Supplementary material

Combining register and radiological visits data allows to reliably identify incident wrist fractures

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1. Clearance period in register data

A common challenge in using secondary administrative data is that the data content is not designed to meet the needs of the research problem. As the treatment episode of a wrist fracture involves several visits to health centres, it needs to be defined which admissions in the medical registers reflect fresh fractures. A common practice is to define a constant fracture free clearance period to distinguish new admissions from readmissions.[1] The use of a long clearance period may exclude some true subsequent fractures, whereas a short period can produce more false positives. In this study, we chose a clearance period of 12 months as it provided a good balance between coverage and false discovery rate based on the experiments with different period lengths (Figure S1).

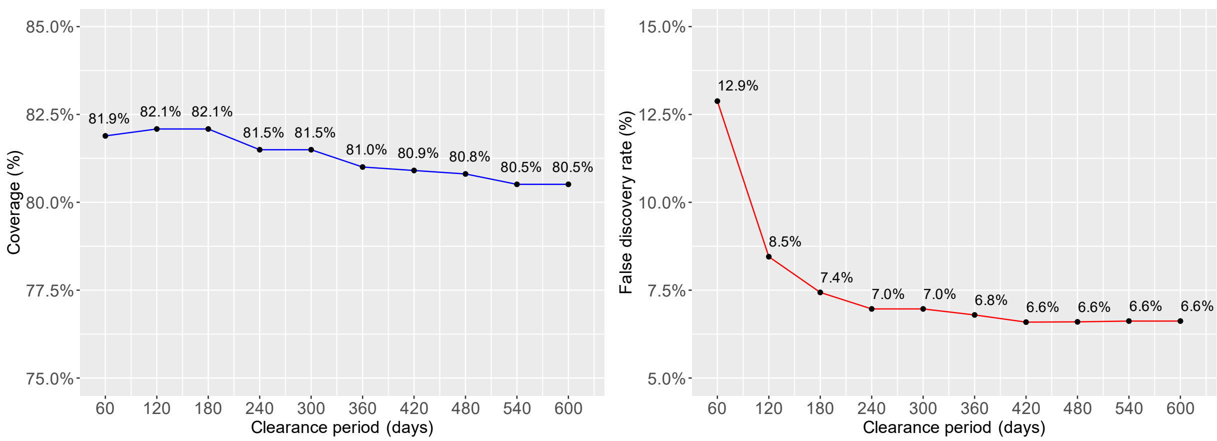

Figure S1. Coverage and false discovery rate (FDR) using different clearance period lengths. The coverage decreases slowly and steadily, whereas the FDR quickly drops and settles at around one year.

2. Fracture collection from registers

The fracture events from the Care Register for Health Care (Hilmo) and the Register for Primary Health Care Visits (Avohilmo) were identified using all available diagnosis code fields in the register datasets. Events with ICD-10 standard[2] diagnosis codes for distal radius fracture (S52.5) and distal radius and ulna fracture (S52.6) were included. Since Avohilmo also uses the ICPC2 standard,[3] we included events with ICPC2 code L72 standing for distal radius and ulna fracture.

By using the selected clearance period of 12 months, the register analysis indicated 822 potential fracture events. 741 of these had a matching self-report or radiology report, but 81 events had no data available in the other systems. We were able to validate 26 cases from the patient records of the hospital information system. For the remaining 55 cases we performed a manual investigation into their contact history in the registers and identified the fresh fractures based on the following criteria.

- 3 or more fracture related contacts within 2 months
  AND no previous fracture during the last year

- 2 fracture related contacts within 2 months
AND (no previous fractures during the last 2 years OR a code indicating a fall/slip)
- 1 fracture related contact
AND (no previous fractures during the last 2 years OR a code indicating a fall/slip)
AND a procedure code indicating fracture treatment

These rules were also tested with the cases where we had a valid label from a radiology report. From those test cases, they covered 570/943 (60.4%) of the fractures and produced 20 false positives (3.4% FDR). The false positives were mostly suspected fractures or arthrosis cases.

3. Analysis of false positives

To understand the limitations of different fracture identification approaches, we analysed the reasons behind the false positives produced by different data sources and identification algorithms (Table S1). Overall, the most common reason for false discoveries was a suspected fracture that was, in a subsequent examination, found not to be one. Sometimes, a conservative treatment episode can be started even without detecting a fracture if no other reason for the symptoms is found. The follow-up images reveal the possible signs of a healing fracture which help the radiologist to confirm or reject the original diagnosis. Although the rejected cases are not fractures in the biological sense, from a healthcare perspective, the treatment and employed resources are identical, making it difficult to distinguish them in administrative data. Another major group of false positives were the arthrosis cases, where a fall can cause symptoms typical of wrist fractures. These cases often required some follow-up to rule out the possibility of a fracture.

Table S1. Explanations for false positives produced by different data sources and algorithms

Data source / algorithm	False positive count	Explanations
Registers combined (Hilmo + Avohilmo)	59	21 unclear cases (e.g., single diagnosis without context. See supplementary section 2) 20 suspected fractures 11 misreported/updated fracture types 7 other problems of the wrist (e.g., arthrosis/rheumatics)
PACS 2+ algorithm	101	50 suspected fractures 30 other problems of the wrist (e.g., arthrosis/rheumatics) 14 other reasons (e.g., additional projections, exams for left/right, duplicate reports) 7 fractures in the carpals, metacarpals, or fingers
PACS 3+ algorithm	10	9 suspected fractures 1 other problem of the wrist
PACS&register algorithm A	18	17 suspected fractures 1 other problem of the wrist
PACS&register algorithm B	23	17 suspected fractures 5 misreported fracture types 1 other problem of the wrist

4. Incidence analysis

Over the analysis period from 2011 to 2021, our gold standard included a total of 1016 fractures among the 12013 participants aged 78.5 years on average. This corresponds to an incidence rate of 883 fractures / 100,000 person-years, which is well in line with the rates of 933/100 000 person-years for women aged 70-79 reported in Oulu[4] and 959/100 000 person-years for women aged 70-84 in Central Finland.[5] A nationwide register study on distal radius fractures in Finland during 2015-2019[6] reported a significantly lower incidence rate of 474/100 000 person-years for women aged 70-79. This supports our findings that incidence statistics based only on register data lead to underestimates. Similar differences between incidence rates and data collection methods can be observed in a review of European wrist fracture studies.[7]

In our analysis, collecting the fractures solely from the registers resulted in an underestimated incidence (-13.2%) compared to the gold standard (Table S2). This was also the case with the less sensitive and more specific PACS 3+ algorithm, whereas PACS 2+ slightly overestimated the incidence in the North Savo subcohort. However, PACS&register algorithm B produced the best estimate of incidence underestimating it only by 3.8% in the North Savo subcohort. These results could be used as correction factors when calculating the incidence based on a certain data source.

Table S2. Wrist fracture incidence estimations calculated from different data sources and algorithms.

Data source / algorithm	Full cohort			North Savo subcohort		
	Indicated fractures	Incidence (fractures / 100 000 person-years	Difference from gold standard incidence	Indicated fractures	Incidence (fractures / 100 000 person-years	Difference from gold standard incidence
Gold standard	1016	**883**	0.0%	892	**896**	0.0%
Hilmo register	467	**406**	-54.0%	392	**394**	-56.1%
Avohilmo register	710	**617**	-30.1%	631	**634**	-29.3%
Registers combined (Hilmo + Avohilmo)	882	**767**	-13.2%	766	**769**	-14.1%
Wrist radiograph in PACS	1846	**1605**	81.7%	1719	**1726**	92.7%
PACS 2+ algorithm	1011	**879**	-0.5%	949	**953**	6.4%
PACS 3+ algorithm	834	**725**	-17.9%	783	**786**	-12.2%
PACS&register algorithm A	900	**782**	-11.4%	844	**848**	-5.4%
PACS&register algorithm B	949	**825**	-6.6%	858	**862**	-3.8%

5. REFERENCES

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