitals, respectively. In 2015 this did not occur.

The number of admissions (i.e. discharges in year *t*) included in the model of 2012-2015 is much larger than in previous models, because the HSMR is now calculated for all diagnosis groups

instead of the 50 CCS groups that were used previously. So the HSMR model now includes all inpatient admissions. Furthermore, in 2015 the observation case types were also added to the model. Table 4.1.2 lists some characteristics of the admissions included. Admissions of foreigners were excluded from the HSMR model.

4.1.2 Admissions in HSMR model 2012-2015

Excluded admissions of foreigners	28 261
Total number of admissions included in model	6 581 314
Number of inpatient admissions	*6 476 217*
Number of observations	*105 097*
Crude mortality (in admissions in model)	1.9%

4.2 Hospital exclusion

In 2015 the total LBZ population comprised 87 hospitals (table 4.1.1). Hospitals were only provided with (H)SMR outcomes if the data fulfilled the criteria stated in paragraph 3.5. In order to qualify for a three-year report (2013-2015) hospitals had to fulfil these criteria for the three consecutive years.

Of the 87 hospitals, the four short stay specialised hospitals and one general hospital had not been asked to grant authorization for providing HSMR numbers because their case mix was very different from that of other hospitals. In fact, four of these hospitals had participated in the LBZ but their data did not meet one or more of the previously stated criteria, such as a minimum number of 60 registered deaths or on average a minimum number of 0.5 comorbidities per admission. Of the 82 hospitals that had granted authorization, only one hospital was excluded because it had not registered all inpatient admissions completely (partial response). The other 81 hospitals fulfilled the criteria and were provided with a HSMR figure for 2015.

For these 81 hospitals the data of 2014 and 2013 was additionally scrutinized in order to determine if a three-year report could be provided. Nine hospitals did not meet one or more criteria in (one of) those years: no participation (4), partial response (2), ≤ 70 percent hospital deaths in 2013 or 2014 within the 50 diagnosis groups considered (1), ≥ 2 percent vague diagnosis codes (1) or multiple criteria (1). As a result, the data of the other 72 hospitals met the criteria in all years considered and so these hospitals were provided with three-year HSMR figures.

4.3 Impact of the covariates on mortality and HSMR

The table in the appendix shows which covariates have a statistically significant (95 percent confidence) impact on in-hospital mortality for each of the 157 diagnosis groups: “1” indicates (statistical) significance, and “0” non-significance, while a dash (-) means that the covariate has been dropped as the number of admissions is smaller than 50 (or as there are no deaths) for all but one category of a covariate; see section 3.6.2. The last row of the table in the Appendix gives the numbers of significant results across the diagnosis groups for each covariate. These values are presented again in table 4.3.1 below, as a summary, but ordered by the number of times a covariate is significant. Age, urgency of the admission, and severity of the main diagnosis are significant for the great majority of the diagnosis groups. This is also true for several of the comorbidity groups, especially groups 2,13 and 16, i.e. for Congestive heart

failure, Renal disease and Metastatic cancer. Comorbidity 15 is seldom registered as a comorbidity; most diagnosis groups had fewer than 50 admissions with HIV comorbidity.

4.3.1 Statistical significance of the covariates for the 157 logistic regressions (summary), HSMR 2015 model.

Covariate	No. of significant results	Covariate	No. of significant results
Age	141	Comorbidity _1	69
Comorbidity _2	128	Comorbidity _5	47
Urgency	121	Comorbidity _17	45
Comorbidity _13	112	Sex	44
Severity main diagnosis	106	Comorbidity _10	37
Comorbidity _16	101	Comorbidity _11	30
Comorbidity _9	95	Comorbidity _7	27
Comorbidity _3	92	Comorbidity _12	27
Source of admission	89	Month of admission	26
Comorbidity _6	86	Comorbidity _8	16
Comorbidity _14	85	SES	12
Comorbidity _4	84	Comorbidity _15	2
Year of discharge	72		

The significance only partially measures the effect of the covariates on mortality. This is better measured using the Wald statistic. Table 4.3.2 presents the total Wald statistics summed over all diagnosis groups for each of the covariates with the respective sum of the degrees of freedom, ordered by value. It shows that severity of main diagnosis has the highest explanatory power. Age and urgency of admission are also important variables. Of the comorbidities comorbidity groups 2, 13 and 16 are again the groups with the most impact on mortality. The explanatory powers of Sex and SES are relatively small. This is also true for a number of comorbidity groups.

4.3.2 Wald chi-square statistics for the 157 logistic regressions, HSMR 2015 model.

Covariate	Sum of Wald statistics	Sum of df	Covariate	Sum of Wald statistics	Sum of df
Severity main diagnosis	33310	426	Comorbidity _4	1727	138
			Comorbidity _1	1277	146
Age	28496	2025	Month of admission	1224	780
Urgency	14827	156	Comorbidity_17	1217	54
Comorbidity _2	10033	138	Comorbidity_5	917	115
Comorbidity _16	4532	135	Sex	873	150
Comorbidity _13	3929	146	SES	774	683
Source of admission	3043	273	Comorbidity _12	448	82
Year of discharge	2409	470	Comorbidity _10	444	152
Comorbidity _9	2284	130	Comorbidity _11	379	112
Comorbidity _6	2060	152	Comorbidity _7	342	120

Comorbidity _14	1935	145	Comorbidity _8	223	33
Comorbidity _3	1920	143	Comorbidity _15	12	5

As was mentioned in section 3.6.2, when the hospitals differ little on a covariate, the effect of this covariate on the HSMR can still be small even if this covariate is strong predictor for mortality. Table 4.3.3 shows the impact of each covariate on the HSMR, as measured by formula (3.6.7), for the hospitals for which HSMRs are calculated. Although the effect of the comorbidities has decreased compared to the HSMR of 2014 (was 8.50), it is still has the largest effect on the HSMR. This is caused by differences in case mixes between hospitals, but possibly also by differences in coding practice (see Van der Laan, 2013). Notice that we consider the comorbidities as one group here. The effect of comorbidity has probably decreased because the HSMR is now based on all hospital mortality. Since the mortality in the new diagnosis groups is much lower, the comorbidities will be removed from the model more often because mortality is too low. However, the decrease is probably also in part due to the fact that there are slightly fewer differences between hospitals in the number of coded comorbidities. Deleting Sex hardly has an impact on the HSMRs. Compared to Sex, SES has a reasonable impact on the HSMR 2015. This is because hospitals differ more in terms of SES categories of the postal areas in their vicinity than in terms of the sex distribution of their patients.

Last year the impact of "source of admission" had increased from 0.86 for the HSMR 2013 to 1.78 for the HSMR 2014. The impact for the HSMR 2015 has decreased again. The higher impact for the HSMR 2014 is probably due to mistakes in the registration of "source of admission" in the 2014 data of a few hospitals. These hospitals have now delivered corrected data, which have been used for the present HSMR 2013-2015 calculation.

4.3.3 Average shift in HSMR 2015 by inclusion/deletion of covariates

Covariate	Average shift in HSMR	Covariate	Average shift in HSMR
Comorbidity [a)]	6.85	Source of admission	1.13
Age	4.59	SES	0.59
Severity main diagnosis	2.65	Month of admission	0.18
Urgency	2.61	Sex	0.12

a) The comorbidities were deleted as one group and not separately.

The differences in the effect of the covariates between this year and the year before are overall quite small considering that the number of diagnosis groups went from 50 to 157. This means that for the new diagnosis groups the effect of the covariates (both in size and direction) is generally the same as for the original 50 diagnosis groups. There are two probable reasons for this. First, the impact of a diagnosis group on the HSMR is relative to the mortality in this group. The original 50 diagnosis groups covered approximately 80 percent of total mortality. Therefore, the impact of the original 50 diagnosis groups is much larger than that of the 107 new diagnosis groups. Second, the pilot study into extending the HSMR to include all mortality (see section 4.6) showed that the SMRs of the original 50 diagnosis groups and the 107 new diagnosis groups are correlated (although there are hospitals for which there is a significant

difference between the mortality in the original 50 diagnosis groups and the 107 new diagnosis groups). All in all the extension of the HSMR to all diagnosis groups has not resulted in large shifts in the effect of covariates.

4.4 Model evaluation for the 157 regression analyses

Table 4.4.1 presents numbers of admissions and deaths, and C-statistics for the 157 diagnosis groups. The C-statistic is explained in section 3.6.2. For those 50 groups that were already present in the HSMR calculation of previous year (CBS, 2015), the present C-statistics do not differ much with those of previous year (less than 0.02). These diagnosis groups are marked with an asterisk.

Only three of the 157 diagnosis groups have a C-statistic below 0.70: “Congestive heart failure, nonhypertensive” (7), “Apiration pneumonitis; food/vomitus” (84) and “Complications of pregnancy, childbirth, and the puerperium; liveborn”(118). For the first two this was also the case in the HSMR calculation of previous year; the third group is one of the new groups that have been added to the HSMR calculation. For these diagnoses the model is only partially able to explain patient mortality. This increases the risk that the model does not completely correct for population differences between the hospitals. For the highest scoring diagnosis groups (above 0.9) the covariates strongly reduce the uncertainty in predicting patient mortality.

4.4.1 C-statistics for the logistic regressions of the 157 main diagnosis groups

Diag. group no.	Description diagnosis group	Number of admissions	Number of deaths	C-statistic
1	Tuberculosis	1 582	31	0,92
2	Septicemia (except in labor)*	22 521	5 856	0,75
3	Bacterial infection; unspecified site	5 477	240	0,81
4	Mycoses	2 054	169	0,83
5	HIV infection	1 403	50	0,76
6	Hepatitis, viral and other infections	24 962	224	0,92
7	Cancer of head and neck	15 040	230	0,87
8	Cancer of esophagus*	9 758	537	0,77
9	Cancer of stomach*	13 028	497	0,80
10	Cancer of colon*	46 448	1 394	0,83
11	Cancer of rectum and anus*	23 742	525	0,83
12	Cancer of liver and intrahepatic bile duct	6 020	356	0,78
13	Cancer of pancreas*	14 705	801	0,79
14	Cancer of other GI organs; peritoneum	6 873	321	0,79
15	Cancer of bronchus; lung*	73 187	4 329	0,84
16	Cancer; other respiratory and intrathoracic	3 084	144	0,86
17	Cancer of bone and connective tissue	7 681	98	0,92
18	Melanomas of skin and other non-epithelial cancer of skin	6 879	83	0,89
19	Cancer of breast*	50 878	410	0,94
20	Cancer of uterus	7 703	97	0,91
21	Cancer of cervix and other female genital organs	10 473	119	0,89
22	Cancer of ovary	9 622	251	0,85

23	Cancer of prostate*	23 245	449	0,91
24	Cancer of testis and other male genital organs	4 328	11	0,94
25	Cancer of bladder*	44 922	410	0,91
26	Cancer of kidney, renal pelvis and other urinary organs	13 174	280	0,88
27	Cancer of brain and nervous system	10 890	245	0,74
28	Cancer of thyroid	4 782	42	0,97
29	Hodgkin`s disease	2 255	43	0,89
30	Non-Hodgkin`s lymphoma*	20 253	864	0,83
31	Leukemias*	21 250	1 152	0,79
32	Multiple myeloma	9 369	489	0,78
33	Cancer; other and unspec. primary; maintenance chemotherapy and radioth.	15 458	182	0,94
34	Secondary malignancies*	76 413	4 033	0,78
35	Malignant neoplasm without specification of site	5 956	442	0,84
36	Neoplasms of unspecified nature or uncertain behavior*	13 958	258	0,84
37	Other and unspecified benign neoplasm	69 869	117	0,84
38	Thyroid and other endocrine disorders	23 978	162	0,89
39	Diabetes mellitus without complication	15 696	76	0,90
40	Diabetes mellitus with complications*	25 556	419	0,85
41	Nutritional deficiencies and other nutritional, endocrine, and metabolic disorders	50 078	357	0,92
42	Fluid and electrolyte disorders*	30 251	800	0,84
43	Cystic fibrosis	2 937	33	0,84
44	Immunity and coagulation disorders, hemorrhagic disorders	11 569	178	0,84
45	Deficiency and other anemia*	44 793	422	0,80
46	Diseases of white blood cells	6 780	134	0,81
47	Mental, affective, anxiety, somatoform, dissociative, and personality disorders	35 174	88	0,80
48	Senility and organic mental disorders	11 689	488	0,76
49	Schizophrenia, mental retardation, preadult disorders and other mental cond.	10 463	23	0,81
50	Other psychoses	4 645	60	0,84
51	Meningitis, encephalitis, and other central nervous system infections	8 542	402	0,89
52	Parkinson`s disease	6 038	72	0,86
53	Multiple sclerosis and other degenerative nervous system conditions	15 842	314	0,89
54	Paralysis and late effects of cerebrovascular disease	4 883	67	0,88
55	Epilepsy and convulsions	44 810	479	0,87
56	Coma, stupor, and brain damage*	3 769	481	0,84
57	Headache and other disorders of the sense organs	85 742	59	0,86
58	Other nervous system disorders	99 966	318	0,95
59	Heart valve disorders*	35 564	1 099	0,79
60	Peri-, endo-, myocarditis, and cardiomyopathy	19 460	628	0,87
61	Essential hypertension, hypertension with compl., and secondary hypertension	14 450	118	0,93
62	Acute myocardial infarction*	111 691	4 333	0,80
63	Coronary atherosclerosis and other heart disease*	165 880	1 152	0,84
64	Nonspecific chest pain	161 136	117	0,75
65	Pulmonary heart disease*	31 449	1 071	0,79
66	Other and ill-defined heart disease	3 759	234	0,83

67	Conduction disorders (heart disease)	22 406	298	0,87
68	Cardiac dysrhythmias*	170 070	1 028	0,88
69	Cardiac arrest and ventricular fibrillation*	10 491	4 005	0,75
70	Congestive heart failure, nonhypertensive*	104 721	8 919	0,67
71	Acute cerebrovascular disease*	113 267	11 919	0,79
72	Transient cerebral ischemia, and other cerebrovascular disease	50 055	616	0,90
73	Peripheral and visceral atherosclerosis*	33 216	1 599	0,91
74	Aortic and other artery aneurysms*	27 518	2 504	0,89
75	Aortic and arterial embolism or thrombosis*	23 301	555	0,87
76	Other circulatory disease*	29 258	584	0,87
77	Phlebitis, varicose veins, and hemorrhoids	17 797	146	0,90
78	Pneumonia*	128 407	9 706	0,77
79	Influenza	5 488	172	0,86
80	Tonsillitis and upper respiratory infections	95 085	129	0,93
81	Acute bronchitis	22 166	94	0,94
82	Chronic obstructive pulmonary disease and bronchiectasis*	117 966	5 118	0,70
83	Asthma	29 782	101	0,88
84	Aspiration pneumonitis; food/vomitus*	6 007	1 443	0,67
85	Pleurisy; pneumothorax; pulmonary collapse*	24 419	655	0,84
86	Respiratory failure; insufficiency; arrest	6 566	1 845	0,78
87	Lung disease due to external agents	1 870	148	0,83
88	Other lower respiratory disease*	46 111	1 620	0,85
89	Other upper respiratory disease	83 048	667	0,91
90	Intestinal infection	36 779	363	0,90
91	Disorders of mouth, teeth, and jaw	20 847	30	0,92
92	Esophageal disorders	15 786	140	0,90
93	Gastroduodenal ulcer	4 596	232	0,91
94	Gastritis, duodenitis, and other disorders of stomach and duodenum	9 071	82	0,89
95	Appendicitis and other appendiceal conditions	58 658	50	0,95
96	Peritonitis and intestinal abscess	4 151	281	0,86
97	Abdominal hernia	50 837	352	0,92
98	Regional enteritis and ulcerative colitis	18 023	52	0,89
99	Intestinal obstruction without hernia*	32 040	1 506	0,83
100	Diverticulosis and diverticulitis*	37 345	488	0,87
101	Anal and rectal conditions	25 142	52	0,94
102	Biliary tract disease*	134 308	701	0,91
103	Liver disease; alcohol-related*	6 074	740	0,72
104	Other liver diseases*	16 790	912	0,81
105	Pancreatic disorders (not diabetes)	26 530	540	0,85
106	Gastrointestinal hemorrhage*	34 632	1 070	0,80
107	Noninfectious gastroenteritis	34 525	352	0,88
108	Other gastrointestinal disorders*	47 111	664	0,94
109	Nephritis; nephrosis; renal sclerosis	12 492	66	0,91
110	Acute and unspecified renal failure*	16 445	1 113	0,78
111	Chronic kidney disease*	15 227	494	0,87
112	Urinary tract infections*	76 971	1 693	0,81
113	Calculus and other diseases of urinary tract	80 243	189	0,91
114	Genitourinary symptoms and ill-defined conditions	32 898	123	0,86

115	Hyperplasia of prostate and other male genital disorders	45 524	55	0,80
116	Nonmalignant breast conditions	18 192	3	0,83
117	Prolapse and other female genital disorders	82 554	39	0,85
118	Complications of pregnancy, childbirth, and the puerperium; liveborn	682 630	36	0,60
119	Skin and subcutaneous tissue infections	50 766	503	0,91
120	Other skin disorders, chronic ulcer of skin	22 924	251	0,91
121	Infective arthritis and osteomyelitis	11 640	218	0,90
122	Osteoarthritis, rheumatoid arthritis, and other musculoskeletal deformities	244 925	256	0,83
123	Other non-traumatic joint disorders	20 614	42	0,91
124	Spondylosis, back problems, and osteoporosis	95 645	144	0,92
125	Pathological fracture	7 417	104	0,79
126	Other connective tissue disease	60 164	198	0,96
127	Cardiac and circulatory congenital anomalies	9 679	159	0,83
128	Noncardiac congenital anomalies	32 731	213	0,92
129	Short gestation; low birth weight; and fetal growth retardation	59 161	643	0,86
130	Intrauterine hypoxia, perinatal asphyxia, and jaundice	51 537	186	0,93
131	Other perinatal conditions	191 741	217	0,87
132	Joint disorders and dislocations; trauma-related; sprains and strains	39 608	27	0,92
133	Fracture of neck of femur (hip)*	69 289	2 279	0,80
134	Skull and face fractures, spinal cord injury	12 642	250	0,90
135	Fracture of upper limb	54 535	137	0,93
136	Fracture of lower limb	53 490	330	0,95
137	Other fractures	43 639	729	0,87
138	Intracranial injury*	51 782	1 937	0,90
139	Crushing injury or internal injury	19 544	268	0,91
140	Open wounds of head; neck; and trunk	7 786	68	0,89
141	Open wounds of extremities	7 909	39	0,94
142	Complication of device, implant or graft*	91 987	1 170	0,86
143	Complications of surgical procedures or medical care*	90 468	955	0,87
144	Superficial injury; contusion	36 525	285	0,90
145	Burns	4 931	68	0,94
146	Poisoning by psychotropic agents, drugs, or other medications	37 146	277	0,83
147	Other injuries and conditions due to external causes	15 649	605	0,90
148	Syncope	53 814	220	0,83
149	Fever of unknown origin	29 607	202	0,82
150	Lymphadenitis and gangrene	8 356	106	0,92
151	Shock*	1 982	856	0,71
152	Nausea and vomiting	15 217	120	0,86
153	Abdominal pain	68 338	288	0,93
154	Malaise and fatigue	15 277	372	0,79
155	Allergic reactions	10 635	23	0,87
156	Rehabilitation and other aftercare, medical examination/evaluation/screening	160 023	456	0,81
157	Residual codes; unclassified	89 966	533	0,93

*Diagnosis groups already present in the HSMR calculation in previous years. Diagnosis group 45 previously only contained CCS group 59 ("Deficiency and other anemia"); now CCS group 60 ("Acute posthemorrhagic anemia") was added to this group.

4.5 Regression coefficients

The file "coefficients HSMR 2015.xls" contains the estimated regression coefficients (columns "Estimate"), also called "log-odds", for each of the 157 logistic regressions, as well as their standard errors (columns "Std. Err."). The estimated regression coefficients are the elements of the vector $\hat{\beta}_d$ in formula (3.6.4), for each diagnosis d. Notice that a β-coefficient has to be interpreted as the difference in log-odds between the category in question and the reference category (first category of the same covariate). For the sake of clarity, the reference categories are given in the first row of the corresponding covariates, and by definition have zero coefficient for each regression. In many cases categories are collapsed (see section 3.6.2). This results in equal coefficients for the collapsed categories. If all categories were collapsed into one category for a certain variable and for a certain diagnosis group (i.e. if there was only one category with ≥50 admissions and ≥1 death), the variable was dropped from the model and all associated coefficients are set to zero.

4.6 Extension of the HSMR to include all hospital mortality

In previous years the main diagnoses included in the HSMR were limited to the 50 CCS groups with the highest total mortality. Together these covered approximately 80 percent of the total mortality in hospitals and approximately 37 percent of the inpatient admissions. However, for individual hospitals these percentages can be lower. Furthermore, the percentage of mortality covered by these 50 diagnoses has decreased. Also, on principal grounds it would be preferable to include all hospital mortality in the HSMR, making the HSMR a true indicator for overall hospital mortality. Therefore, in 2015 the effects of extending the HSMR to include all inpatient admissions in the HSMR were investigated (Van der Laan and De Bruin, 2016).

There are two possible complications. First, when including all diagnoses, there will also be diagnosis groups with few deaths. This can cause problems during modelling, making it difficult to correct for differences in the patient population between hospitals. Second, for some of the diagnosis groups added to the HSMR, there could be differences in the patient population between hospitals for which it is not possible to correct using the currently used variables in the model. This is also an issue with some of the diagnoses groups in the current HSMR: some hospitals receive, on average, patients with a higher mortality risk, which is not sufficiently reflected in the variables included in the model, resulting in a higher SMR for these hospitals for these diagnosis groups. Both issues were investigated. The main findings are summarised below:

- There is a correlation of 0.55 between the HSMR of the original 50 diagnosis groups and the HSMR of the remaining diagnoses. In about a quarter of the hospitals the HSMR of the 50 groups differed significantly (95 percent confidence level) from the HSMR of the remaining groups. This was also the case when the top 70 of diagnosis groups with highest mortality were compared with the remaining groups. Therefore, extending the HSMR to include all mortality does lead to a better indicator.
- For the diagnosis groups added to the HSMR, it was decided to use a further clustering of CCS groups, largely comparable to the clusters used for the SHMI in the UK. The models were able to capture most of the differences in mortality in these clusters (see section 4.4). Therefore, we are able to model the mortality in the new diagnosis groups.

- Because the number of SMRs increases, the likelihood of accidentally finding SMRs significant while they are not significant in reality (type I error) increases. Therefore, the confidence level used for determining the significance of the SMRs of the 157 diagnosis groups has been increased from 95 to 98 percent. A confidence level of 98 percent with 157 diagnosis groups leads to about the same number of significant SMRs as a confidence level of 95 percent with 50 diagnosis groups.
- University hospitals have, on average, a higher HSMR than general hospitals. This difference increases slightly when all mortality is included compared to the situation in which only the mortality in the 50 most important groups is included (increases from 9 to 12 points). However, most diagnosis groups with the largest differences (e.g. acute cerebrovascular disease and intracranial injury) are also part of the original 50 groups. The increase in difference is caused by the addition of some other groups, e.g. perinatal conditions.
- Together with a group of medical specialists, the most important groups that contribute to this difference were investigated. However, no solution was found with which this difference could be reduced in the short term, with the present variables registered in the LBZ. However, because this problem already existed in previous years, this is in itself no reason to not extend the HSMR to all diagnosis groups. The problem may be partly addressed by peer group comparisons of hospitals (see section 1.6).

More details of the study of the extension of the HSMR are described in Van der Laan and De Bruin (2016, in Dutch).

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Appendix. Results of the logistic regressions

Statistical significance (95% confidence) of the covariates for the 157 logistic regressions (1=significant; 0=non-significant; "-"=variable dropped because all categories are collapsed, due to < 50 admissions or no deaths in all but one category)

No. diagnosis group	Severity main diagnosis	Sex	Age	Urgency	Comorbidity_1	Comorbidity_2	Comorbidity_3	Comorbidity_4	Comorbidity_5	Comorbidity_6	Comorbidity_7	Comorbidity_8	Comorbidity_9	Comorbidity_10	Comorbidity_11	Comorbidity_12	Comorbidity_13	Comorbidity_14	Comorbidity_15	Comorbidity_16	Comorbidity_17	SES	Month admission	Year discharge	Source admission
1	0	0	1	1	-	-	-	-	-	0	-	-	-	0	-	-	1	-	-	-	-	0	0	0	0
2	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	-	1	1	1	1	1	1
3	1	0	1	0	0	1	1	0	0	0	0	-	1	0	1	-	1	0	-	1	-	0	0	0	0
4	1	1	0	0	0	1	0	-	-	0	0	-	0	0	-	-	0	1	-	1	-	0	0	0	1
5	0	0	0	0	-	-	-	-	-	0	-	-	0	0	-	-	0	0	1	-	-	0	0	0	1
6	1	0	1	1	1	1	0	0	0	0	0	-	1	0	0	0	1	0	-	0	1	0	0	0	1
7	1	0	1	1	0	0	0	1	0	1	0	-	1	0	-	-	0	1	-	1	-	0	0	0	0
8	-	0	0	1	0	1	1	0	-	0	0	-	1	0	0	-	1	0	-	1	-	0	0	0	1
9	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	-	1	1	-	1	-	0	0	1	0
10	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	1	1	-	1	1	0	0	1	1
11	-	0	1	1	1	1	1	1	0	1	0	-	1	0	0	-	1	0	-	1	-	0	0	1	0
12	0	1	0	1	1	1	0	1	-	0	-	-	0	1	0	-	1	0	-	1	1	0	0	1	0
13	0	0	1	1	0	1	1	1	0	0	0	-	0	1	0	-	1	1	-	1	1	1	0	1	0
14	0	0	1	1	0	1	1	0	-	0	0	-	1	0	-	-	1	0	-	1	-	0	0	0	1
15	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	1	1	-	1	1	0	0	1	1

16	0	0	0	1	1	-	0	-	-	0	-	-	-	1	-	-	1	0	-	1	-	0	0	0	0
17	1	0	1	1	0	-	1	-	-	0	-	-	-	1	-	-	0	0	-	1	-	0	0	0	0
18	0	0	0	1	0	0	0	0	0	0	-	-	-	0	-	-	0	0	-	1	-	0	0	0	1
19	1	0	1	1	0	1	1	1	0	0	1	-	1	0	-	-	1	0	-	1	-	0	0	1	1
20	0	-	1	1	0	-	-	-	-	0	-	-	-	0	-	-	1	0	-	1	-	0	0	0	0
21	1	-	1	1	0	-	0	0	-	1	1	-	-	0	-	-	1	-	-	1	-	0	0	1	1
22	-	-	0	1	1	1	1	0	-	1	-	-	0	0	-	-	1	0	-	1	-	0	0	0	1
23	-	-	1	1	0	1	0	0	0	0	0	-	1	1	0	0	1	1	-	1	-	0	0	1	0
24	0	-	0	1	0	-	-	-	-	-	-	-	-	0	-	-	-	-	-	1	-	0	0	0	0
25	1	0	1	1	1	1	0	1	0	0	1	-	1	1	0	-	1	1	-	1	-	0	1	1	1
26	1	0	1	1	1	1	0	0	-	1	0	-	0	0	0	-	0	0	-	1	-	0	1	1	1
27	0	0	1	1	0	-	0	1	-	0	-	-	-	1	-	0	0	0	-	1	-	0	0	1	1
28	-	1	1	1	0	-	-	-	-	0	-	-	-	0	-	-	-	0	-	0	-	0	0	0	-
29	0	0	1	1	-	-	-	-	-	0	-	-	-	0	-	-	-	-	-	-	-	0	0	0	-
30	0	0	1	1	1	1	0	1	0	1	0	0	1	0	1	1	1	0	0	1	-	1	0	1	1
31	1	0	1	1	1	1	0	1	1	0	0	-	1	0	0	0	1	1	-	0	-	0	0	1	1
32	0	0	1	1	0	1	1	1	-	1	0	-	1	0	-	0	1	1	-	1	-	0	0	0	0
33	1	0	1	1	0	0	0	1	-	0	-	-	-	0	-	-	1	0	-	1	-	0	0	0	1
34	1	0	1	1	1	1	1	1	0	1	0	1	1	0	1	0	1	0	-	1	1	0	1	1	1
35	0	0	1	1	0	1	1	1	-	1	-	-	1	0	-	-	1	1	-	0	-	0	0	0	1
36	1	0	1	1	0	1	0	1	1	1	0	-	1	0	0	0	0	0	-	0	-	0	0	0	1
37	1	1	1	1	0	1	1	0	0	1	0	-	1	0	0	1	0	0	-	1	0	0	0	1	0
38	0	0	1	1	1	1	1	1	0	0	0	-	1	0	1	0	0	0	-	0	-	0	1	0	1
39	0	0	1	1	0	1	1	1	1	0	0	-	0	0	0	-	1	0	-	0	0	0	0	0	0
40	1	0	1	1	0	1	1	1	0	1	0	-	1	0	0	0	1	0	-	1	-	0	0	1	1
41	1	1	1	1	0	1	0	0	0	0	0	-	1	0	0	0	0	0	-	1	1	0	0	0	1

42	1	1	1	1	0	1	1	0	1	1	0	-	0	0	0	1	0	1	-	1	1	0	1	1	0
43	0	0	1	1	-	-	-	-	-	0	-	-	1	0	-	-	-	-	-	-	-	0	0	0	1
44	1	0	1	0	0	1	1	1	0	0	0	-	0	1	0	-	0	0	-	1	-	0	0	0	0
45	1	0	1	1	0	1	1	0	0	1	0	0	1	0	0	0	1	0	-	1	1	0	0	1	1
46	0	0	1	0	1	1	0	1	-	1	0	-	1	0	-	-	1	0	-	1	-	0	0	0	0
47	1	0	1	0	1	1	0	0	1	0	-	-	1	0	-	-	0	1	-	0	1	0	0	0	0
48	1	1	1	1	1	1	0	1	0	1	1	-	1	0	1	0	1	1	-	1	-	0	0	0	1
49	1	0	0	0	1	-	-	0	-	0	-	-	1	-	-	-	-	1	-	-	-	0	0	0	0
50	0	0	1	0	0	1	1	0	0	1	-	-	0	0	1	-	0	0	-	0	-	0	0	0	0
51	1	0	1	1	0	1	0	1	1	1	0	-	1	0	-	0	1	1	-	1	-	0	0	0	1
52	0	0	0	1	0	1	0	0	0	0	-	-	-	0	-	-	0	0	-	-	-	0	0	0	0
53	1	0	1	1	1	1	0	0	1	1	0	-	0	0	0	0	0	1	-	0	-	0	0	0	1
54	1	0	1	1	0	0	0	0	0	0	-	-	-	0	0	0	0	0	-	0	-	0	0	0	1
55	1	0	1	0	1	1	1	1	1	1	0	-	1	1	0	0	1	1	-	1	0	0	0	0	1
56	1	0	1	1	0	1	0	1	0	1	-	-	0	0	0	0	1	1	-	1	-	0	0	0	0
57	0	0	1	1	0	1	0	0	0	0	1	-	0	0	1	1	1	1	-	0	-	0	1	1	1
58	1	0	1	1	1	1	0	1	0	1	0	-	0	1	0	0	1	1	-	0	1	0	1	0	1
59	1	0	1	1	1	1	1	1	1	1	0	-	1	0	1	0	1	1	-	1	-	1	0	1	1
60	1	1	1	1	1	1	1	1	-	0	0	-	1	0	0	0	1	1	-	1	-	0	0	1	1
61	1	0	1	1	0	1	1	1	0	0	0	-	0	1	1	-	1	1	-	0	-	0	1	0	0
62	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	-	1	1	0	1	1	1
63	1	0	1	1	1	1	1	1	0	1	0	1	1	1	0	0	1	1	-	1	1	0	0	0	1
64	-	1	1	0	0	0	0	1	0	1	0	-	1	0	0	-	1	1	-	1	-	0	0	1	-
65	1	1	1	1	1	1	1	1	1	1	0	-	1	1	1	0	1	1	-	1	1	0	1	1	1
66	1	0	1	1	1	1	1	1	-	0	-	-	-	0	-	-	1	1	-	-	-	0	0	1	1
67	1	0	1	1	1	1	0	1	1	1	0	-	1	1	0	-	1	0	-	0	-	0	0	0	0

68	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	-	1	1	1	1	1	1
69	1	1	1	1	1	0	1	1	1	1	1	-	1	1	1	-	1	1	-	1	-	0	0	1	1
70	-	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	-	1	1	0	1	1	1
71	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	-	1	1	0	1	1	1
72	1	0	1	1	1	1	1	1	0	1	0	-	1	0	1	1	1	1	-	0	-	0	1	1	1
73	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	-	1	1	0	1	1	1
74	1	1	1	1	1	1	1	1	1	1	0	-	1	0	1	1	1	0	-	1	-	0	0	1	0
75	1	0	1	1	1	1	1	1	1	1	1	-	1	0	0	0	1	1	-	1	-	0	0	0	1
76	1	0	1	1	1	1	1	1	0	1	1	-	1	0	0	0	1	1	-	1	1	0	1	1	1
77	1	0	1	1	0	1	1	1	0	0	0	-	1	0	0	0	1	1	-	1	1	0	0	0	0
78	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1
79	1	0	1	0	1	0	0	0	0	1	0	-	0	0	0	-	0	0	-	0	-	0	0	0	1
80	0	1	1	1	0	1	1	0	0	1	0	-	0	0	0	0	1	1	-	0	-	0	0	0	1
81	0	0	1	0	0	1	0	1	0	0	0	-	0	0	0	-	1	0	-	0	-	0	0	0	1
82	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	0	1	1	0	1	1	1
83	0	0	1	0	1	1	0	0	0	1	0	-	1	0	0	-	1	0	-	0	-	0	0	1	1
84	-	1	1	0	0	1	1	0	1	0	0	-	1	0	0	0	1	1	-	1	-	0	0	1	0
85	1	0	1	1	1	1	0	1	1	1	0	-	0	1	0	1	1	0	-	1	1	0	0	1	1
86	1	1	1	1	1	0	1	1	1	1	0	-	1	0	0	0	0	1	-	1	-	0	0	1	1
87	0	1	1	1	0	1	-	-	-	0	-	-	-	0	-	-	0	0	-	0	-	0	1	0	0
88	1	1	1	1	1	1	1	1	1	1	1	-	1	0	0	0	1	1	-	1	1	0	0	1	1
89	1	1	1	1	0	1	0	1	0	1	0	-	0	0	1	0	0	1	-	1	1	0	0	1	1
90	1	0	1	0	0	1	1	0	0	1	0	-	0	0	0	0	1	1	-	1	1	0	0	0	1
91	0	0	1	1	1	1	0	0	-	0	0	-	1	0	-	-	1	1	-	0	-	0	0	1	1
92	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	-	0	0	-	1	1	0	0	0	0
93	1	0	1	0	1	0	1	0	-	1	-	0	1	0	-	-	1	1	-	0	-	0	0	0	0

94	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	-	0	0	-	0	0	1	0	0	0
95	0	1	1	0	0	1	1	0	-	1	1	-	0	1	-	-	1	0	-	1	-	0	0	1	1
96	1	1	1	1	1	1	1	0	-	1	-	-	1	0	0	-	1	1	-	1	1	0	0	1	1
97	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	-	1	0	-	1	1	0	0	1	0
98	-	0	1	0	0	0	0	0	-	0	0	-	1	0	-	-	0	1	-	-	-	0	0	0	0
99	1	1	1	1	0	1	1	1	1	1	0	-	1	1	1	1	1	1	-	1	-	0	0	1	0
100	1	0	1	1	1	1	1	0	1	1	1	-	1	0	0	-	1	1	-	1	-	0	0	0	1
101	0	0	1	0	1	1	0	0	0	1	0	-	1	0	0	-	1	0	-	1	-	0	0	0	0
102	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	-	1	1	0	0	1	1
103	1	0	1	1	0	1	1	0	-	0	-	0	1	0	0	-	1	0	-	-	1	0	0	0	0
104	1	0	1	1	0	1	1	0	0	1	1	0	1	1	1	-	1	1	-	1	1	0	0	1	1
105	1	0	1	1	1	1	1	0	1	1	0	1	1	0	0	0	1	1	-	1	1	0	0	1	1
106	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	1	-	1	1	0	0	1	1
107	0	1	1	1	0	1	1	0	1	1	0	-	0	0	0	0	1	1	-	1	0	1	0	0	0
108	1	0	1	1	0	1	1	1	0	0	0	1	1	1	0	0	1	1	-	1	0	0	0	0	1
109	1	0	1	1	0	1	1	1	0	0	0	-	0	0	0	-	0	0	-	1	-	0	0	0	0
110	1	0	1	1	1	1	1	0	0	1	0	1	1	0	0	0	1	1	-	1	1	1	0	1	1
111	1	0	1	1	1	1	1	0	1	1	0	-	1	0	0	-	0	1	-	1	-	0	0	1	1
112	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	0	1	1	1
113	1	0	1	1	0	1	0	0	0	1	0	-	1	0	1	1	1	1	-	1	-	0	0	0	0
114	1	0	1	1	0	1	0	0	0	1	0	-	0	0	0	-	1	1	-	0	-	0	0	0	1
115	0	-	1	1	0	1	0	0	0	1	0	-	1	0	0	-	0	0	-	1	-	0	0	0	0
116	-	-	0	-	-	-	-	-	-	-	-	-	-	1	-	-	-	0	-	-	-	0	0	0	-
117	1	0	1	1	0	1	1	-	0	0	1	-	-	0	-	-	0	0	-	0	-	0	0	0	0
118	1	0	1	1	-	1	1	1	-	1	-	-	1	-	-	-	-	1	-	-	-	0	0	1	0
119	1	0	1	0	1	1	1	1	1	1	0	-	1	1	1	0	1	1	-	1	1	0	1	1	1

120	1	0	1	1	1	1	0	1	0	0	0	-	1	1	0	0	1	0	-	0	-	0	0	0	1
121	1	0	1	1	0	1	0	0	0	0	0	-	1	0	0	1	1	0	-	0	-	0	0	0	1
122	1	0	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	-	1	-	0	0	1	1
123	0	0	1	1	1	1	1	1	0	0	1	-	1	0	0	-	1	0	-	1	-	0	0	0	0
124	1	0	1	1	0	1	0	1	0	0	0	-	1	1	0	1	1	0	-	1	-	0	0	1	0
125	0	0	1	0	0	1	1	0	0	1	0	-	0	0	0	0	1	0	-	1	-	0	0	0	1
126	1	0	1	1	0	1	1	1	0	0	1	-	1	0	0	0	1	1	-	0	-	1	0	0	0
127	1	0	1	1	-	1	0	1	-	0	-	-	-	0	-	-	1	-	-	-	-	0	0	0	1
128	1	0	1	0	1	-	1	0	-	0	-	-	1	0	-	1	1	-	-	-	-	0	0	0	0
129	1	1	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	1
130	1	0	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	1
131	1	0	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	1
132	1	1	1	0	0	1	1	0	1	1	0	-	-	0	-	-	0	1	-	-	-	0	0	0	0
133	1	1	1	0	1	1	1	1	1	1	1	-	1	0	1	0	1	1	-	1	1	0	1	1	0
134	1	1	1	1	0	-	0	0	1	0	-	-	-	0	-	0	1	1	-	-	-	0	0	1	0
135	0	1	1	1	0	1	1	1	0	1	1	-	1	0	0	0	1	1	-	0	-	0	0	0	0
136	1	1	1	1	1	1	1	1	0	1	0	-	1	1	0	0	1	0	-	1	-	0	0	1	0
137	1	1	1	1	0	1	1	1	1	1	0	-	1	0	0	1	1	1	-	1	-	0	1	0	1
138	1	1	1	1	1	1	1	1	1	1	0	-	1	0	0	0	1	1	-	1	-	1	0	0	1
139	1	0	1	1	1	1	1	1	0	1	0	-	1	0	1	-	0	1	-	0	-	0	0	1	0
140	1	0	1	0	1	1	0	0	1	0	-	-	-	0	-	-	1	1	-	-	-	0	1	0	0
141	1	0	1	1	0	1	1	-	-	1	1	-	-	0	-	-	1	-	-	-	-	0	0	0	0
142	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1
143	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	-	1	1	0	0	1	1
144	1	1	1	0	0	1	1	1	1	1	0	-	1	0	0	0	1	1	-	1	-	1	0	0	0
145	1	0	1	1	-	-	-	-	-	0	-	-	-	0	-	-	-	-	-	-	-	0	0	0	0

146	1	1	1	0	0	1	0	0	0	1	0	-	0	0	0	0	0	1	-	0	1	0	0	0	1
147	1	1	1	0	0	1	0	1	0	1	0	-	1	1	0	0	0	1	-	0	-	0	0	0	1
148	-	0	1	0	0	1	1	1	0	0	0	-	0	0	0	1	1	0	-	1	-	0	0	1	0
149	-	0	1	0	0	1	0	0	0	0	0	-	1	0	0	0	1	1	-	1	1	0	0	0	1
150	1	0	1	1	0	1	1	0	0	0	0	-	-	0	0	-	1	0	-	0	-	0	0	1	0
151	-	0	1	0	1	1	1	1	-	0	-	1	1	0	0	-	0	0	-	1	1	0	0	0	0
152	-	0	1	0	0	1	0	0	0	0	0	-	0	0	0	-	1	0	-	1	-	0	0	0	0
153	-	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	1	1	-	1	0	0	0	1	0
154	-	1	1	1	0	1	1	0	0	0	0	-	1	0	0	1	1	0	-	1	0	0	0	1	1
155	1	0	0	0	0	1	0	-	-	0	0	-	1	0	-	-	1	0	-	-	-	0	0	0	0
156	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	1	1	1	-	1	0	0	0	1	0
157	1	1	1	1	0	1	1	1	0	1	0	-	0	0	0	0	1	1	-	1	1	0	0	1	1
total	106	44	141	121	69	128	92	84	47	86	27	16	95	37	30	27	112	85	2	101	45	12	26	72	89

The numbers of the comorbidity groups in the header of the table above are the following comorbidities:

Comorbidity_1 - Acute myocardial infarction
Comorbidity_2 - Congestive heart failure
Comorbidity_3 - Peripheral vascular disease
Comorbidity_4 - Cerebral vascular accident
Comorbidity_5 - Dementia
Comorbidity_6 - Pulmonary disease
Comorbidity_7 - Connective tissue disorder
Comorbidity_8 - Peptic ulcer
Comorbidity_9 - Liver disease / Severe liver disease

Comorbidity_9 - Liver disease / Severe liver disease
Comorbidity_10 - Diabetes / Diabetes complications
Comorbidity_11 - Diabetes complications
Comorbidity_12 - Paraplegia
Comorbidity_13 - Renal disease
Comorbidity_14 - Cancer
Comorbidity_15 - HIV
Comorbidity_16 - Metastatic cancer
Comorbidity_17 - Severe liver disease

The names of the diagnosis groups are described in Table 4.4.1, and the corresponding CCS groups and ICD10 codes are given in the file 'Classification of variables', published together with this report

Explanation of symbols

Empty cell	Figure not applicable
.	Figure is unknown, insufficiently reliable or confidential
*	Provisional figure
**	Revised provisional figure
2015–2016	2015 to 2016 inclusive
2015/2016	Average for 2015 to 2016 inclusive
2015/'16	Crop year, financial year, school year, etc., beginning in 2015 and ending in 2016
2013/'14–2015/'16	Crop year, financial year, etc., 2013/'14 to 2015/'16 inclusive

Due to rounding, some totals may not correspond to the sum of the separate figures.

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