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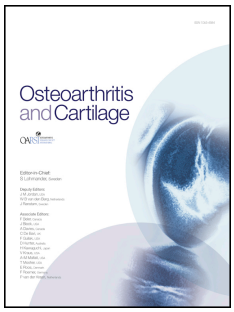

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Estimating incidence and prevalence of hip osteoarthritis using electronic health records: a population-based cohort study

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ABSTRACT

Objective: To determine the incidence and prevalence of hip osteoarthritis (OA) in electronic health records (EHRs) of Dutch general practices by using narrative and codified data.

Method: A retrospective cohort study was conducted using the Integrated Primary Care Information database. An algorithm was developed to identify patients with narratively diagnosed hip OA in addition to patients with codified hip OA. Incidence and prevalence estimates among people aged ≥30 were assessed from 2008 to 2019. The association of comorbidities with codified hip OA diagnosis was analysed using multivariable logistic regression.

Results: Using the hip OA narrative data algorithm (positive predicted value=72%) in addition to codified hip OA showed a prevalence of 1.76 to 1.95 times higher and increased from 4.03% in 2008 to 7.34% in 2019. The incidence was 1.83 to 2.41 times higher and increased from 6.83 to 7.78 per 1000 person-years from 2008 to 2019. Among codified hip OA patients, 39.4% had a previous record of narratively diagnosed hip OA, on average approximately 1.93 years earlier. Hip OA patients with a previous record of spinal OA, knee OA, hypertension, and hyperlipidaemia were more likely to be recorded with a hip OA code.

Conclusion: This study using Dutch EHRs showed that epidemiological estimates of hip OA are likely to be an underestimation. Using our algorithm, narrative data can be added to codified data for more realistic epidemiological estimates based on routine healthcare data. However, developing a valid algorithm remains a challenge, possibly due to the diagnostic complexity of hip pain in general practice.

Keywords: *hip osteoarthritis, incidence, prevalence, epidemiology, electronic health records*

INTRODUCTION

Osteoarthritis (OA) is one of the most prevalent joint diseases and has been ranked as the 10th leading contributor to global disability.[1-3] The hip joint is often affected by OA, as it is one of the most weight-bearing joints of the human body.[4] In 2017, the global prevalence of hip OA was estimated at 40 million people and the global incidence at 2 million people.[5] There is no cure for hip OA and current treatment focuses on reducing symptoms and improving function.[6] The only effective treatment is a joint replacement as an end-stage, which accounts for the majority of the healthcare costs associated with hip OA.[7] In 2017, 18.3% of the total healthcare costs for musculoskeletal diseases in the Netherlands was due to OA.[8] This is expected to increase due to the ageing of the population and increasing obesity rate.[5]

Current incidence and prevalence of OA are estimated using primary care electronic health records (EHRs) from routine healthcare data, largely focused on codified data containing specific codes for specific diseases.[9-13] However, EHRs also contain narrative data that include free text notes from healthcare providers. In a previous study[14] using primary care EHRs from the Netherlands, we found that a substantial proportion of knee OA patients did not have a record of codified knee OA, but had a record of a knee OA diagnosis in the free text of their EHR. Adding these narratively diagnosed knee OA patients to codified knee OA patients yielded approximately twofold higher prevalence and incidence estimates. Problems with under-recording of OA were also found in UK primary care EHRs.[15] Several reasons may contribute to this problem, such as GPs giving lower priority to record diseases or symptoms[15-17], which is likely in patients with OA as multimorbidity is common[18].

While misclassifications and under-recordings may have major impact on the accuracy of epidemiological estimates, healthcare policy of hip OA is still based on epidemiological estimates obtained from routine healthcare data using codified data alone. More accurate information on epidemiological estimates is urgently needed to adequately respond to the large increase of the burden of hip OA.[5]

Therefore, this study aimed to determine the incidence and prevalence of hip OA using the complete EHR consisting of both codified and narrative data from a routine primary care database in the Netherlands.

METHODS

Design and setting

This retrospective cohort study was conducted using the Integrated Primary Care Information (IPCI) database which contains EHRs from Dutch general practices of approximately 2.5 million patients. Details of this database have been published elsewhere.[19, 20] In summary, EHRs from the IPCI database comprise all medical journal entries written in free text by GPs, diagnoses using the International Classification of Primary Care (ICPC) codes, laboratory findings, drug prescriptions, referrals, and correspondence with other healthcare providers from primary and secondary care (e.g. physiotherapist and orthopaedic surgeon). EHRs from the IPCI database contain the majority of patients' medical information, as all citizens in the Netherlands are obliged to register with a GP which acts as the first point of contact and the gatekeeper to secondary care.[21, 22]

Study cohort

We used a similar research method for the development of an algorithm based on narrative data to identify under-recorded hip OA patients as we did in an earlier study[14] in which we examined the under-recording of knee OA. Patients were included during each study year from 1 January 2008 until 31 December 2019 if they were aged ≥30 with at least 12 months of valid database history prior to the study entry. Patients with a codified diagnosis of hip OA were selected. The codified diagnosis of hip OA was based on the ICPC code L89.

In addition, an algorithm was developed by our research group, including GPs, to identify patients with keywords referring to hip OA in narrative data (i.e. the free text in their EHR) without any record of codified hip OA (ICPC code L89). An overview of our workflow is illustrated in Figure 1. In the first phase, the algorithm included patients with an ICPC code L13 (i.e. hip complaints) plus keywords related to OA or keywords related to hip plus OA without ICPC code L13, for example 'hip' plus 'osteoarthritis'. Keywords combined with terms indicating negation (e.g. 'not' or 'no') were excluded, as were combinations with relatives (e.g. 'father has', 'mother has'), patient's anxiety about a possible diagnosis of OA, and expressions of uncertainties regarding the OA diagnosis by the GP or other healthcare providers in primary care or secondary care (e.g. 'probably', 'differential diagnoses'). A random sample of 100 patients identified by the algorithm was assessed by one author (IGA) to check for terminology variations and misspellings of keywords. Textual alternations were made after discussion with all authors to improve the algorithm.

In the second phase, we randomly selected 50 patients of these potential narratively diagnosed hip OA patients without a record of codified hip OA. These cases were assessed on true and false positive for having hip OA through a blinded medical record review by two authors, IGA (physiotherapist and researcher) and JD (academic GP). True positive cases were defined by: "Patients where the GP, healthcare provider from primary care (e.g. physiotherapist) or secondary care (e.g. orthopaedist or radiologist) reported a hip OA diagnosis in the free text in their EHR, with or without X-ray imaging"; a commonly used and generally accepted reference standard.[16] When the hip OA diagnosis was documented in a radiology report only, documentation of hip pain in the EHR at the time of X-ray or MRI request was required to classify as a true positive hip OA case. Hip OA as an incidental finding on X-ray or MRI after a traumatic event was not considered as a true positive case, given the poor correlation between the severity of structural damage of the joint and the severity of symptoms[23, 24].Consensus was reached through discussion with the last author (DS, senior researcher experienced with IPCI database). Results were then discussed with the research group and modifications to the algorithm were made to reduce the number of false positive cases.

In the last phase, the positive predicted value (PPV) of the modified narrative data algorithm was re-assessed using the same methods as in the second phase. To compare the validity of the algorithm with that of codified hip OA, one author (IGA) assessed the PPV of a random selection of 50 patients identified with codified hip OA (i.e. ICPC code L89) with the same methods as for the PPV assessment of narratively diagnosed hip OA and with scrutiny by the co-authors (JD or DS) if necessary. Different random samples of patients were used for all three phases in the algorithm development process.

87

88 **Outcomes**

89 PPVs were calculated as the proportion of patients who were confirmed as having hip OA, based
90 on the information reported in the EHR. The annual lifetime prevalence was calculated as the
91 total number of people ever diagnosed as at 1 July each calendar year, divided by the total
92 number of patients in the population on that date, and multiplied by 100. The entire
93 retrospective record available for patients was used to estimate the prevalence. The annual
94 incidence rate was calculated by the number of new cases between 1 January and 31 December
95 (i.e. no previous diagnosis of hip OA) in each calendar year, divided by the number of person
96 years at risk between 1 January and 31 December each calendar year. This at risk period is the
97 period that a patient participated in the IPCI database without a recorded hip OA diagnosis until
98 the moment of death, changing practice, hip OA diagnosis, or end of participation in the IPCI
99 database. The entire retrospective record available for patients was used to exclude prior hip OA
100 when estimating the incidence rates. Thus, patients with a hip OA diagnosis in their medical
101 history (i.e. medical history before enrolment in the IPCI database or before 1 January 2008) were
102 defined as prevalent cases. See Supplementary File S1 for more information regarding the
103 medical history available for the study cohort. Prevalence and incidence estimates were
104 calculated separately for: 1) patients with codified hip OA diagnosis defined as at least one ICPC
105 code hip OA (i.e. L89), and 2) patients with narratively diagnosed hip OA according to the free-
106 text algorithm without any record of codified hip OA in their EHR. Incidence and prevalence
107 estimates were calculated stratified by sex. Further details of the study design are illustrated in
108 Figure 2.

To determine the effect of including narrative data in addition to codified data, annual rate ratios between prevalence and incidence estimates of codified hip OA and codified plus narratively diagnosed hip OA were calculated.

Furthermore, some of the patients identified with codified hip OA may have been identified with hip OA at an earlier date based on narrative data. We explored the proportion of patients with a narrative hip OA diagnosis prior to a codified hip OA diagnosis. The number of days between the first narrative hip OA diagnosis and the first codified hip OA diagnosis was calculated.

We explored differences in demographics and comorbidities between patients with codified hip OA and patients with narratively diagnosed hip OA. In addition, based on previous research[15-17], we hypothesized that GPs may give patients with comorbidities lower priority to also record OA with a code. Therefore, we analysed the association between concurrent comorbidities (i.e. occurring before the first hip OA diagnosis) and codified hip OA among all prevalent hip OA patients. Prevalent hip OA patients are either codified or narratively diagnosed between 1 January 2008 and 31 December 2019. Narratively diagnosed hip OA patients are the reference category of the outcome in this analyses. We selected the following common comorbidities in patients with OA from an earlier systematic review[18]: 1) hypertension, hyperlipidaemia, overweight, diabetes mellitus (i.e. disorders related to metabolic syndrome); 2) heart/vascular diseases and events (i.e. stroke/TIA, peripheral arterial disease, and myocardial infarction/angina pectoris), 3) asthma, 4) Chronic Obstructive Pulmonary Disease (COPD), 5) a small selection of OA related to joints other than the hip (i.e. spinal OA and knee OA), 8) low back

pain. For the comorbidities we used the codified diagnosis based on ICPC-codes (see Supplementary Table S2 for the full list of ICPC-codes). This analysis was adjusted for age and sex.

Statistics

Binomial 95% confidence intervals (CIs) were calculated for the PPVs. Prevalence and incidence estimates were standardized for age and sex using the annual distribution for the whole Dutch population as given by the StatLine database of Statistics Netherlands from 2008 up to 2019[25]. The Poisson distribution was used to provide 95% CIs for prevalence and incidence estimates. Descriptive characteristics were reported as means and standard deviations (SDs), medians and interquartile ranges (IQRs), and counts (n) and percentages (%), as appropriate. Multivariable logistic regression was performed to determine the association of comorbidities with the codified diagnosis among patients with hip OA (either narratively diagnosed or codified diagnosed); the results were expressed as odds ratios (ORs) including 95% CIs. The significance level throughout was set at two-tailed P<.05. Statistical analyses were performed using R Studio Software V.4.0.2.

RESULTS

Validity assessment

Narrative data algorithm

An overview of our workflow for the development of the narrative data algorithm is illustrated in Figure 1 and full details in Supplementary Data S3. The first version of the algorithm yielded a PPV of 60% (95%CI = 46.4% to 73.6%) (Phase 2). False positive cases were found frequently due to codified hip complaints (i.e. ICPC code L13) plus keywords for OA in the lower back or sacroiliac joint, and were therefore excluded in the second revised algorithm. We also excluded the keyword 'prosthesis', as this was often found after a hip fracture and not due to hip OA. Subsequently, the PPV of this final narrative data algorithm resulted into 72% (95% CI = 59.6% to 84.4%) (Phase 3). In the final algorithm, false positive cases were still frequently found due to keywords for OA in the lower back or sacroiliac joint in combination with a keyword related to the hip joint or codified hip complaints, but also due to unclear diagnosis of hip OA and hip OA as an incidental finding on X-ray to rule out a hip fracture after traumatic event. For 80.6% (29 out of 36) of the true-positive narratively diagnosed hip OA patients, an X-ray was used to confirm the diagnosis, either requested by the GP or documented in the correspondence from an orthopaedic surgeon in secondary care to the GP.

Codified hip OA diagnosis

The PPV of codified diagnosed hip OA was 98% (95% CI= 94.1% to 100%). The reason for the false positive case was a coding error where the GP recorded the ICPC code L89 (hip OA) instead of L90 (knee OA). For 87.8% (43 out of 49) of the true-positive codified diagnosed hip OA patients, an X-ray was used to confirm the diagnosis, either requested by the GP or documented in the correspondence from an orthopaedic surgeon, rheumatologist, internist, or urologist in secondary care to the GP.

Study cohort

The study cohort consisted of 117,758 patients with hip OA. A total of 63,470 patients had a record of codified hip OA with a mean age of 68.2 (SD=11.7) and 34.3% were men. The remaining 54,288 patients did not have any record of codified hip OA, but were identified with narratively diagnosed hip OA alone. These patients were younger (mean age=65.4 (SD=12.8)) and comprised a slightly greater percentage of men (36.0%) compared to codified hip OA patients.

Narrative diagnosis prior to codified diagnosis

Of the patients identified with codified hip OA, 39.4% (n=25030) was at an earlier time point diagnosed narratively with hip OA; on average 1.93 years earlier (median number of days = 706; IQR = 48 to 2378).

Prevalence

The standardized prevalence of codified hip OA in 2008 was 2.07% (95%CI 2.06-2.08) and increased to 4.01% (95%CI 4.00-4.02) in 2019 (Figure 3A). The standardized prevalence of narratively diagnosed hip OA alone (i.e. without any record of codified hip OA) was estimated to be 1.96% (95%CI 1.96-1.97) in 2008 and increased to 3.33% (95%CI 3.32-3.34) in 2019 (Figure 3B). The annual crude and standardized prevalence proportions are presented in Supplementary Table S4, as well as the accurate number of included people each year in analysis.

Adding narrative data to codified data showed prevalence proportions with a rate ratio between 1.76 and 1.95 during the study period (Table 1) and increased from 4.03% (95%CI 4.02-4.04) in 2008 to 7.34% (95%CI 7.32-7.35) in 2019 (Figure 4A).

Incidence

The standardized incidence of codified hip OA declined from 3.74 per 1000 person-years (95%CI 3.70-3.78) in 2008 to 3.22 per 1000 person-years (95%CI 3.19-3.25) in 2019 (Figure 5A) and peaked in 2013 with 4.19 per 1000 person-years (95%CI 4.15-4.23). In contrast, the standardized incidence of narratively diagnosed hip OA alone increased consistently year by year with 2.72 per 1000 person-years (95%CI 2.68-2.75) in 2008 to 3.86 per 1000 person-years (95%CI 3.82-3.89) in 2019 (Figure 5B). The annual crude and standardized incidence rates are presented in Supplementary Table S4.

Adding narrative data to codified data showed incidence rates with a rate ratio between 1.83 and 2.41 during the study period (Table 1). The incidence increased from 6.83 per 1000 person-years (95%CI 6.78-6.88) in 2008 to 7.78 per 1000 person-years (95%CI 7.78-7.83) in 2019 and was highest in 2011 with 7.89 per 1000 person-years (95%CI 7.84-7.94) (Figure 4B).

Prevalence and incidence estimates for all case definitions were at any given time point higher for women than for men. Sex stratified estimates are presented in Supplementary Table S5.

Factors associated with a record of codified hip OA

In general, multivariable analysis showed small to no statistically significant associations of demographic variables and concurrent comorbidities with codified hip OA (Figure 6). Among the concurrent comorbidities, spinal OA (OR 1.13 [95%CI 1.07-1.19]), knee OA (OR 1.10 [95%CI 1.05-1.14]), hyperlipidaemia (OR 1.11 [95%CI 1.07-1.15]), and hypertension (OR 1.10 [95%CI 1.07-1.13]) were associated with a record of codified hip OA. Concurrent stroke/TIA, diabetes, and low back pain reduced the likelihood of being recorded with codified hip OA, but with small associations. The remaining comorbidities showed no statistically significant associations. Full details are provided in Supplementary Table S6.

DISCUSSION

This study developed an algorithm to determine the incidence and prevalence of hip OA in EHRs of Dutch general practices by using a combination of narrative and codified data. Adding narrative data based on this algorithm to codified data showed prevalence and incidence estimates of almost twice as many on average from 2008-2019. Our algorithm had a positive predicted value of 72%. False positive cases mainly occurred due to keywords for OA in the lower back or sacroiliac joint combined with keyword related to the hip joint or codified hip complaints, unclear diagnosis of hip OA, and hip OA as an incidental finding on X-ray to rule out a hip fracture after traumatic event. Contrary to current guidelines [24, 26-29], an X-ray was used to confirm the diagnosis in most of the hip OA patients.

A previous record of spinal OA and knee OA showed a positive association with codified hip OA. It may be that GPs are more prone to record hip OA with a code when the patient is already known to have OA in joints other than the hip. Furthermore, a previous record of hyperlipidaemia and hypertension increased the likelihood of hip OA patients being recorded with a hip OA code. The Dutch healthcare system includes reimbursement schemes for cardiovascular risk management. Patients included in this program are routinely invited to visit their GP to monitor their health status, including screening on hypertension and hyperlipidaemia. It may be that patients who are routinely monitored are more likely to have a record of codified hip OA. Previous research[15-17] hypothesized that GPs may under-record codified OA because they give it lower priority than other diseases. Although we found that a record of concurrent stroke/TIA, diabetes, and low back pain reduced the likelihood of hip OA patients being recorded with codified hip OA, these associations were too small to support this hypothesis.

The current study found that hip OA was increasingly under-recorded over time, since the incidence of codified hip OA diagnosis decreased over time, while that of narratively diagnosed hip OA alone increased. However, it should be noted that these patients with narratively diagnosed hip OA alone may be recorded with codified hip OA in the future, since almost 40% of codified hip OA patients had a previous record of narratively diagnosed hip OA. In contrast, Swain et al.[11] found an increase of codified hip OA and a decrease of codified 'unspecified' OA over time in EHRs from the UK. The authors suggested that this may be due to better recording of codified hip OA, since hip OA patients are increasingly being recorded with codified hip OA rather than unspecified OA.

Similar to our previous study[14] on knee OA, the current study showed that adding narrative data to codified data yielded almost twice as many hip OA patients than the standard approach of using codified data alone. However, the development of the algorithm to identify narratively diagnosed hip OA patients in the current study was more complex than for narratively diagnosed knee OA patients in our previous study[14]. The algorithm for hip OA included false-positive cases resulting from keywords for spinal OA combined with hip complaints, which was not present in the knee OA algorithm. This can be explained by a strong association of low back pain with hip OA compared to knee OA.[30] Also, false-positive cases in the hip OA algorithm occurred due to keywords for hip prosthesis after a hip fracture rather than for hip OA. These false-positive cases were not present in the knee OA algorithm, as arthroplasty is far more commonly used in patients with acute femur fracture than in knee fractures.[31, 32] Although exclusion of these combinations increased the PPV from 60% to 72%, the validity of the narrative data algorithm for hip OA remained lower than for knee OA (i.e. PPV=94%). This reflects the greater clinical diagnostic challenge of hip OA compared to knee OA. The differential diagnosis of hip pain presented to a GP is much broader than in knee pain, e.g. hip pain is sometimes difficult to distinguish from trunk pain and is often associated with a variety of hip conditions, such as OA, gluteal tendinopathy, and femoral acetabular impingement syndrome.[33-35] While current guidelines do not recommend imaging to diagnose OA in clinical practice, but recommend using history taking and physical examination instead [24, 26-29], we found in the current study that an X-ray was used for most hip OA patients to confirm the diagnosis. This overuse of X-rays for diagnosing hip OA in the general practice may reflect the clinical diagnostic complexity of hip OA.

It may also indicate the demand of patients, asking their GP to confirm a likely chronic diagnosis with potential major implications for the patient.

Furthermore, similar to the findings in our previous study[14] on knee OA, around 40% of the codified hip OA patients in the current study had a previous record of a narrative diagnosis. Capturing hip OA patients earlier may help policymakers to plan and prioritize resources more adequately to keep healthcare affordable. Remarkably, the time between the narrative diagnosis and codified diagnosis was shorter for hip OA than for knee OA (1.9 years vs 3 years, respectively).[14] This difference may relate to findings from a previous research in which the symptom duration at the time of initial presentation was found to be shorter for hip OA than for knee OA (2.7 years and 3.9 years, respectively).[36] However, to date, the reason for this difference in clinical presentation is unclear.

A previous study[15] found an under-recording of codified OA in UK primary care EHRs in a quarter of severe OA patients aged 40 with total hip and knee replacements. However, these results do not apply to the less severe OA patients (i.e. without joint replacement) where under-recording may be even more present since patients with less severe OA are less likely to have a codified OA diagnosis[37]. To the best of our knowledge, the current study is the first that presented the under-recording of hip OA across the entire spectrum of severity.

The Dutch National Institute for Public Health and the Environment (RIVM) published prevalence and incidence estimates of codified hip OA based codified data alone retrieved from Nivel Primary Care Registrations.[13] Comparing their estimates with our results is difficult because of the differences in age restriction. We therefore reproduced our analyses without restriction

294 on age as estimates published by RIVM, which showed similar estimates; i.e. crude prevalence in
295 2019, 1.97% for men and 3.44% for women in the current study versus 1.96% for men and 3.34%
296 for women published by RIVM. Nevertheless, estimates published by RIVM are probably
297 underestimated, since they only include codified hip OA patients.

298 A strength of this study is the use of a representative sample of the Dutch population
299 from IPCI database.[19, 20] Limitations of this study include that, although we captured a substantial
300 part of under-recorded hip OA patients by adding narrative data to codified data, our prevalence
301 and incidence estimates might still be an underestimation due to the restrictiveness of the
302 algorithm. On the other hand, the PPV of 72% of the narrative data algorithm might imply an
303 overestimation of 28% of the hip OA patients identified with narrative data, as they possibly do
304 not have hip OA. In addition, we were able to calculate the PPV of the diagnoses, but not other
305 features of the algorithm, such as negative predicted value or sensitivity, and future research on
306 this is required. Also, an important aspect to consider when interpreting our results is that under-
307 recording of hip OA could be related to several factors, such as the type of general practice and
308 the type of information systems, as Dutch GPs are free to choose among competing information
309 systems that significantly differ in user interfaces and features[20]. Future research into this is
310 warranted to better understand factors contributing to under-recording of diseases in routine
311 healthcare data.

312 Current healthcare policy on prevention and management is based on routine primary
313 care data using codified data alone from EHRs. Findings from the current study and previous
314 studies[14, 15] demonstrating the under-recording of OA indicate a serious underestimation of

epidemiological estimates and other estimates obtained from EHR-based studies (i.e. association studies, descriptive management policy studies). This leads to inaccurate outcomes and eventually inaccurate healthcare policy making. Narrative data can be added to codified data in EHR-based OA research. In that way, policy makers will have a more realistic picture of the current and future burden of OA and can better respond to its predicted large increase.[5] However, it should be noted that the use of narrative data may not always be feasible, since coding systems and the use of narrative data fields built into EHRs may differ between countries and systems. Data protection may even limit access to narrative data fields, making other alternatives to identify under-recorded hip OA patients in EHR data more suitable, for example using process, referral, and intervention codes. In addition, developing an algorithm based on patient characteristics (i.e. age and occupation) in combination with symptomatic codes (i.e. hip complaints ICPC code L13 in the Netherlands) may potentially help to identify patients with OA in joints without an OA code.

CONCLUSIONS

This study developed an algorithm to determine the incidence and prevalence of hip OA in EHRs of Dutch general practices by using a combination of narrative and codified data. The positive predicted value of narratively diagnosed hip OA patients alone was 72%. Adding narrative data to codified data yielded prevalence and incidence estimates of almost twice as many on average from 2008-2019. A previous record of spinal OA, knee OA, hypertension, and hyperlipidaemia increased the likelihood of hip OA patients being recorded with a hip OA code. This study showed

the importance of using narrative data in addition to codified data in EHR-based OA research to produce realistic epidemiologic estimates. However, developing a valid algorithm to identify hip OA patients based on narrative data remains a challenge, possibly due to the diagnostic complexity of hip pain in general practice.

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AUTHOR CONTRIBUTIONS

IGA, JD, MdW, JJvdD, PJEB, DS, and SMAB-Z participated in the design of the study. IGA, JD, and DS reviewed electronic health records for validity assessment. IGA conducted statistical analysis. IGA, JD, MdW, JJvdD, PJEB, JvdL, DS, and SMAB-Z gave their comment on the first version of the manuscript and approval of the final manuscript.

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest.

ETHICAL APPROVAL INFORMATION

This study was approved by the Board of Directors of the IPCI database.

DATA SHARING STATEMENT

The aggregated data are available on request from the corresponding author.

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FIGURES LEGENDS

Figure 1. Workflow diagram for the development of the narrative data algorithm

Figure 2. Details of the study design

Figure 3. Standardized prevalence of hip OA based on codified data (A) and narrative data alone (B)

Figure 4. Standardized (A) prevalence and (B) incidence of hip OA based narrative data alone in addition to codified data

Figure 5. Standardized incidence of hip OA based on codified data (A) and narrative data alone (B)

Figure 6. Characteristics associated with codified hip OA diagnosis among all hip OA patients (either codified diagnosed or narratively diagnosed without a hip OA code)

TABLES

Table 1. Prevalence and incidence of hip OA based on codified data versus a combination of codified and narrative data

Standardized prevalence [95% CI]				Standardized incidence [95% CI]			
Year	Codified data	Codified + narrative data	Rate ratio	Year	Codified data	Codified + narrative data	Rate ratio
2008	2.07 [2.06-2.08]	4.03 [4.02-4.04]	1.95	2008	3.74 [3.70-3.78]	6.83 [6.78-6.88]	1.83
2009	2.23 [2.22-2.24]	4.19 [4.18-4.21]	1.88	2009	3.82 [3.79-3.86]	7.08 [7.03-7.14]	1.85
2010	2.43 [2.42-2.44]	4.52 [4.51-4.54]	1.87	2010	3.90 [3.86-3.93]	7.48 [7.43-7.53]	1.92
2011	2.67 [2.66-2.68]	4.97 [4.96-4.99]	1.86	2011	4.08 [4.04-4.11]	7.89 [7.84-7.94]	1.94
2012	2.86 [2.85-2.87]	5.28 [5.27-5.30]	1.85	2012	4.04 [4.01-4.08]	7.51 [7.46-7.56]	1.86
2013	3.07 [3.06-3.08]	5.50 [5.48-5.51]	1.79	2013	4.19 [4.15-4.23]	7.76 [7.70-7.81]	1.85
2014	3.30 [3.29-3.31]	5.83 [5.82-5.85]	1.77	2014	3.87 [3.83-3.90]	7.42 [7.37-7.47]	1.92
2015	3.47 [3.46-3.48]	6.11 [6.09-6.12]	1.76	2015	3.70 [3.66-3.74]	7.50 [7.45-7.55]	2.03
2016	3.62 [3.61-3.63]	6.41 [6.40-6.43]	1.77	2016	3.49 [3.46-3.53]	7.22 [7.17-7.27]	2.07
2017	3.76 [3.75-3.77]	6.71 [6.69-6.72]	1.78	2017	3.56 [3.52-3.59]	7.68 [7.63-7.73]	2.16
2018	3.92 [3.90-3.93]	7.06 [7.04-7.07]	1.80	2018	3.39 [3.36-3.43]	7.46 [7.41-7.51]	2.20
2019	4.01 [4.00-4.02]	7.34 [7.32-7.35]	1.83	2019	3.22 [3.19-3.25]	7.78 [7.72-7.83]	2.41

Note: Standardized prevalence and incidence estimates are standardized for age and sex distribution of the total population from the Netherlands.

FIGURES

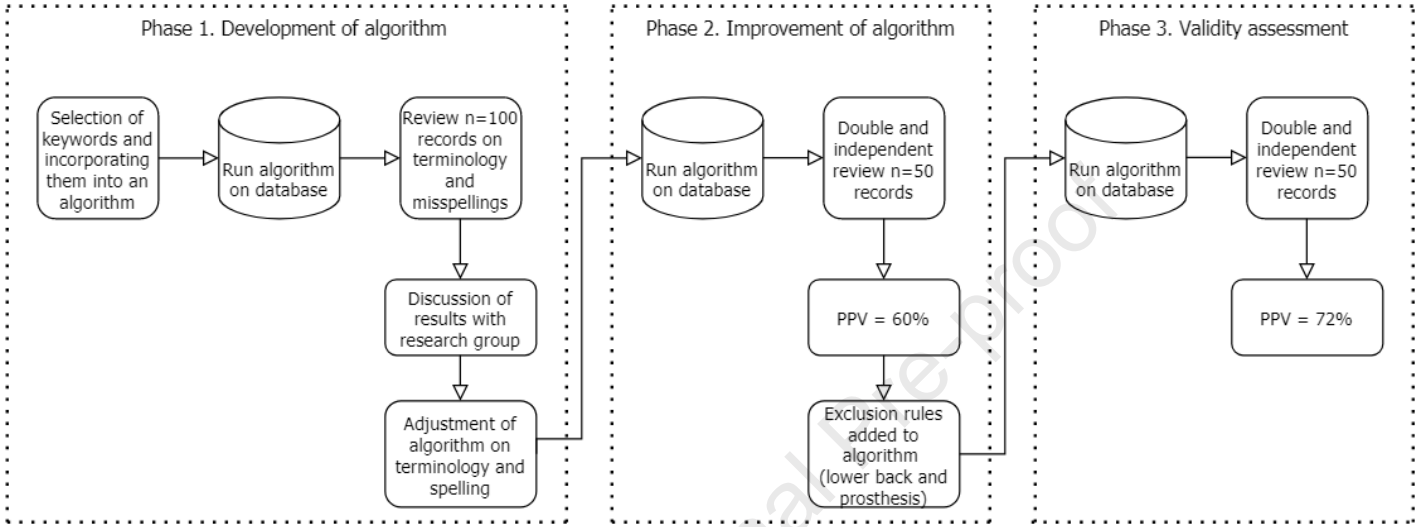


Figure 1. Workflow diagram for the development of the narrative data algorithm

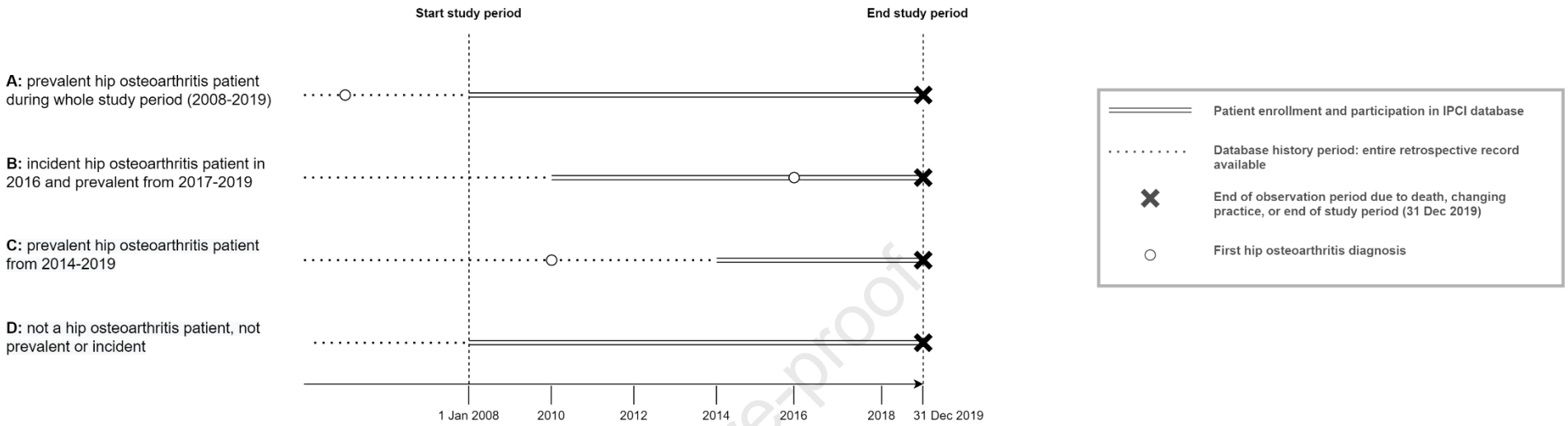


Figure 2. Details of the study design

Notes. Figure 2 shows four examples of patients in the study cohort (A-D). The study period started on 1 January 2008 until 31 December 2019. The IPCI database is an open cohort, meaning that patients can also enter the database after the start of study period and stop before the end of study period due to death or changing practice. Patients were followed from the start of study period (patient A and patient D) or from the moment they entered the IPCI database if this moment was after 1 January 2008 (patient B and patient C). Patients were followed until the end of the study period (patient A, B, C and D) or until the moment of death or changing practice when this moment was before 31 December 2019. A first hip OA diagnosis was defined as incident when the first diagnosis was given within the study period and participation in IPCI database (patient B). The incidence rate was calculated annually by the number of new cases in each calendar year, divided by the number of person years at risk between in each calendar year. For example, when calculating the incidence rate of the year 2016, patient B is included in the numerator and patient B and D are included in the denominator. The prevalence was calculated annually as the total number of people ever diagnosed as at 1 July each calendar year, divided by the total number of patients in the population on that date, and multiplied by 100. For example, when calculating the prevalence of the year 2014, patient A and C are included in the numerator and patient A-D are included in the denominator.

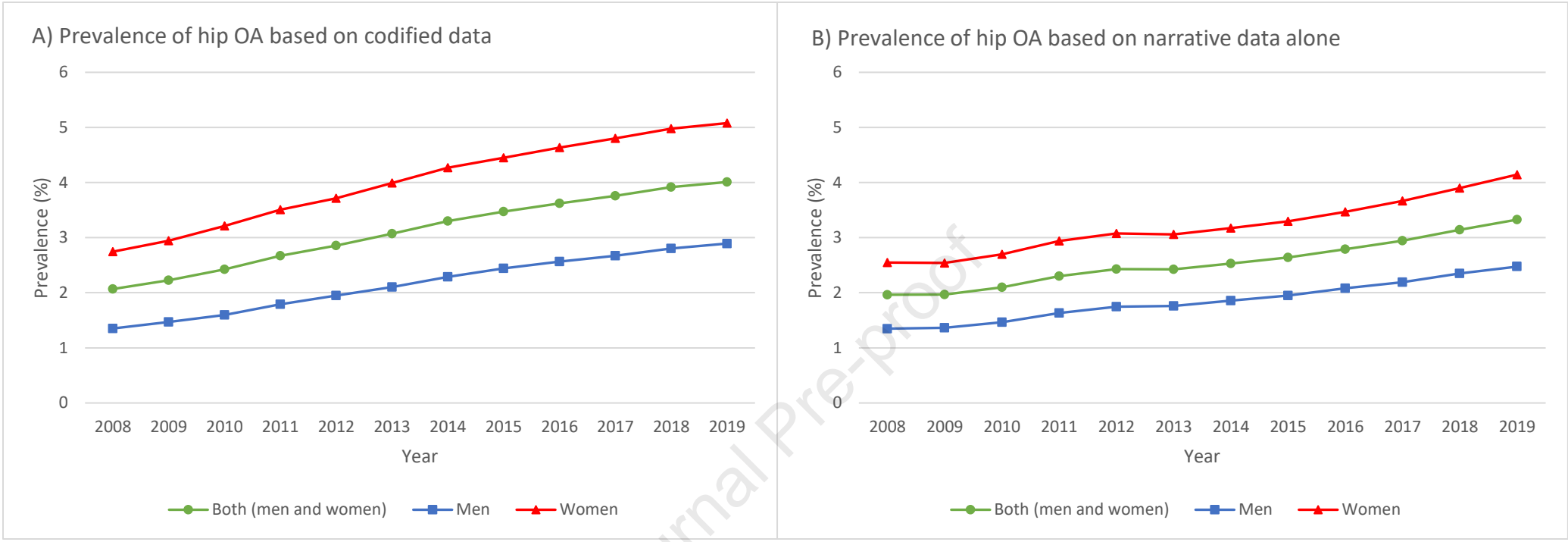
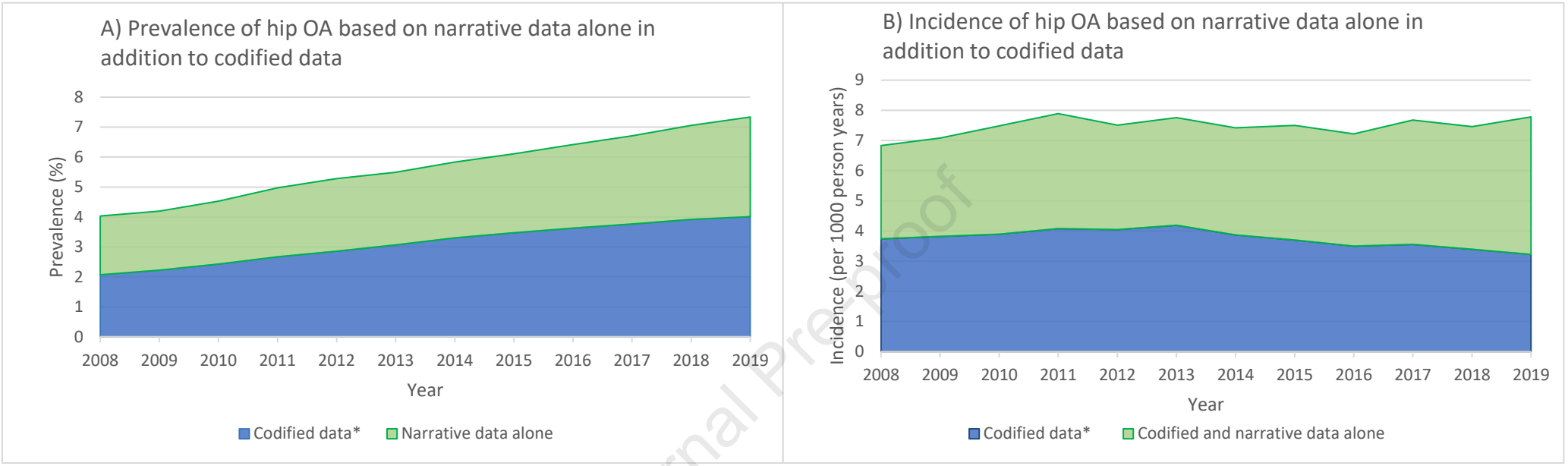


Figure 3. Standardized prevalence of hip OA based on codified data (A) and narrative data alone (B)



* Among patients identified with codified hip OA, 39.4% were previously diagnosed narratively with hip OA, which was approximately 1.9 years prior to the first codified hip OA diagnosis. These patients are not counted in the annual lifetime prevalence proportions of narrative data alone.

Figure 4. Standardized (A) prevalence and (B) incidence of hip OA based narrative data alone in addition to codified data

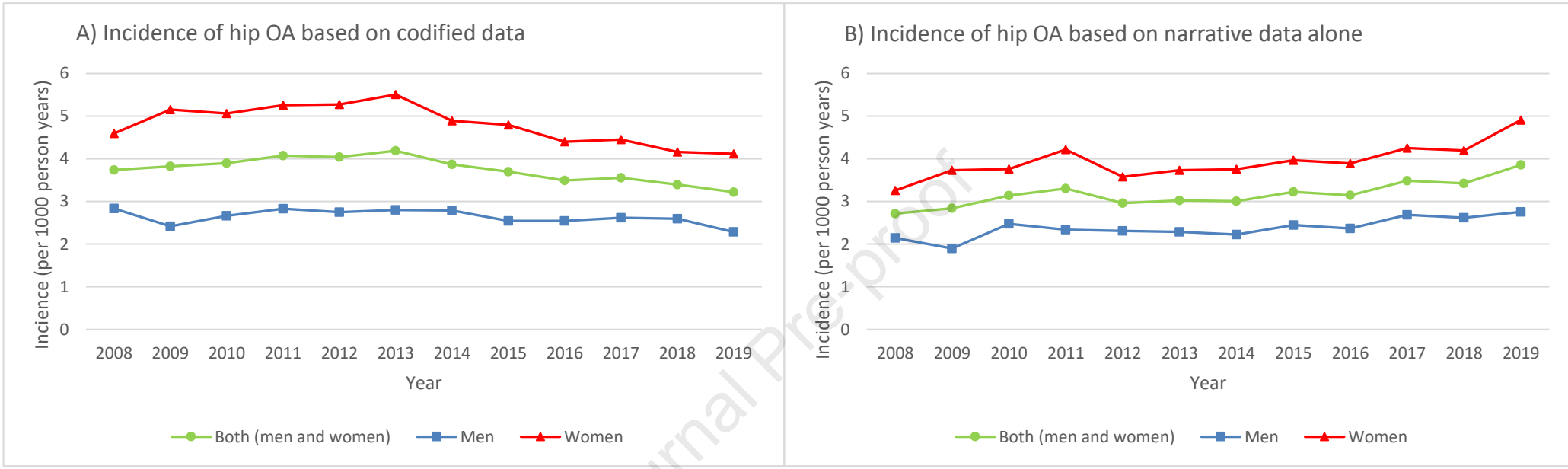


Figure 5. Standardized incidence of hip OA based on codified data (A) and narrative data alone (B)

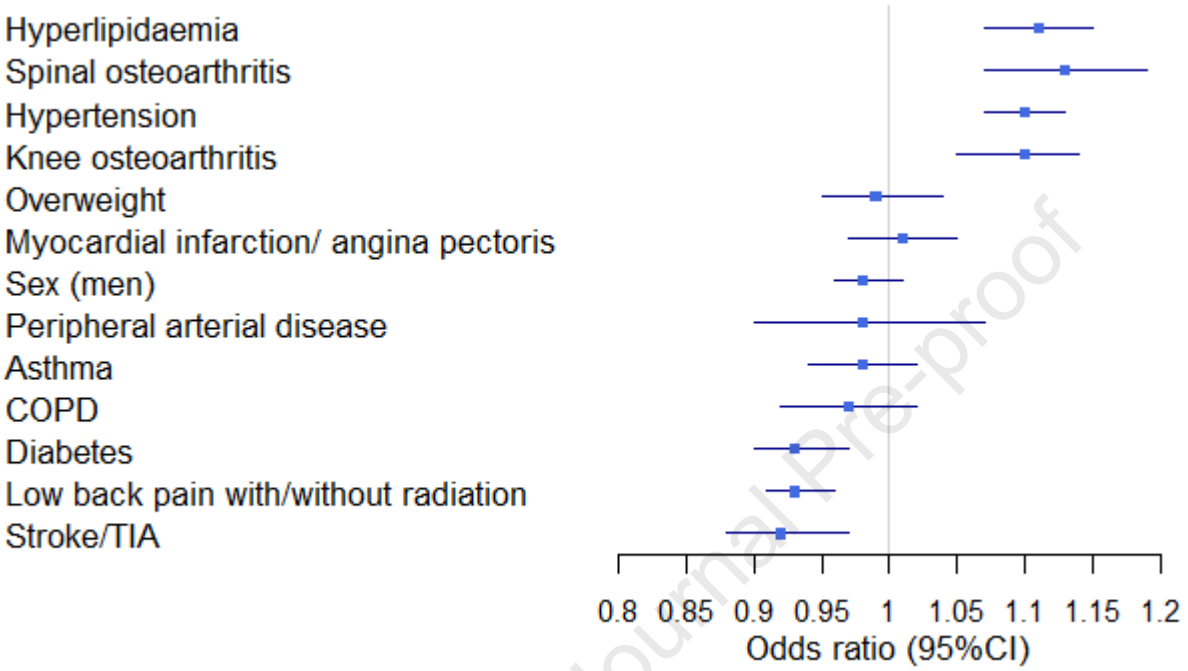


Figure 6. Characteristics associated with codified hip OA diagnosis among all hip OA patients (either codified diagnosed or narratively diagnosed without a hip OA code)

Note. Full details are provided in Supplementary Table S6.