Method description and quality assurance for the update of the Norwegian Hip Fracture Database (NORHip) 2008-2013

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Summary

Background: The NORHip database 1994-2008 was based on data collected from all hospitals treating hip fractures in Norway through a collaboration with the Norwegian Knowledge Center for Health Services and was ready for use in 2010. In 2014-2015 the NORHip database was updated with data from the Norwegian Patient Register (NPR), this time with data from 2008-2013.

Methods: The coding principles for the new data were the same as in the first NORHip data collection. In short, a search for all hospitalizations with the ICD-10 (International Classification of Disease version 10) diagnosis codes: S72.0, S72.1 or S72.2 was performed by the NPR for the period 2008-13. Both hospitalizations with the relevant diagnosis as *main* or *additional diagnoses* were included. For all records retrieved, selected additional diagnosis codes (ICD10), and surgical procedure codes (NOMESCO Classification of Surgical Procedures; NCSP) were also obtained. This information was used to divide the hospitalizations/records in three groups 1). A certain incident fracture, 2) Not an incident fracture 3) A possible incident fracture. Time between hospitalizations was also used to classify the hospitalizations, by counting records occurring less than three weeks apart as one hospital stay. A total of two fractures (hospitalizations) per individual were allowed.

After preparing the 2008-2013 data, it was merged with the original NORHip datafile. After this merge, the data were cleaned again to include a maximum of two hip fractures per individual.

A validation of the two data retrieval methods was performed for the calendar year 2008. The original 2008 data obtained from the hospitals was compared with register data for the same year (NPR).

Finally, the updated NORHip was compared with data from a recent report from the Norwegian Hip Fracture Register (NHBR-The orthopedic surgeons' register of hip fracture surgeries in Norway) in which they defined hip fractures with specific procedure codes in NHBR, NPR or both as the gold standard of hip fractures in Norway. The report used data for the years 2008-2012.

Main results:

2008-2013: A total of 92,342 records were obtained from NPR for the calendar years 2008-2013, of which 34,449 were categorized as "not an incident fracture".

1994-2013: Based on the quality assurance it was decided to use data from NPR for 2008 (please confer validation of 2008-data for details below and on page 15). The new updated NORHip 1994-2013 includes data on 167,502 hip fracture patients with a total of 188,199 fractures.

Validation of 2008-data from NORHip and NPR: There were 9,534 and 9,880 fractures in the NORHip and NPR, respectively. When comparing the agreement between the two data sources, 95% of the hip fractures were correct on the individual level (including number of fractures per individual). If excluding December 2008 from the comparison (data seem to be

incomplete in NORHip for December 2008), 97.4% of the subjects had the same number of fractures in 2008 with both data collection methods.

Validation of NORHip with the a report from NHBR (orthopedic surgeons' register of hip fracture surgeries): The total number of hip fractures in NORHip was between 1.9-3.9% higher than the calendar-year-specific total number in the NHBR report.

Contents

Introduction

In 2010 we presented a database of all hip fractures treated in Norwegian hospitals during a 15-year period from 1994 (the first year all somatic hospitals in Norway used electronic patient administrative systems) up to and including 2008. All information was retrieved electronically, providing a historic database for research. This database is hereafter called NORHip 1.

In 2014 we obtained updated data 2008-2013 to be included in the database, but this time the data were obtained from the Norwegian Patient Register (NPR). This is a central health register including information about all patients who have been in contact with the specialist health care service in Norway, which became identifiable at the individual level from 2008. The new data supply results in 5 more years of data and in addition we were able to validate the NORHip data from 2008 with the new data from NPR. Furthermore, we also compared the new data with results from a recently published report comparing hip fracture data from NPR and the orthopedic register of hip fracture surgeries (the Norwegian Hip Fracture Register) [1].

Data collection

Codes and variables

All hip fractures treated in Norwegian hospitals in the period 2008-2013 were obtained from NPR.

All hits on hospital stays occurring between 01.01.2008 and 31.12.2013 that contained a diagnosis code for hip fracture were retrieved. These codes included: **S72.0, S72.1** and **S72.2 with all subcodes** according to the international classification of disease (ICD)-10 .

Additional information retrieved for all hits were:

- Hip fracture diagnosis code
- Hospital and department
- Type of hospitalization (in-patient,"day treatment", out-patient)
- Relevant diagnosis codes*
- Surgical procedure codes (up to 20 codes)
- Date and time of admission
- Date and time of discharge
- Gender
- Age at discharge

*Diagnosis codes (those used for coding in NORHip 1) were obtained for all patients with a hip fracture diagnosis codes. When preparing the datafile, NPR replaced codes not relevant by an asterisk (*) (due to data protection concerns).

Hospitals reporting hip fractures

Rikshospitalet
Kysthospitalet i Hagevik
Haugesund sanitetsforenings revmatismesykehus
Bergen legevakt
Martina Hansens hospital
Diakonhjemmet sykehus
Lovisenberg diakonale sykehus
Haraldsplass diakonale sykehus
Orkdal sjukehus
Haukeland universitetssykehus
Spesialsykehuset for rehabilitering Stavern
Mork rehabiliteringssenter
Aker universitetssykehus
Oslo universitetssykehus
Sunnaas sykehus
Spesialsykehuset for rehabilitering, Kr.sand
Sykehuset Buskerud
Kongsberg sykehus
Ringerike sykehus
Sykehuset Telemark, Notodden
Sykehuset Telemark
Sykehuset i Vestfold
Sykehuset Østfold
Stavanger universitetssykehus
Vestre Viken
Akershus universitetssykehus
Radiumhospitalet
Helse Fonna
Sykehuset Innlandet
Sørlandet sykehus
Stord sjukehus
Odda sjukehus
Voss sjukehus
Førde sjukehus
Molde sjukehus
Kristiansund sjukehus
Ålesund sjukehus
Volda sjukehus
St. Olavs hospital
Sykehuset Namsos
Sykehuset Levanger
Nordlandssykehuset, Bodø
Universitetssykehuset Nord-Norge, Narvik
Helgelandssykehuset, Sandnessjøen
Helgelandssykehuset, Mosjøen
Helgelandssykehuset, Mo i Rana
Nordlandsssykehuset, Lofoten
Nordlandssykehuset, Vesterålen
Universitetssykehuset Nord-Norge, Harstad
Universitetssykehuset i Nord-Norge
Helse Finnmark, klinikk Hammerfest

Helse Finnmark, klinikk Kirkenes
Sykehuset Telemark, Rjukan
Betanien hospital (Telemark)
Sykehuset Telemark, Kragerø
Oslo kommunale legevakt

Data preparation

The code search for S72.0, S72.1 and S72.2 was performed at the Norwegian Patient Register. The data was thereafter received and managed at the Norwegian Institute of Public Health, Division of Epidemiology, in the statistics software SPSS 22 for Windows.

A total of 92,342 records had hip fracture S72.0, S72.1 or S72.2 with all subcodes either as main or additional diagnosis (Figure 1).

In NORHip 1, we did not receive data on out-patients. This time we received this type of data and checks of data marked as «out-patient» were performed, in total 26,430 records. All records except one were coded as «not a new hip fracture», but as we did not have this type of information on out-patients in NORHip 1, the patient was not included in the database.

A total number of 7,570 records were categorized as "not a new fracture" and deleted (Figure 1). Among the 7,570 deleted records, a total of 372 records were registered in 2007, whereas at total of 2,567 records did not have surgical procedure codes and diagnosis codes or no relevant ones and were also not a subjects first hospitalization. A total of 999 (13.2%) had surgical procedure codes which always imply revision. The rest, 3,632 records were deleted because time between hospitalizations was less than three weeks and/or, the patient had more than two records.

After using the algorithm on the 2008-2013 data, the datafile was merged with NORHip 1. In this process 449 records were excluded, either because time between hospitalizations was less than 3 weeks or because the subjects had three recorded hospitalizations for hip fracture, and one of the three fractures was excluded.

A data inspection was performed to investigate the number of hospitalizations per hospital per year (data not shown here).

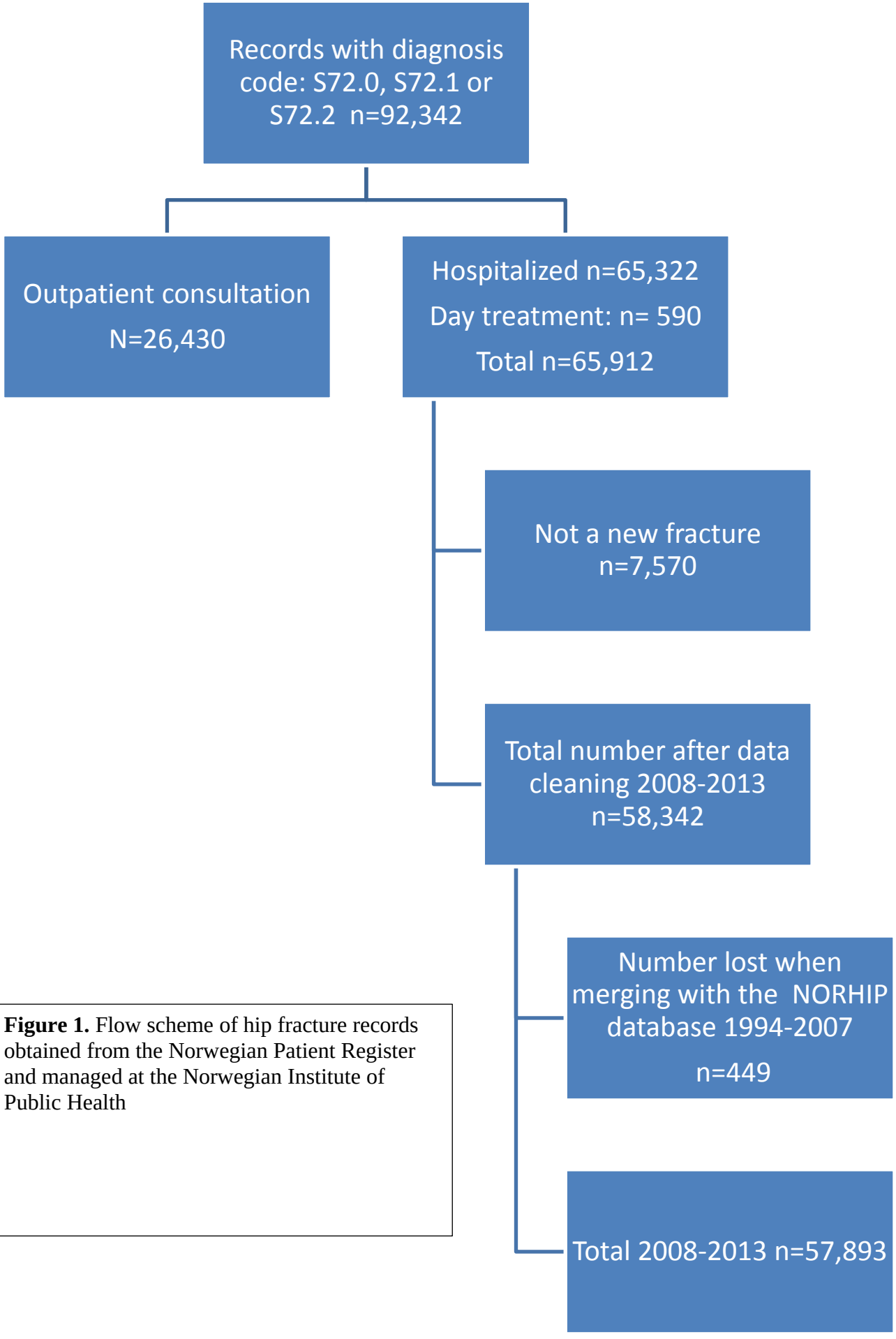

Figure 1. Flow scheme of hip fracture records obtained from the Norwegian Patient Register and managed at the Norwegian Institute of Public Health

Assessment of hip fractures

A similar algorithm used to compile data for the 1994-2008 NORHip, was also used for the new dataset. Hence, the records were categorized into one of three categories:

1. A *certain* hip fracture
2. *Not* a hip fracture
3. A *possible* hip fracture

The categorization was performed stepwise and temporary variables were used to categorize the data. The following three temporary variables were constructed:

- **Hip fracture diagnosis code** (variable referred to as "hip fracture code")
  - as main diagnosis (1)
  - as secondary diagnosis (2)

- **Presence or absence of other ICD-10 diagnosis codes** (variable referred to as "other diagnosis codes")
  - No other diagnosis code except hip fracture (1)
  - Diagnosis code for sequela /mechanical complications following hip fracture surgery (2)
  - Diagnosis code for rehabilitation or medical conditions which are common after hip fracture surgery, e.g. deep vein thrombosis or pressure sore (3)
  -
  - All other (no relevant) diagnosis codes (5)

- **Presence or absence of certain specific surgical procedure codes** (The NOMESCO Classification of Surgical Procedures; NCSP)
  - No surgical procedure codes (1)
  - Surgical procedure codes common for a primary hip fracture (2)
  - Surgical procedures which may represent both primary hip fractures and revisions, i.e. hemiarthroplasty or total hip replacement (3)
  - Surgical procedures which always imply revision (4)
  - Both of the above, i.e. 2 and 4 (5)
  - All other (no relevant) surgical procedure codes (6)

Possible fractures were divided into several subgroups (category 3+ 31-37) according to combination of diagnosis and procedure codes and this resulted in the following categories (Table 1):

Table 1: Categories of conclusion regarding hip fracture

Value	Category	Criteria
1	A certain hip fracture	Procedure codes typical for a primary hip fracture surgery (procedure codes = 2 or procedure codes = 5)
2	Not a hip fracture	Procedure codes that always imply revision (procedure codes = 4)
3	Possible hip fracture, subgroup I	Hospital stay lacking procedure codes (procedure codes=1). Including hip fracture code only, or other diagnosis codes (codes for complications/sequela, or not relevant codes): Other diagnosis codes=1, 2 or 5. It is a later hospital stay for the individual.
31	Possible hip fracture, subgroup II	Hospital stay lacking procedure codes (procedure codes=1). Including hip fracture code only, or other diagnosis codes (codes for complications/sequela, or not relevant codes): Other diagnosis codes=1, 2 or 5. It is the first or only hospital stay for the individual.
32	Possible hip fracture, subgroup III	The patient has received hemiarthroplasty or total hip replacement and it seems to be a primary operation; there are no present codes that imply that this may be a revision. Procedure codes=3 (not 2 or 4), and other diagnosis codes ≠ 2.
33	Possible hip fracture, subgroup IV	There are procedure codes, but no relevant such (procedure codes = 6)
34	Possible hip fracture, subgroup V	The hip fracture is main diagnosis. The hospital stay includes codes for rehabilitation but no procedure codes. (hip fracture code=1; other diagnosis codes=3; procedure codes=1)
35	Possible hip fracture, subgroup VI	Hospital stay with hip fracture as secondary diagnosis, includes diagnosis codes for rehabilitation or medical complications, but no surgical procedures or no relevant surgical procedures. (hip fracture code=2; other diagnosis codes=2 or 3; procedure codes=1 or 6)
36	Possible hip fracture, subgroup VII	Hospital stay with hip fracture as secondary diagnosis, includes diagnosis codes for rehabilitation or medical complications, and hemiarthroplasty or total hip replacement. (hip fracture code=2; other diagnosis codes=2 or 3; procedure codes=3)
37	Possible hip fracture, subgroup VIII	Hospital stay with hip fracture as primary diagnosis, hemiarthroplasty or total hip replacement as procedure codes, and including diagnosis codes for sequela/mechanical complications. (hip fracture code=1; other diagnosis codes=2; procedure codes=3 (not 2 or 4).)

Differences in the algorithm used for the 1994-2008 algorithm and the new algorithm used for the 2008-2013 data

Coding of diagnosis codes and surgical procedure codes
Some small changes were made with respect to how the search for diagnosis codes was performed. In the old algorithm we searched specifically for all subcodes that were present in the dataset. In the new algorithm we performed a broader search for some of the diagnoses groups. The new algorithm was somewhat different from the old one for the following search codes (as it allowed all possible subcodes): 'T81', 'T84', 'I80', 'T931', 'I828', 'I829', 'Z508', 'Z509', 'Z540', 'Z544', 'Z547', 'Z549. The very same algorithm was used for the surgical procedure codes both times.

Taking time between hip fracture hospitalizations and diagnoses codes into account
A revised algorithm was used to take into account information about time between hospitalizations for hip fracture and codes in other hospitalizations. In the old algorithm there were more steps and consequently a longer algorithm. In the new algorithm, help files containing running number, matched sequence, dates of hospital admissions and conclusions were made (for subjects with more than one record only). The total numbers of hours between subsequent hospitalizations were calculated, and the help file was then merged with the main file so that each record line contained information about time between hospitalizations and conclusions for all the other records for the same subject. An algorithm taking time between hospitalizations and codes into account was run, resulting in 3 different conclusions: *A certain hip fracture, not a hip fracture, a possible hip fracture.* All temporary files were saved. A total of 19 subjects had 9 records or more, and these were evaluated manually, so that the iterations with the help files were run only for records up to number 9. Records labeled "not a new fracture" were removed before repeating the iteration with help-file for those with more than one record.

After preparing the 2008-2013 data, it was merged with the original NORHip datafile 1994-2007=NORHip 1). For an explanation for the choice of using NPR data for 2008, please confer page 15. After this merge, the data had to be "cleaned" once more to include a maximum of two records per individual, and the process with help files was used to clean the data. Both time between hospitalizations, number of records and type of information (i.e. code in Table 1), was taken into consideration.

Principles of coding of time between hospital admissions

After giving each record a conclusion regarding fracture status, time between hospital stays was taken into consideration.

Multiple records for the same incident were recorded if time between two hospital admissions was >0 (for example if a patient was transferred to another hospital). Likewise, if time between within-hospital transfers (between departments) was >0, multiple records were recorded for the same hospital stay.

Only one fracture was counted if time between two records was less than three weeks (504 hours). The rationale was that the majority of hospitalizations occurring within 0-3 weeks after the first fracture are due to rehospitalizations rather than new hip fractures.

If two records occurred <504 hours apart, one of the records were coded as 'not a new fracture' (category 2).

In general, the latest record was recoded into "not a new fracture" (i.e. deleted) if two records with conclusion 1 (certain) or possible (conclusion 32-37) hip fracture occurred <504 hours apart.

However, there were some exceptions:

If a *possible* hip fracture (conclusion 33-37) occurred (<504 hours) before a *certain* hip fracture, the *certain* hip fracture was counted (*possible* was recoded into "not a new fracture" (=deleted)).

If **31** (first or only record + missing surgical procedure codes) occurred (<504 hours) before **32** (total hip replacement/hemiarthroplasty), **31** was recoded into "not a new fracture" (=deleted), whereas 32 was recoded as *certain* record.

If **32** (hemiarthroplasty) occurred (<504 hours) before a *certain* record, **32** was recoded into "not a new fracture" (=deleted)

The coding reflects that category 32 is more likely to represent a true incident hip fracture than 31, and 1 is more likely to represent a true incident hip fracture than 32 and so on. Hence, in case of duplicate records for the same hospital stay or admissions closer in time than ***three weeks***, we aimed to include the admission with the best evidence of a new fracture.

Extraction of data

All records with conclusion=2 (=no fracture) were deleted. The remaining records were renumbered (by time).

1. Up to two hip fracture records were kept per person.

2. Both records with *certain* conclusion or *possible* conclusion were included.

In case of multiple records (more than two):

3. *certain* records were given priority over *possible* ones.

4. Given that time between records was more than 504 hours, the two first records were kept if conclusions were equal (for example conclusions 1,1,1 or 3,3,3)

Recoding of possible fractures

Above we have concluded that conclusions 1 and 32 were recoded into 1) *certain* fracture whereas 31, 33, 34, 35, 36 and 37 and were coded as 2) *Possible* hip fracture

Our decisions were based on discussions in a group of orthopedics and epidemiologists with expert knowledge in the field.

Distribution of codes in the final version of the database

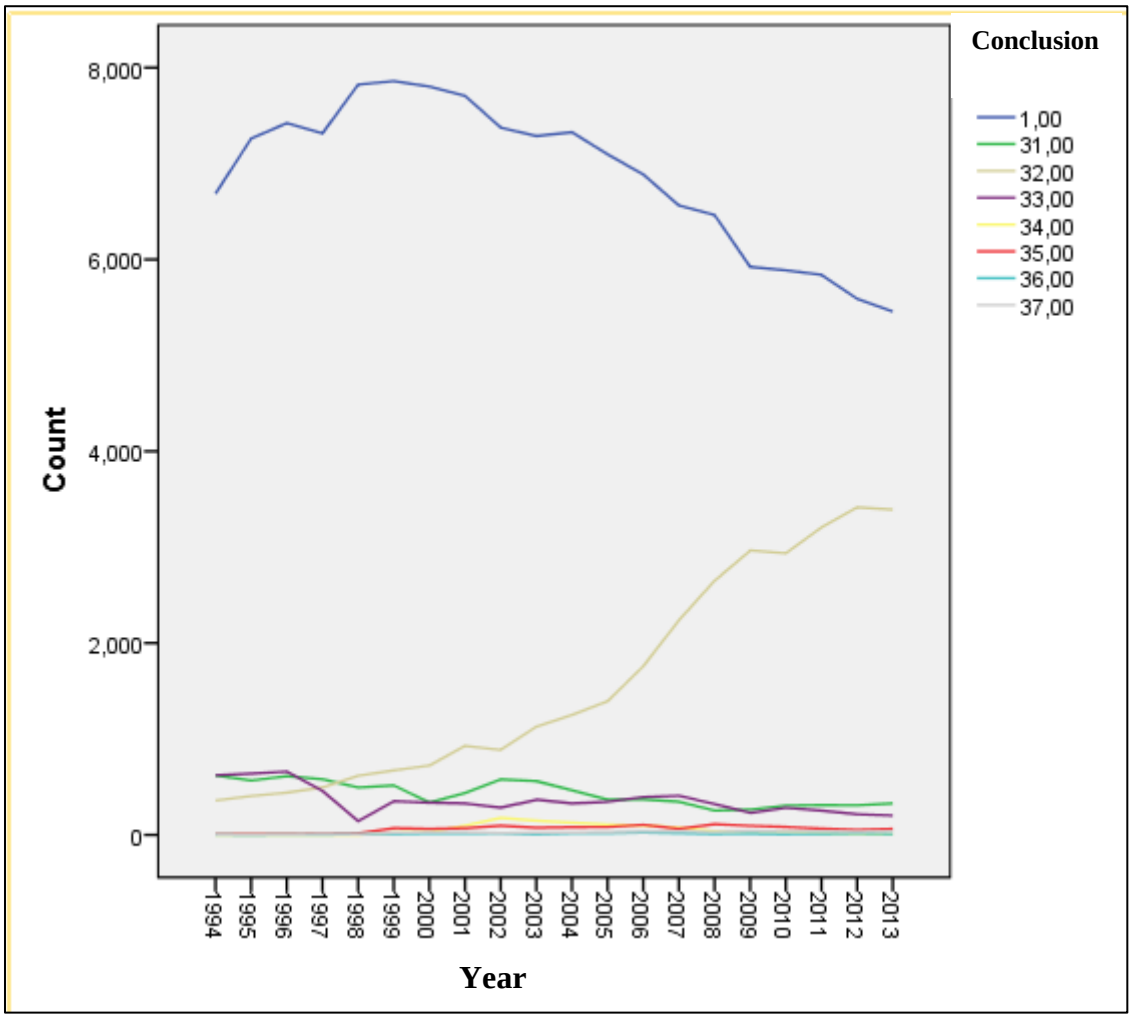

Figure 2. Total number of records with the different conclusions by calendar year.

The distribution of codes (conclusion) by calendar year shows that code 32 has increased over time whereas code 1 has decreased. This is meaningful as the use of hemiarthroplasty or total hip replacement has increased over time. The use of hemiarthroplasty has increasingly been implemented as the primary choice of surgical procedure for dislocated hip fractures (dislocated fractures of the femoral neck), as they have been demonstrated to entail lower revision rates [2-4].

Quality checks in random samples

In a random sample of 150 patients, the coding was evaluated against the original diagnosis codes and procedure codes and time between hospitalizations to validate /appraise the coding algorithms. The check was performed independently by two researchers. The coding was correct according to our coding practice in all 150 random patients.

Validation of the 2008-data in NORHip 1 versus the new NPR-based data from 2008

Number of fractures in NPR in 2008: **9,880**
Number of fractures in NORHip 1 in 2008: **9,534**

In total, there were 346 more fractures in NPR in 2008 compared to NORHip 1.

However, the majority of fractures that differed in 2008 were registered in December. If excluding December 2008 from the comparison, the total numbers were:

Number of fractures in NPR in 2008: **8,782**
Number of fractures in NORHip 1 in 2008: **8,702**

However, the above comparisons are not comparisons on the individual level. If comparing the number of hip fractures that were correct on the individual level (including the number of hip fractures per individual), it resulted in the cross table below (Table 2). In this comparison 95% of the subjects had exactly the same number of hip fractures in NORHip 1 and NPR.

Table 2. Number of hip fractures recorded in 2008 in NORHip 1 and in NPR

Number of fractures*		NPR			
		0	1	2	Total
NORHip 1	0	0	391	0	391
	1	53	9128	27	9208
	2	1	17	145	163
Total		54	9536	172	9762

*As all subjects had a fracture in either NORHip 1, NPR or both, there were no subjects with zero records.

If excluding December 2008 from the comparison due to possibly incomplete registration in this moth in the first dataset (NORHip 1), a total of 97.4% of the subjects had the same number of fractures in 2008. The comparison of hip fractures on the individual level is shown in Table 3.

Table 3. Number of hip fractures recorded in 2008 in NORHip 1 and in NPR (except December 2008)

Number of fractures		NPR			
		0	1	2	Total
NORHip 1	0	0	135	0	135
	1	56	8335	19	8410
	2	1	16	129	146
Total		57	8486	148	8691

Table 4 compares whether a patient had a hip fracture or not in 2008 (December 2008 excluded), regardless of the number of fractures. The agreement was 97.8%.

Table 4. Total number of patients with one or two hip fractures in 2008 in NORHip and in NPR (December 2008 excluded)

Fracture patients versus no fracture in 2008		NPR		
		0	1	Total
NORHip 1	0	0	135	135
	1	57	8499	8556
Total		57	8634	8691

The number of hip fractures registered per month in NORHip 1 and NPR in 2008 is compared in Figure 3. For comparison the mean number of hip fractures per calendar month registered during the year during 1998-2013 (excluding 2008) is also shown in the figure. The discrepancy in the number of fractures between NORHip 1 and NPR in December 2008 was 260 fractures, whereas the mean monthly difference in the other months of 2008 was 8 fractures. Based on these data we think there is reason to believe that the collected dataset from the hospitals in December 2008 was incomplete. December 2008 was the last month that data from the hospitals were collected from the hospitals in the first data retrieval – ie. NORHip 1, and this increases the likelihood that some data were missing.

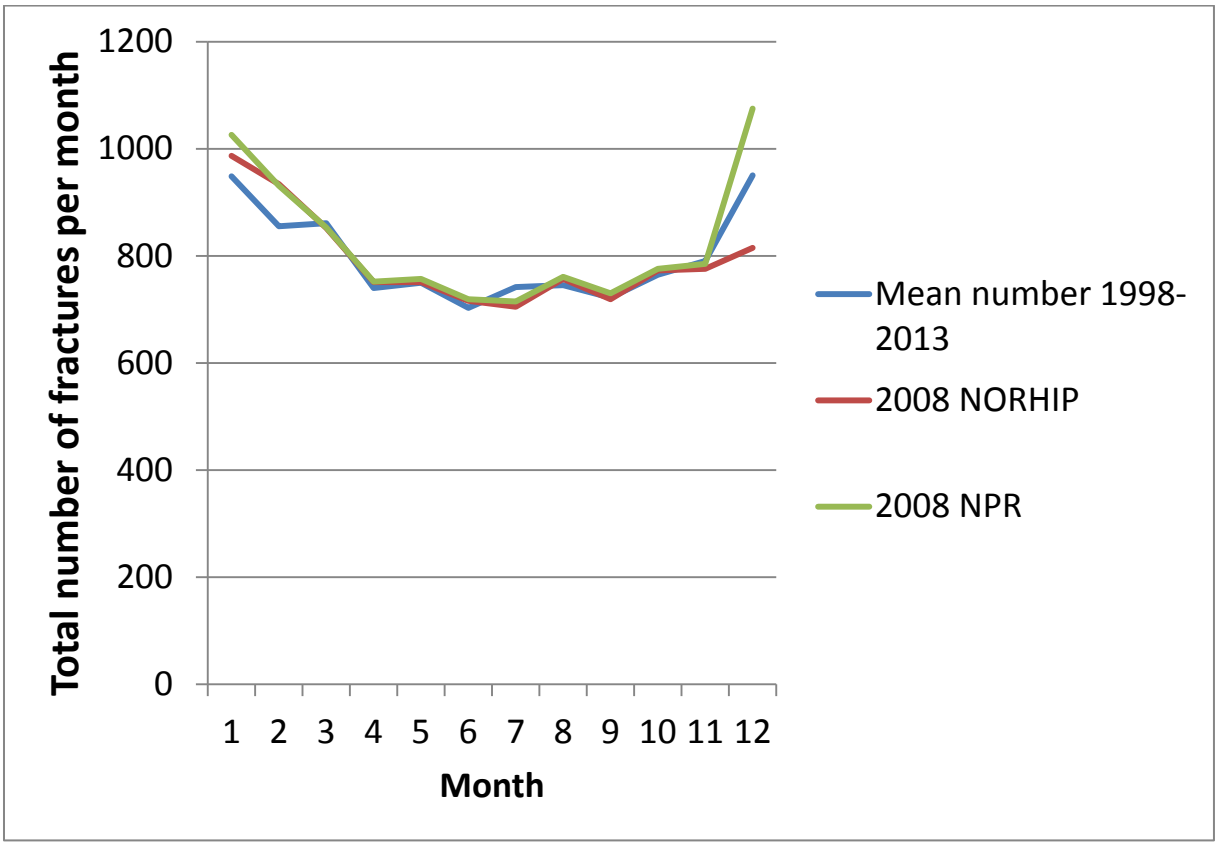

Figure 3. Total number of hip fractures per month in the calendar year 2008 in the first (NORHip 1; red curve) and second (NPR; green curve) data collections, respectively, compared with the average number of hip fractures per calendar month in other years (blue line).

Comparison of the updated NORHip with data from a hip fracture coverage report from the Norwegian Hip Fracture Register

The NORHip data for 2008-2012 were compared with a report using hip fracture data from the Norwegian Patient Register and the Norwegian Hip Fracture Register in the same time period [1].

The Norwegian Hip Fracture Register is managed by the Norwegian Orthopedic Association and is based on reports submitted by orthopedic surgeons after hip fracture surgery [5,6]. It contains data on surgically treated hip fractures (fractures of neck of femur, trochanteric and sub-trochanteric fractures). In the NPR-search they have included the ICD-10 codes S720 (femoral neck), S721 (trochanteric), S722 (sub-trochanteric), S723 (femoral shaft). I.e. they initially included a wider search for ICD-codes than we did in NORHip, but the fractures included in the report are those of the proximal femur only – as we used in NORHip. The report defined *incident* hip fractures only if there were surgical procedure codes indicating surgery in the proximal femur. But, in addition to surgical procedure codes for neck of femur, trochanter and sub-trochanter they have also included searches for the surgical procedure codes "proximal femur, other". The total number of fractures in the report (gold standard) was defined as a fracture with specific surgical procedure codes in the Norwegian Patient Register, a hit in the Norwegian Hip Fracture Register, or both.

A comparison of the updated NORHip (NORHip 2) with data from the hip fracture coverage report from the Norwegian Hip Fracture Register is shown in Figure 4. Due to the different methodology used to define hip fractures, the results are not directly comparable. However, NORHip data with a surgical procedure code involving "proximal femur, other", were counted as a hip fracture anyway (an uncertain hip fracture). As the total number of hip fractures include both the certain and the uncertain ones in NORHip, the "proximal femur, other" should not theoretically lead to differences in the results. In the NORHip-database records occurring for the first and only time but without relevant procedure codes where also coded as new hip fractures. The background for this was that we concluded that it is unlikely to be recorded with a hip fracture diagnosis without ever having sustained a hip fracture (the procedure codes might have been lost, and/or not all patients with an incident hip fracture has undergone surgery or had surgery while spending time abroad). Moreover, some patients die before they get the chance to have surgical intervention, and will therefore not exist in NHBR register.

Table 5. Percentage difference in the total number of hip fractures in the NORHip 2 database and the combined NPR-NHBR surgical procedure-based definition

2008	2009	2010	2011	2012
3,9	2,7	2,8	2,2	1,9

The total number of hip fractures in NORHip 2 was between 186-384 (1.9-3.9%) higher than the year-specific number in the NHBR-report.

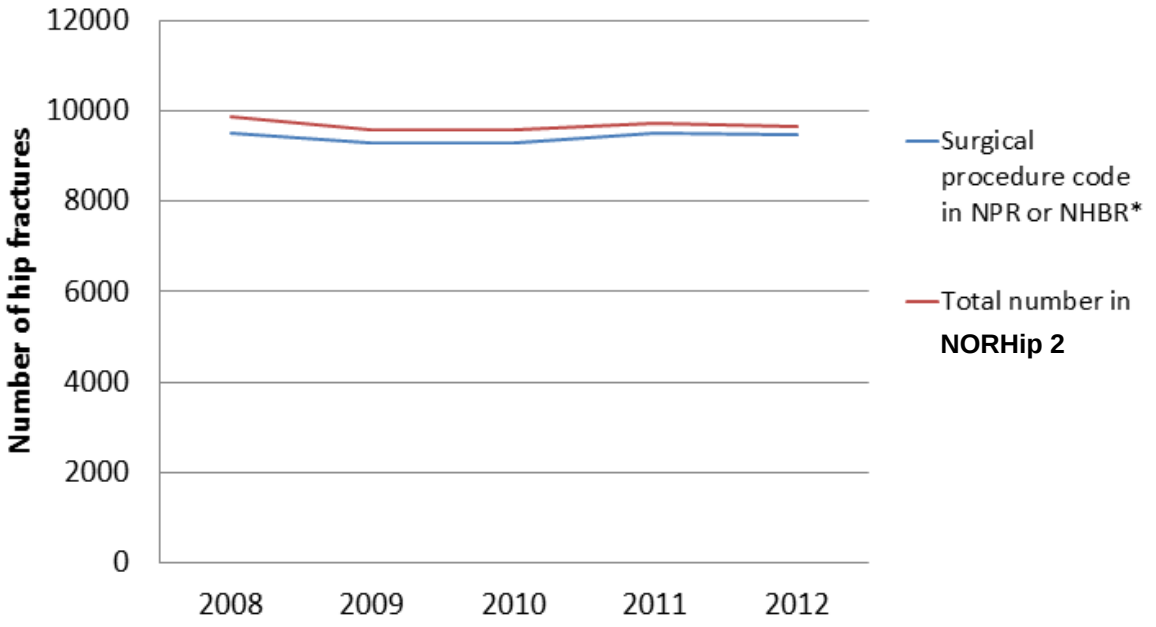

Figure 4. Total number of hip fractures in the NORHip 2 database (red) and with the combined NPR-NHBR surgical procedure-based definition (blue)

Comparison with validation study of the Norwegian Patient Register

In a validation study of the Norwegian patient register including a sample of 1000 patients, they estimated the total number of fractures in Norway based on NPR data which were compared with validated hospital data from the 1000 patients (which included copies of discharge summaries, descriptions of performed surgical procedures from medical records and X-ray reports requested from the hospitals).

In one of the analyses the validation study defined hip fractures by a combination of diagnostic (s72.0-s72.2) and procedure codes (NOMESCO version 1.14 NFBxy (x=0-9, y=0-2) or NFJxy (x=0-9, y=0-2) in 2008-2009[7], and concluded that the annual average number of hip fractures in Norway was 9,092. The study report that only 6.5% of fractures are missed if defining hip fractures based on the above surgical procedure code(compared to their "gold standard" of hospital verified hip fractures).

If projecting this number (6.5%) to the total Norwegian population, this means that approximately 592 records in NPR did not have surgical procedure codes in 2008-2009. This means that there should be approximately 9,684 fractures in Norway in each of the years 2008 and 2009. In NORHip, there were 9,880 fractures in 2008 and 9,563 in 2009 – mean number 9,722, which is 38 more hip fractures in NORHip 2 based on our definitions.

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