# KNEE AND HIP OSTEOARTHRITIS IN GENERAL PRACTICE

## Incidence, prevalence and efforts to optimize care

Ilgin G. Arslan

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**Ilgin G. Arslan**

Department of General Practice
Erasmus MC University Medical Center Rotterdam

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# Knee and Hip Osteoarthritis in General Practice

Incidence, prevalence and efforts to optimize care

## Knie- en heupartrose in de huisartspraktijk

Incidentie, prevalentie en inzet om de zorg te optimaliseren

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# CHAPTER 1

## General introduction

Osteoarthritis (OA) is the most common chronic musculoskeletal disease. It involves the entire joint, including articular cartilage, subchondral bone, ligaments, capsule, synovium and periarticular muscles.[1-3] Typical symptoms of OA are pain, morning stiffness and limited function of the joint. Periodically, the synovial membrane may be activated, leading to joint inflammation and an increase in symptoms.[4] Factors associated with an increased risk of OA include advanced age, female sex, overweight, previous traumatic injury, malalignment of the joint, genetics and heavy work activities.[2] In the Netherlands, OA is primarily managed in general practice [5, 6], where the diagnosis is predominantly based on symptoms and physical examination.[7-10] The physical examination signs include crepitus, restricted range of motion, joint line tenderness and observation of bony enlargement. The use of radiographs for the diagnosis of OA is not recommended, given the poor correlation between the severity of structural damage of the joint and the severity of symptoms.[11, 12]

## EPIDEMIOLOGY

OA is most common in the knee, followed by the hand and hip.[2] This thesis focuses on knee and hip OA. There is wide heterogeneity in the reported prevalence of knee and hip OA, related to the differences in the definition used for OA, the sex ratio and age distribution of the study population, and the country of origin.[2] Prevalence estimates based on radiographic OA are higher than those based on symptomatic OA.[2] In Europe, the prevalence of symptomatic knee OA among the older population (≥60 years) is 15% for women and 9% for men, while for hip OA the prevalence of symptomatic OA is 8% for women and 7% for men.[2] The prevalence of OA, as measured by Dutch primary care registry data, is predicted to increase by 36% between 2018 and 2040.[13] OA has been ranked as the 10$^{th}$ leading contributor to global disability and was — in addition to diabetes — responsible for the largest increase in disability burden worldwide between 2007 and 2017.[1, 14] The number of healthy life years lost due to disability attributable to OA of the knee increased by 30.8%; for hip OA the increase was 35.3%.[1, 14] Current data shows that in high-income countries (i.e. US, Canada, UK, France and Australia) 1% to 2.5% of gross domestic product is attributable to medical costs for knee and hip OA.[15] In the Netherlands, 18.3% of the total healthcare costs for musculoskeletal disorders in 2017 was attributable to OA — largely due to knee and hip replacements.[16] As a consequence of the increasing prevalence of OA, demand for healthcare relating to OA is expected to increase dramatically in the future, putting pressure on the healthcare system.

## REUSE OF ROUTINE HEALTHCARE DATA FOR RESEARCH

Healthcare data routinely recorded in electronic health records (EHRs) as part of the healthcare process are often reused to estimate the prevalence and incidence of knee and hip OA. However, so far, these studies have all focused on codified data from EHRs and neglected narrative data. Codified data — also called 'structured data' — refers to information based on specific codes for specific diseases and tests, while narrative data — also called 'unstructured data' — includes narrative free-text notes by healthcare providers that are documented during consultations and in clinical letters. Codified and narrative data often complement each other in such a way that a richer view can be obtained when using both in research. The limitations of using codified data alone for knee and hip OA research have been demonstrated in a previous study[12] using UK primary care EHR data. This study found that a quarter of patients with total knee or hip arthroplasty had no record of joint pain or OA in codified data in the past ten years.[12] A previous study with EHRs in the UK found that less severely affected patients are less likely to have a record of OA as identified with codified data, and are therefore less likely to be included when focusing on codified data only.[17] Thus, current evidence regarding the under-recording of knee and hip OA indicates that there are substantial shortcomings in the validity of information on the incidence and prevalence of knee and hip OA that is based on EHRs. This may hamper adequate planning and prioritization of healthcare resources, while this is extremely important considering the continuing increase in the prevalence and burden of knee and hip OA. Utilizing both codified and narrative data from EHRs may increase the validity of findings from knee and hip OA research and facilitate better planning and prioritization of healthcare resources, thereby enabling a sustainable healthcare system.

*Therefore, this thesis investigates the opportunities for using codified and narrative data from EHR data to estimate the prevalence and incidence of knee and hip OA and to describe patterns of management in general practice.*

In this thesis, we develop algorithms to identify knee and hip OA patients using codified and narrative data in EHRs from a primary care database in the Netherlands: the Integrated Primary Care Information (IPCI) database[18, 19]. This database contains data on almost 2.5 million patients that are recorded routinely as part of the healthcare process in primary care. Based on these algorithms, we aim to obtain a more accurate picture of the incidence and prevalence of knee and hip OA and patterns of management in general practice.

## MANAGEMENT OF KNEE AND HIP OSTEOARTHRITIS

Current national and international guidelines are consistent in their recommendations for managing knee and hip OA by a combination of non-pharmacological and pharmacological treatments.[8, 9, 12, 20, 21] Non-pharmacological treatments include education and self-management, exercise therapy, weight loss if overweight or obese, and walking aids when indicated. Pharmacological treatment includes oral or topical analgesics for pain reduction. In patients who have not responded to oral or topical analgesics, intra-articular corticosteroids are recommended as a possible next step. Surgical treatment is indicated for those who have not responded appropriately to non-surgical approaches. In the Netherlands, management of knee and hip OA is mainly provided in general practice, since general practitioners (GPs) are the first point of contact for patients in the Netherlands.[5, 6] GPs can offer knee and hip OA patients information and advice, non-pharmacological treatment such as a referral to other healthcare providers in primary care (e.g. physiotherapists), pharmacological treatment for pain reduction, and a referral to an orthopaedic surgeon in secondary care for surgical treatment. Patients in the Netherlands have also been able to access physiotherapy care without a GP referral since 2006 [22], but can only access secondary care services (i.e. hospital care) through a referral from their GP, as in the Netherlands GPs act as a gatekeeper to secondary care.[5, 6] Figure 1 visualizes the pathway of the management of knee and hip OA in Dutch general practice.

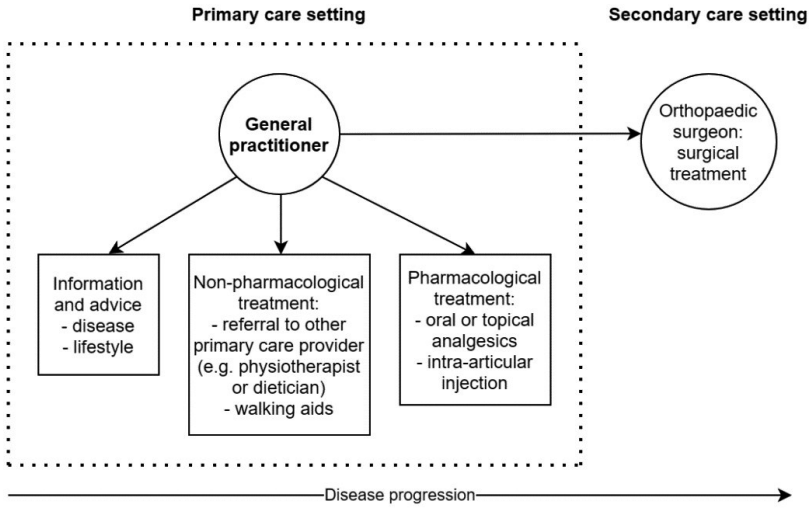


**FIGURE 1.** Pathway of the management of knee and hip OA in Dutch general practice

## ADHERENCE TO GUIDELINES IN CLINICAL PRACTICE

Although guidelines are consistent about the diagnosis and treatment of knee and hip OA, studies of clinical practice show low consistency with these recommendations in several countries and healthcare settings.[8-10, 20, 21, 23-28] Patients are often undertreated in primary care and often referred too early to an orthopaedic surgeon in secondary care, before optimum use has been made of non-surgical core treatments for OA (e.g. self-management education and exercise therapy[29]). This can lead to premature joint replacements, which can result in little or no benefit while exposing the patient to the risks of major surgery.[30-33] Also, X-ray imaging for the diagnosis of knee and hip OA is used frequently, even though it is not recommended by current guidelines.[34] This so-called 'underuse' of non-surgical core treatments and so-called 'overuse' of non-recommended care leads to a low quality of care, redundant healthcare consumption, high healthcare costs, poor healthcare outcomes, and low patient and healthcare provider satisfaction.[30, 31] This will become a major problem for the demand for healthcare in the context of the predicted increase in the burden of OA in the future. Initiatives to tackle this problem are urgently needed to keep healthcare affordable. The current thesis describes and evaluates initiatives to tackle the overuse and underuse of medical resources to optimize knee and hip OA care, with an emphasis on Dutch general practice.

**Monitoring and providing feedback on the quality of care**

One way to optimize care is by using quality indicators for routinely monitoring and providing feedback on the quality of care for quality improvement.[35] Quality indicators are evidence-based measurable elements to assess the quality of care.[36-38] The use of quality indicators has been given more priority in recent years in the context of knee and hip OA care.[39] To date, numerous quality indicator sets have been provided for knee and hip OA care. However, the content of knee and hip OA care may differ between countries and healthcare settings, for example general practices or hospital care. When measuring the quality of care, it is extremely important to select the right quality indicators so that feedback for quality improvement can be given in a valid way.

*Therefore, this thesis provides an overview of quality indicators for knee and hip OA from various countries and settings to facilitate optimal care.*

**Substitution of care in general practice for secondary care**

In 2012, the Dutch Ministry of Health, Welfare and Sport formulated recommendations to reduce national healthcare costs by focusing on healthcare in 'the right place'. As a consequence, the

Ministry of Health, Welfare and Sport and the National General Practitioners Association (i.e. "*Landelijke Huisartsen Vereniging*") introduced the shift of certain forms of care from secondary care to primary care in the Dutch healthcare system.[40] 'Intermediate care' is one of the substitution models implemented in the Netherlands, often in the form of one-off consultations by medical specialists in the general practice.[41, 42] The idea is that this may prevent unnecessary GP referrals to secondary care (i.e. overuse of care) and encourage the optimal use of core treatments in primary care for example for knee and hip OA (i.e. tackle underuse of care). Furthermore, intermediate care may strengthen the relationship between medical specialists and GPs and foster professional consensus and knowledge exchange. In addition, waiting lists for specialist care in hospitals may be avoided, which could lead to improved access to healthcare services. Although intermediate care for knee and hip OA is now widely used in the Netherlands, research into the effect of these intermediate care projects is lacking.

*This thesis evaluates intermediate care for knee and hip OA in Dutch general practice to provide more information on optimal care.*

**Patient preferences for knee and hip osteoarthritis care**

Another way to facilitate optimal knee and hip OA care is to tailor healthcare to patients' preferences to provide patient-centred care.[35] It is important to consider patients' preferences since this can improve uptake, adherence and effectiveness.[2, 43] After all, patients are the most important stakeholders in the healthcare process. However, current guidelines for knee and hip OA hardly include patient preferences at all. As with the content of specific treatments, the range of healthcare settings for knee and hip OA has increased, for example with the introduction of the intermediate care setting in 2012. These healthcare settings differ in their material and human resources— also called the 'structural aspects'— such as waiting times and the duration of consultations. Understanding patient preferences for structural aspects of knee and hip OA care is needed to inform policymakers and healthcare providers about the optimal healthcare setting from the perspective of patient preferences.

*Therefore, this thesis determines the preferences of different stakeholders for knee and hip OA to provide recommendations for the optimal healthcare setting.*

## AIM AND OUTLINE OF THIS THESIS

In summary, knee and hip OA research using routinely recorded electronic healthcare data as part of the healthcare process is often limited to codified data, which may lead to an invalid and incomplete patient selection. The primary objective of this thesis is to investigate the opportunities for utilizing codified and narrative data from EHRs for knee and hip OA research. In addition, overuse of non-recommended care (e.g. inappropriately early referrals from primary to secondary care and X-ray imaging for the diagnosis of OA) and underuse of non-surgical core treatments for knee and hip OA are common, posing a major problem for the sustainability of the healthcare system. The secondary objective of this thesis is therefore to provide information on initiatives to optimize knee and hip OA care, with a focus on Dutch general practice.

In **Chapter 2**, we develop an algorithm to select patients with knee OA based on codified and narrative data from EHRs and to provide a more accurate picture of the incidence and prevalence than the standard approach of using codified data alone. In **Chapter 3**, we use similar research methods to the methods in Chapter 2, but with a focus on selecting patients with hip OA with codified and narrative data from EHRs. In **Chapter 4**, we use EHR data to describe patterns of knee OA management in Dutch general practices based on the algorithm for patient selection developed in Chapter 2. **Chapter 5** provides an overview of quality indicators for knee and hip OA care in various healthcare settings. This information can help healthcare providers and policymakers monitor the quality of care in a valid way. In **Chapter 6**, we evaluate intermediate care for knee and hip OA, which incorporates specialist services into general practices in the Netherlands to prevent unnecessary referrals to hospitals. In **Chapter 7**, we determine patient preferences for the structural aspects of knee and hip OA care, and identify similarities and differences with respect to the preferences of healthcare providers and health insurance company employees. Finally, **Chapter 8** summarizes and discusses the key findings from previous chapters and provides recommendations for practice and future research.

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# CHAPTER 2

## Incidence and prevalence of knee osteoarthritis using codified and narrative data from electronic health records: a population-based study

Ilgin G. Arslan, Jurgen Damen, Marcel de Wilde, Jacoline J. van den Driest, Patrick J.E. Bindels, Johan van der Lei, Dieuwke Schiphof, Sita M.A. Bierma-Zeinstra

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## ABSTRACT

**Objective:** This study aimed to determine the incidence and prevalence of knee osteoarthritis (OA) using codified and narrative data from general practices throughout the Netherlands.

**Methods:** A retrospective cohort study was conducted using the Integrated Primary Care Information database. Patients with codified knee OA were selected and an algorithm was developed to identify patients with narratively diagnosed knee OA only. Point prevalence proportions and incidence rates among people aged ≥30 were assessed from 2008 to 2019. The association of comorbidities with codified knee OA was analysed using multivariable logistic regression.

**Results:** The positive predicted value of narratively diagnosed knee OA only was 94.0% (95%CI 87.4%-100%) and for codified knee OA 96.0% (95%CI 90.6%-100%). Including narrative data in addition to codified data resulted in a prevalence of 1.83 to 2.01 times higher (over the study years); prevalence increased from 5.8% to 11.8% between 2008 and 2019. The incidence rate was on 1.93 to 2.28 times higher and increased from 9.98 per 1000 person-years to 13.8 per 1000 person-years between 2008 and 2019. Among patients with codified knee OA, 39.4% were previously diagnosed narratively with knee OA, on average approximately three years earlier. Comorbidities influenced the likelihood of being recorded with codified knee OA.

**Conclusion:** Our study of a Dutch primary care database showed that current incidence and prevalence estimates based on codified data alone from electronic health records are underestimated. Narrative data can be incorporated in addition to codified data to identify knee OA patients more accurately.

# INTRODUCTION

Osteoarthritis (OA) has been ranked as the 10th leading contributor to global disability, with the knee as the most commonly affected joint.[1-3] Between 2007 and 2017, the years lived with disability attributed to knee OA increased by 30.8%, which was a large increase for non-communicable diseases.[4] The prevalence is expected to increase significantly in the coming years due to the increasing age and obesity population.

Population-based incidence and prevalence estimates and predictions concerning the disease burden of knee OA are mostly based on electronic health records (EHR). EHRs consist of codified data (i.e. specific codes for specific diseases) and narrative data (i.e. free-text notes by general practitioners (GPs) and correspondence between GPs and other healthcare providers). Current epidemiological research on knee OA is largely limited to codified data.[5-9] However, diagnoses may not be codified by the GP or updated after disease progression or a change in the final diagnosis. Earlier research[10-12] suggested that patients in general practice may present multiple health problems and GPs may not be inclined to code for OA in circumstances where other health problems appear more urgent during the consultation, leading to under-recording of knee OA. In addition, diagnoses may include misclassification of codes due to various reasons, such as lack of time.[13, 14] These misclassifications and under-recording of codes may have impact on the accuracy of epidemiological estimates of knee OA. Earlier research showed significant under-recording of OA in UK primary care EHRs. A quarter of the patients who underwent a total knee or hip replacement did not have codified joint pain or a codified OA diagnosis in the previous 10 years.[12]

Including narrative data in addition to codified data can help to provide more reliable estimations of the burden of knee OA. Reliable estimates are needed for health policy makers in order to respond to the increase in the demand for healthcare relating to knee OA, but also to enable researchers and healthcare providers to identify patients with knee OA more accurately.

Therefore, the aim of this study was determine the incidence and prevalence of knee OA using the complete EHR consisting of both codified and narrative data from a large primary-care database from the Netherlands in the period 2008-2019. By combining narrative and codified data, this study aims to detect patients with knee OA more accurately than the standard approach of using codified data alone.

# METHODS

**Design and setting**

A retrospective cohort study was conducted using the Integrated Primary Care Information (IPCI) database. A detailed description of the IPCI database has been given elsewhere.[15, 16] In summary, the IPCI database is a dynamic database and contains primary care EHRs for approximately 2.5 million patients in the Netherlands. The EHRs contain detailed clinical information on the medical journal documented using free-text notes by the GP, diagnoses according to the International Classification of Primary Care (ICPC) codes, laboratory findings, drug prescriptions, and referrals and correspondence with other healthcare providers in primary and secondary care. In the Netherlands, all citizens are obliged to register with a GP. GPs are the first point of contact and act as a gatekeeper to secondary care.[17, 18] We therefore assume that EHRs from the IPCI database contain all relevant medical information, including medical findings and diagnoses from secondary care.

**Study cohort**

Patients were included during each study year from 1 January 2008 until 31 December 2019 if they were aged ≥30. To increase the reliability of the data, the first year a patient is part of the IPCI database was not included as new medical information (i.e. this information was included as part of medical history). Patients with a codified diagnosis of knee OA were selected. The codified diagnosis of knee OA was based on the ICPC code L90. In addition, an algorithm was developed by the research group, which included GPs, to identify patients with keywords referring to knee OA in narrative data (i.e. the free text in their EHR) without any record of codified knee OA based on the ICPC code L90. The algorithm included patients with an ICPC code L15 (i.e. knee complaints) plus keywords related to OA or keywords related to knee plus OA without ICPC code L15, for example 'knee' plus 'osteoarthritis', 'gonarthrosis', and 'knee' plus 'prosthesis'. 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. Full details of the algorithm are provided in Supplementary File 1.

**Validity of the algorithm**

Two authors, IGA (physiotherapist and researcher) and JD (academic GP), independently assessed the positive predictive value (PPV) of the algorithm by reading the full EHRs of a random selection of 50 narratively diagnosed knee OA patients without any record of codified knee OA. Patients were defined as true-positive when there was supporting evidence that the GP, healthcare provider in primary care (e.g. physiotherapist) or healthcare provider in secondary care (e.g. orthopaedist or radiologist) reported a knee OA diagnosis in the free text of the EHR; this is a commonly used reference standard to identify the PPV in EHRs.[10] Inconsistencies were resolved by consensus and if necessary, through discussion with a co-author (DS, senior researcher with wide experience with the IPCI database). To compare the validity of the algorithm with that of codified knee OA, one author (IGA) assessed the PPV of a random selection of 50 patients identified with codified knee OA (i.e. ICPC code L90) by reading the full EHRs, with scrutiny by the co-authors (JD or DS) if necessary. Similar to the PPV assessment for narratively diagnosed knee OA, patients with codified knee OA were defined as true-positive when there was supporting evidence that the GP, healthcare provider in primary care or in secondary care reported a knee OA diagnosis in the free text of the EHR. PPVs were calculated as the proportion of patients who were confirmed as having knee OA, based on the information reported in the EHR.

**Outcomes**

Point prevalence proportions and incidence rates were presented for two independent groups: 1) patients with codified diagnosis of knee OA, and 2) patients with narratively diagnosed knee OA without any record of codified knee OA in their EHR according to the algorithm. The point prevalence proportion was calculated for each year between 2008-2019 as the total number of people ever diagnosed with knee OA as at 1 July each calendar year, divided by the total number of patients in the population as at 1 July of that calendar year, and multiplied by 100. The entire retrospective record available for patients was used to estimate the prevalence proportion. The annual incidence rate was calculated for each year between 2008-2019 by the number of new cases between 1 January and 31 December in each calendar year, divided by the number of person years at risk between 1 January and 31 December each calendar year. The at risk period is the period that a patient was participating in the IPCI database (i.e. from the moment of enrolment in the IPCI database) and not recorded with a knee OA diagnosis until the time of a knee OA diagnosis, death, changing practice, or end of participation in IPCI database. When estimating the incidence rates, the entire retrospective record available for patients was used to exclude prevalent knee OA. Thus, patients with a diagnosis in their medical history (i.e. before enrolment in the IPCI database) were defined as prevalent knee OA. Patients with a diagnosis

before 1 January 2008 were also defined as prevalent knee OA. See Supplementary File 3 for more information. A codified knee OA diagnosis was defined as at least one diagnostic code for knee OA (ICPC code L90). A narrative knee OA diagnosis was defined as at least one narrative diagnosis according to our algorithm. Incidence and prevalence estimates were calculated stratified by sex. Detailed information regarding the study design is illustrated in Figure 1.

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

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

Differences in descriptive characteristics between patients with a codified knee OA diagnosis and patients with narratively diagnosed knee OA were determined. Furthermore, as described earlier, comorbidities in patients with OA may be a reason why codified knee OA is under-recorded. Among patients with prevalent knee OA (either codified or narratively diagnosed) during the observation period (i.e. 1 January 2008 to 31 December 2019), we analysed the association of concurrent comorbidities (i.e. occurring before the first knee OA diagnosis) with codified knee OA diagnosis. Frequently occurring comorbidities in patients with OA were selected based on an earlier systematic review[19]: 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 knee (i.e. spinal OA and hip OA) (see Supplementary File 2 for the full list of ICPC codes). Analysis of the association of concurrent comorbidities with codified knee OA was adjusted for age and sex.

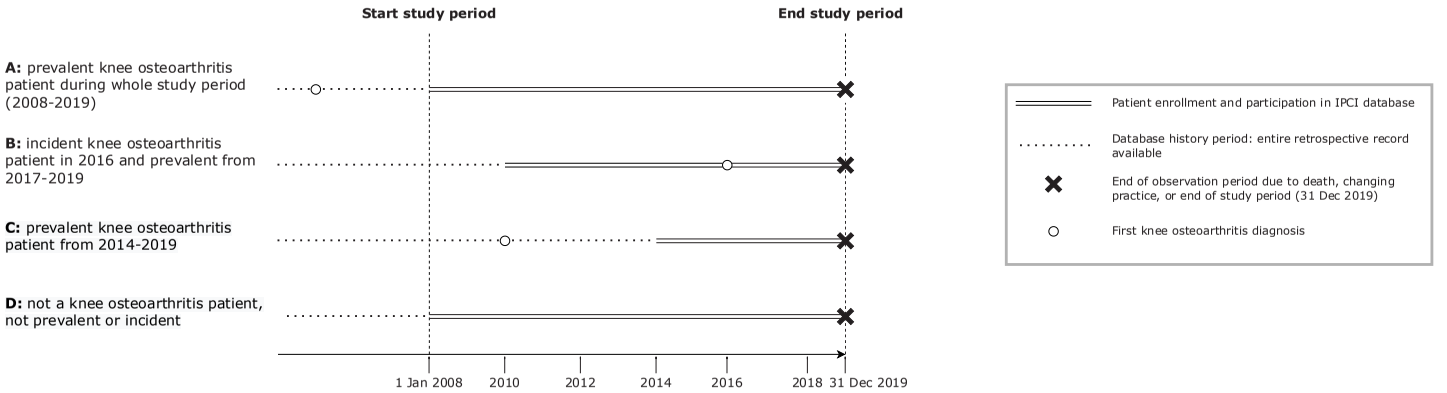


**FIGURE 1.** Details of the study design

**Notes.** Figure 1 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 the study period (1 January 2008) and stop before the end of study period (31 December 2019) due to death or changing practice. Patients were followed from the start of study period (patient A and D) or from the moment they entered the IPCI database if this moment was after 1 January 2008 (patient B and 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. The entire retrospective record available for patients was used to exclude prior knee OA when estimating the incidence rates (patient A and C). A first knee OA diagnosis was defined as incident when the first diagnosis was given within the study period and participation in IPCI database (patient B). The entire retrospective record available for patients was used to estimate the prevalence proportions. Patients with a knee OA diagnosis in before 1 January 2008 were defined as prevalence knee OA (Patient A), as were patients with a first knee OA before participation in IPCI database (Patient C).

**Statistical analyses**

Binomial 95% confidence intervals (CIs) were calculated for the PPV of the algorithm. Prevalence and incidence estimates were standardized for the changing annual age and sex structure of the Dutch population as given by the StatLine database of Statistics Netherlands from 2008 up to 2019[20]. 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 in patients with knee OA, adjusted for age and sex; the results were expressed as odds ratios (ORs) including 95% CIs. Prior to the multivariable regression analysis, a variance inflation factor (VIF) was leveraged to detect the co-linearity of comorbidities in the multivariable logistic regression analysis. A VIF > 5 was considered indicative of multi-collinearity. Nonlinearity between age and the logit of the outcome was observed using the Box-Tidwell test and restricted cubic spline plot. A model with linear splines with 4 knots at the 5$^{th}$, 35$^{th}$, 65$^{th}$ and 95$^{th}$ percentiles based on the recommendations of Harrell[21] showed the best model fit based on the Akaike information criterion, and was used as the final multivariable logistic regression model. 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 of the algorithm**

The PPV of the algorithm based on narrative data without a record of codified knee OA was estimated to be 94.0% (95%CI 87.4%-100%). Reasons for the three false positives were physician typing errors (n=1), patient's anxiety about a possible diagnosis of OA (n=1), and expression of uncertainty about the OA diagnosis (n=1), which could not be excluded by the algorithm (see Supplementary File 1 for more details). The PPV of codified knee OA (i.e. ICPC code L90) was estimated to be 96.0% (95%CI 90.6%-100%). Reasons for the two false positives were expressions of uncertainty about the OA diagnosis.

**Trends in prevalence and incidence estimates**

Of the 180,986 knee OA patients included in the cohort, 94,969 were diagnosed with codified knee OA and 86,017 with narratively diagnosed knee OA only without any record of codified knee OA.

*Prevalence proportions*

The standardized prevalence of codified knee OA increased from 2.88% (95%CI 2.87-2.89) in 2008 to 6.15% (95%CI 6.14-6.17) in 2019 (Figure 2A). The standardized prevalence of narratively diagnosed knee OA only without any record of codified knee OA increased from 2.92% (95%CI 2.91-2.93) in 2008 to 5.60% (95%CI 5.58-5.61) in 2019 (Figure 2B). The annual crude and standardized prevalence are presented in Supplementary File 4.

*Incidence rates*

The standardized incidence rate of codified knee OA increased from 4.88 per 1000 person-years (95%CI 4.84-4.93) in 2008 to 6.04 per 1000 person-years (95%CI 6.00-6.09) in 2019 and peaked around the year 2013 with 6.60 per 1000 person-years (95%CI 6.55-6.65) (Figure 2C). The standardized incidence of narratively diagnosed knee OA only without any record of codified knee OA increased consistently over the years from 4.42 per 1000 person-years (95%CI 4.38-4.46) in 2008 to 6.21 per 1000 person-years (95%CI 6.16-6.26) in 2019 (Figure 2D). The annual crude and standardized incidence rates are presented in Supplementary File 4. Both the prevalence and incidence rates were higher for women than for men at any given time point (Supplementary File 5).

*Effect of adding narrative data to codified data*

Adding narrative data to codified data resulted into a prevalence that was 1.83 to 2.01 higher over the study period (Table 1). The standardized prevalence was 5.80% (95%CI 5.79-5.82) in 2008, and it increased to 11.75 (95%CI 11.73-11.77) in 2019 (Figure 3). The standardized incidence was 1.93 to 2.28 higher over the study period when adding narrative data to codified data (Table 1) and increased from 9.98 per 1000 person-years (95%CI 9.92-10.04) in 2008 to 13.78 per 1000 person-years (95%CI 13.71-13.84) in 2019 (Figure 4). Both the prevalence and incidence rates were higher for women than for men at any given time point (Supplementary File 6).

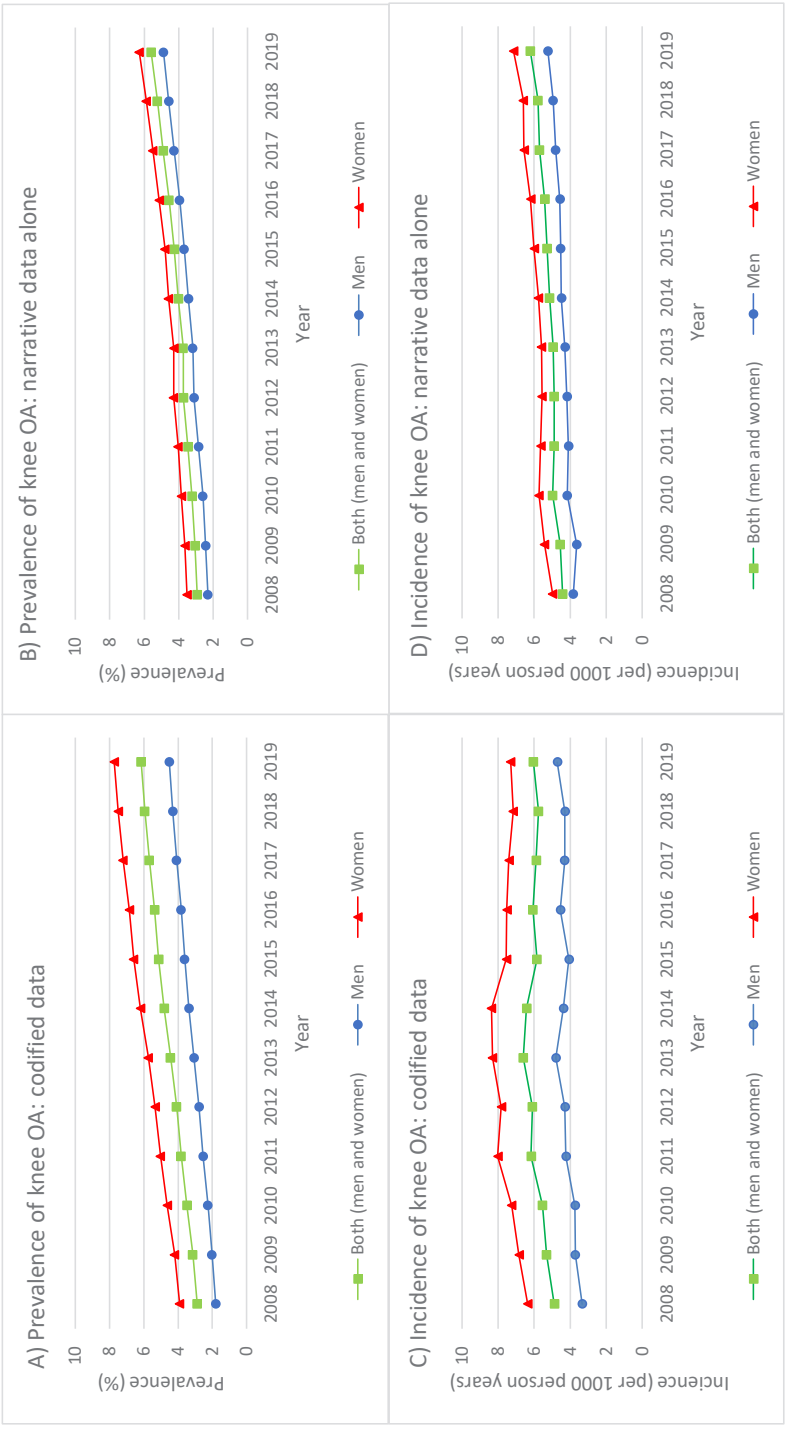


**FIGURE 2.** Prevalence of knee OA based on codified data (A) and narrative data alone (B) and incidence of knee OA based on codified data (C) and narrative data alone (D)

**TABLE 1.** Prevalence and incidence of knee OA based on codified data versus a combination of codified and narrative data

| Standardized point prevalence [95% CI] | | | | Standardized incidence [95% CI] | | | |
|---|---|---|---|---|---|---|---|
| Year | Codified data | Codified + narrative data | Rate ratio | Year | Codified data | Codified + narrative data | Rate ratio |
| 2008 | 2.88 [2.87-2.89] | 5.80 [5.79-5.82] | 2.01 | 2008 | 4.88 [4.84 - 4.93] | 9.98 [9.92 - 10.04] | 2.04 |
| 2009 | 3.14 [3.13-3.15] | 6.18 [6.17-6.20] | 1.97 | 2009 | 5.32 [5.27 - 5.36] | 10.61 [10.55 - 10.67] | 1.99 |
| 2010 | 3.47 [3.46-3.48] | 6.70 [6.68-6.71] | 1.93 | 2010 | 5.53 [5.49 - 5.58] | 11.31 [11.24 - 11.37] | 2.04 |
| 2011 | 3.81 [3.80-3.82] | 7.26 [7.25-7.28] | 1.90 | 2011 | 6.17 [6.13 - 6.22] | 11.95 [11.88 - 12.01] | 1.93 |
| 2012 | 4.09 [4.07-4.10] | 7.80 [7.79-7.82] | 1.91 | 2012 | 6.10 [6.05 - 6.14] | 11.92 [11.86 - 11.99] | 1.96 |
| 2013 | 4.43 [4.42-4.45] | 8.17 [8.15-8.19] | 1.84 | 2013 | 6.60 [6.55 - 6.65] | 12.57 [12.50 - 12.64] | 1.90 |
| 2014 | 4.81 [4.80-4.83] | 8.83 [8.81-8.85] | 1.83 | 2014 | 6.42 [6.37 - 6.47] | 12.63 [12.57 - 12.70] | 1.97 |
| 2015 | 5.14 [5.12-5.15] | 9.38 [9.36-9.40] | 1.83 | 2015 | 5.84 [5.80 - 5.89] | 12.24 [12.17 - 12.30] | 2.09 |
| 2016 | 5.37 [5.36-5.38] | 9.92 [9.90-9.94] | 1.85 | 2016 | 6.07 [6.02 - 6.11] | 12.67 [12.60 - 12.74] | 2.09 |
| 2017 | 5.68 [5.66-5.69] | 10.58 [10.56-10.59] | 1.86 | 2017 | 5.89 [5.84 - 5.93] | 12.89 [12.82 - 12.96] | 2.19 |
| 2018 | 5.94 [5.92-5.95] | 11.17 [11.15-11.19] | 1.88 | 2018 | 5.76 [5.72 - 5.80] | 12.93 [12.86 - 12.99] | 2.24 |
| 2019 | 6.15 [6.14-6.17] | 11.75 [11.73-11.77] | 1.91 | 2019 | 6.04 [6.00 - 6.09] | 13.78 [13.71 - 13.84] | 2.28 |

**Notes.** Standardized point prevalence proportions and incidence rates are standardized for age and sex distribution of the total population from the Netherlands.

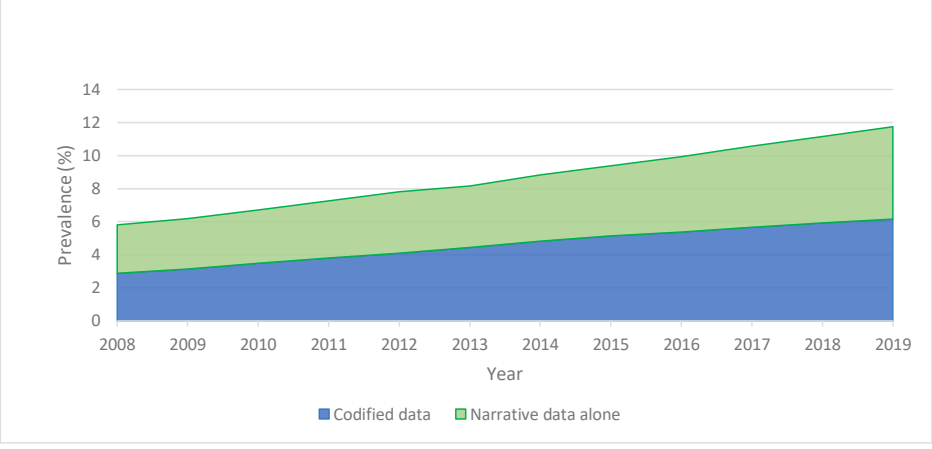


**FIGURE 3.** Prevalence of knee OA based narrative data alone in addition to codified data

**Notes.** Among patients identified with codified knee OA, 39.4% were diagnosed narratively with knee OA at an earlier stage, which was approximately 3 years prior to the first codified knee OA diagnosis. These patients are not counted in the prevalence proportions of narrative data alone.

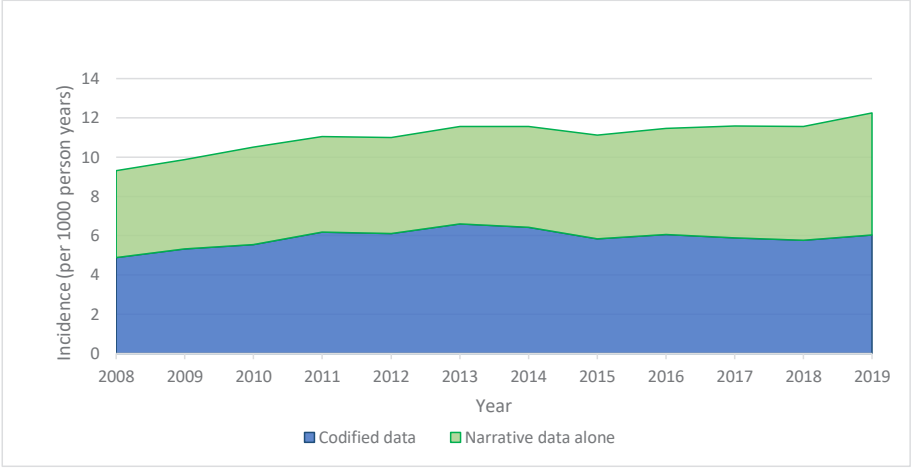


**FIGURE 4.** Incidence of knee OA based narrative data alone in addition to codified data

**Notes.** Among patients identified with codified knee OA, 39.4% were diagnosed narratively with knee OA at an earlier stage, which was approximately 3 years prior to the first codified knee OA diagnosis. These patients are not counted in the annual incidence rates of narrative data alone.

***Narrative diagnosis prior to codified diagnosis***

Among patients identified with codified knee OA (*n* = 94969), 39.4% (*n* = 37375) were diagnosed narratively with knee OA at an earlier stage, which was approximately three years on average prior to the first codified knee OA diagnosis (median number of days = 1111; IQR = 143 to 2836).

**Characteristics associated with codified knee OA diagnosis**

The VIF of all independent variables was < 1.20, indicating that there is no collinearity between variables. Multivariable analysis adjusted for age and sex showed that the presence of hypertension, hyperlipidaemia, diabetes mellitus —especially the presence of overweight (OR 1.37 [95%CI 1.32-1.42])— prior to knee OA diagnosis was associated with a greater likelihood of being recorded with a codified knee OA diagnosis (Table 2). Furthermore, knee OA patients with hip OA or spinal OA prior to knee OA diagnosis had a greater likelihood of being recorded with a codified knee OA diagnosis (OR 1.15 [95%CI 1.10- 1.19] and OR 1.28 [95%CI 1.23-1.35] respectively).

**TABLE 2.** Characteristics associated with codified knee OA diagnosis

| | **Codified knee OA (n=94969)** | **Narratively diagnosed knee OA alone (n=86017)** | **Multivariable analysis OR (95%CI)* *Codified diagnosis vs narrative diagnosis*** |
|---|---|---|---|
| Age at knee OA hit, mean (SD) | 66.8 (11.9) | 61.3 (13.1) | - |
| Men, n (%) | 32971 (34.7) | 35217 (40.9) | - |
| Hypertension, n (%) | 33550 (35.3) | 21945 (25.5) | 1.18 [1.15 – 1.21] |
| Hyperlipidaemia, n (%) | 10481 (11.0) | 7300 (8.49) | 1.04 [1.01 – 1.08] |
| Overweight, n (%) | 8470 (8.92) | 5914 (6.88) | 1.37 [1.32 – 1.42] |
| Diabetes mellitus, n (%) | 13182 (13.9) | 8539 (9.93) | 1.12 [1.08 – 1.15] |
| Myocardial infarction/ angina pectoris, n (%) | 9583 (10.1) | 6013 (6.99) | 1.09 [1.05 – 1.13] |
| Stroke/TIA, n (%) | 5372 (5.66) | 3514 (4.09) | 0.98 [0.93 – 1.02] |
| Peripheral arterial disease, n (%) | 1535 (1.62) | 1021 (1.19) | 1.00 [0.92 – 1.09] |
| COPD, n (%) | 5224 (5.50) | 3512 (4.08) | 1.04 [1.00 – 1.09] |
| Asthma, n (%) | 8170 (8.60) | 6832 (7.94) | 1.05 [1.01 – 1.09] |
| Hip osteoarthritis, n (%) | 7312 (7.70) | 4207 (4.89) | 1.15 [1.10 – 1.19] |
| Spinal osteoarthritis, n (%) | 5466 (5.76) | 2976 (3.46) | 1.28 [1.23 – 1.35] |

**Abbreviations:** OR= odds ratio; CI= confidence interval

*Adjusted for age and sex.

## DISCUSSION

This study investigated the incidence and prevalence of knee OA using a combination of narrative and codified data in the Netherlands. The point prevalence rate was 1.83 to 2.01 times higher (over the study years) and the incidence rate on 1.93 to 2.28 times higher when including narrative data in addition to codified data. Around 40% of codified knee OA patients had a previous record of narratively diagnosed knee OA, with the narrative diagnosis being made on average approximately three years earlier. This suggests that a substantial proportion of patients that we identified with narratively diagnosed knee OA alone without any record of codified knee OA might be diagnosed with codified knee OA in their EHR in the future. Comorbidities influenced the likelihood of a codified knee OA diagnosis being recorded.

The Dutch National Institute for Public Health and the Environment (RIVM) has predicted that the number of people with knee OA in the Netherlands will rise by 41% in the period 2015 to 2040.[9] RIVM estimated the prevalence of knee OA based on ICPC code L90 in 2019 at 5.1% for women and 3.0% for men. These numbers were based on Nivel Primary Care Registrations, which is an integrated primary care registration. However, the predicted prevalence is seriously underestimated, since it is based on codified data alone from EHRs. Our study showed a

twofold higher prevalence of knee OA when including narrative data in addition to codified data; in 2019, the prevalence of knee OA based on ICPC code L90 in the current study was estimated at 4.5% for men and 7.7% for women, but including narrative data to codified data showed a prevalence rate of 9.4% for men and 14.0% for women. To make adequate preparations for the large increase in the prevalence of knee OA that has been predicted, a complete picture of the current and future impact of knee OA is needed. Therefore, healthcare policy should be more aware that epidemiological measures of knee OA based on codified data are likely to be underestimated. Incorporating narrative data in addition to codified data can be used to obtain a more adequate picture of the burden of knee OA. We also found that around 40% of codified knee OA patients had a previous record of narratively diagnosed knee OA on average approximately three years earlier. Capturing knee OA patients earlier may help policymakers to plan and prioritize resources more adequately to keep healthcare affordable.

In the present study, we found incidence and prevalence estimates that were higher than the estimates from RIVM (i.e. prevalence in 2019, 4.5% for men and 7.7% for women in the current study versus 5.1% for women and 3.0% for men published by RIVM). We included patients aged 30 and older, while estimates from RIVM were based on all patients regardless of their age. Without restriction on age, our analysis showed similar estimates as those by RIVM (i.e. crude prevalence in 2019, 3.0% for men and 4.4% for women in the current study). Furthermore, our study showed that the incidence of narratively diagnosed knee OA alone without any record of codified knee OA increased consistently year by year, while this was less pronounced in the incidence of codified knee OA. In contrast, Swain et al.[7] found a decline in the incidence of OA using primary care EHR data from the UK. As proven in the current study, the authors acknowledge that their results are open to misclassification bias due to inconsistent recording. To minimize this bias, narrative data in addition to codified data can be used, to show the actual trend in the incidence of OA. However, coding systems of diagnoses built into EHRs differ between countries and therefore may require different applications of narrative data. It should also be noted that the use of narrative fields may differ across countries and systems and data protection may limit access to such data fields. There may be other possible alternatives to identify under-recorded knee OA patients, which may be more suitable in countries and systems other than the Dutch GP system, for example using algorithms that include process, referral and intervention codes.

This current study showed substantial under-recording of codified knee OA; around half of the knee OA patients did not have codified knee OA and were identified based on narrative data alone. Yu et al. 2017[12] also found under-recording of codified OA in UK primary care EHRs. They found that a quarter of severe OA patients aged 40 with total hip and knee replacements did not have codified joint pain or codified OA diagnosis in the previous 10 years. However, these

results do not apply to the entire spectrum of OA severity, as the average lifetime risk for knee replacement is shown to be around 30%[22]. Moreover, previous research[23] showed that patients with less severe OA are less likely to have a codified OA diagnosis. This suggests that severe knee OA patients are over-represented in current epidemiological research that uses codified data alone. To our knowledge, this is the first study that used both narrative and codified data, and it therefore adds to the current body of knowledge on the incidence and prevalence of knee OA across the entire spectrum of severity.

Similarly to a previous study[23], we found that a record of codified knee OA was associated with overweight. In addition, our results showed that patients with a concurrent record of hypertension, hyperlipidaemia, diabetes mellitus, overweight and OA in joints other than the knee were more likely to be diagnosed with codified knee OA. It may be that GPs are more prone to give a codified knee OA diagnosis to patients who fit the risk factor profile of knee OA (metabolic syndrome). In contrast, other studies[10-12] suggested that multimorbidity may cause GPs to give a lower priority to recording codified knee OA. Our results do not support this hypothesis for hypertension, hyperlipidaemia, diabetes mellitus, overweight and OA in joints other than the knee.

A strength of the current study is the use of the IPCI database, which contains a representative sample of the Dutch population.[15, 16] A limitation of this study is that some patients diagnosed with knee OA by physiotherapists without a GP referral were not captured within the IPCI database. Since 2006, patients in the Netherlands can access physiotherapy care without a GP referral.[24] Prevalence and incidence estimates of knee OA might therefore be underestimated in this study. Also, an important aspect to consider when interpreting our results is that changes in the healthcare system of the Netherlands may have influenced the time trend of the incidence of knee OA. Examples that might have influenced the time trend are: GPs' skills for using digital EHRs and changes in permission for data exchange. In addition, to reduce the number of false positives, we excluded keywords for knee OA combined with expressions of uncertainty (e.g. 'probably' or 'differential diagnoses') from the narrative data algorithm. The restrictiveness of this algorithm may also have led to an underestimation of knee OA. Furthermore, we were not able to request additional information from the GPs to confirm the diagnosis of knee OA in EHRs, which is considered to be the most robust validation method[25]. However, this method is subject to selection bias and a low response rate, and it is expensive.[25] Instead, we used a manual review of the EHRs, which is more cost-effective and a generally accepted method[25]. Finally, our findings are limited to primary care EHR data from the Netherlands and replication of the development of such narrative data algorithms is needed when using EHR data from countries other than the Netherlands.

Under-recording may also be present for OA in joints other than the knee, such as hip OA (i.e. ICPC code L89) and future research into this would be warranted. In the Netherlands, however, OA in some other joints does not have specific codes in EHR data and GPs use symptomatic codes instead of OA codes, for example the use of the ICPC code hand complaints (i.e. ICPC code L12) in case of hand OA. Developing an algorithm with narrative data in combination with such symptomatic codes can be a solution to identify patients with OA in joints without an OA code.

## CONCLUSIONS

In conclusion, the prevalence of knee OA was 1.83 to 2.01 times higher (over the study years) and the incidence 1.93 to 2.28 times higher when including narrative data in addition to codified data. Comorbidities influenced the likelihood of being recorded with codified knee OA. Our study of a Dutch primary care database showed that current knowledge and predictions concerning the epidemiology of knee OA based on codified data alone in EHRs from primary care seriously underestimate its prevalence and incidence. Policy makers should be more aware of the underestimated epidemiological measures of knee OA when using codified data alone. For a more adequate picture of the current and future impact of knee OA, narrative data in addition to codified data can be used to identify patients with knee OA more accurately.

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# SUPPLEMENTARY FILE 1.
## Specifications of the algorithm to identify patients with knee OA

**Inclusion of knee OA patients based on codified data**

Patients with a codified diagnosis of knee OA (i.e. ICPC code L90) were included.

**Inclusion of knee OA patients based on narrative data**

Knee OA patients identified with narrative data with a combination of knee-word plus osteoarthritis-word within 100 characters were included. Keywords combined with terms of negation (e.g. 'not' or 'no') and patient's anxiety about a possible diagnosis of OA were excluded, as were combinations with relatives and expressions of uncertainty (e.g. 'father has', 'mother has', 'probably', 'differential diagnoses').

The algorithm based on narrative data was specified as follows:

| Knee-word | Explanation | Alterations resulting from assessment of 100 random hits on terminology variations and misspellings of keywords |
|---|---|---|
| Knie | Translation into English: knee | None |
| Ghon | Note: start of word 'ghonartrose' (NL)<br>Translation into English: gonarthrosis | None |
| Retropat | Note: start of word 'retropatellair' (NL)<br>Translation into English: retropatellar | None |
| Patellofem | Note: start of word 'patellofemoraal'/ 'patellofemorale' (NL)<br>Translation into English: patellofemoral | None |
| Tibiofem | Note: start of word 'tibiofemoraal'/ 'tibiofemorale' (NL)<br>Translation into English: tibiofemoral | None |
| Gon | Note: start of word 'gonartrose' (NL)<br>Translation into English: gonarthrosis | None |
| ICPC code L15 | ICPC L15 is a codified diagnosis of knee complaints/symptoms | None |

| Osteoarthritis-word | Explanation | Alterations resulting from the assessment of 100 random hits on terminology variations and misspellings of keywords |
|---|---|---|
| Artro* | Stands for: artrose (NL)<br>Translation into English: osteoarthritis | Ingore: 'artrogeen' (NL)<br>Translation into English: artrogen |
| | | Ingore: 'artrotec' |
| | | Ingore when 'cox' appears immediately before 'artro', which makes: 'coxartrosis' |
| | | Ingore when 'haem' appears immediately before 'artro', which makes: 'haemartros' |
| | | Ignore: 'artrodese' (NL)<br>Translation into English: artrodesis |
| | | Ingore when 'panadol' appears immediately before 'artro', which makes: 'panadolartrose' |
| Arthro* | Stands for: arthrose (NL)<br>Translation into English: osteoarthritis | Ignore: 'arthrogeen' (NL)<br>Translation into English: artrogen |
| | | Ingore: 'arthrotec' |
| | | Ingore when 'cox' appears immediately before 'arthro', which makes: 'coxarthrosis' |
| | | Ingore when 'haem' appears immediately before 'arthro', which makes: 'haemarthros' |
| Slijt* | Stands for: slijtage (NL)<br>Translation into English: wear<br>Note: commonly used Dutch synonym for osteoarthritis | None |
| Versleten* | Stands for: versleten (NL)<br>Translation into English: wear<br>Note: commonly used Dutch a synonym for osteoarthritis | None |
| Prothese | Translation to English: prosthesis | None |
| TKP | Abbreviation for: totale knie prothese (NL)<br>Translation into English: total knee replacement | Should appear in combination with a knee word, since a hit of TKP as abbreviation for prosthesis of the shoulder was found. |

The positive predictive value of the algorithm based on narrative data alone was estimated to be 94.0% (95%CI 87.4%-100%); 3 out of 50 randomly selected patients were assessed as false positive cases. Reasons were:

- Physician typing error (n=1): patients with hip OA (ICPC code L89) with indication for total hip replacement, but GP accidentally reported knee OA instead of hip OA in one sentence (NL: "'artrose aan de knie")
- Patient's anxiety about possible diagnosis of OA (n=1) (NL: "angst arthrose/DM" + ICPC L15)
- Expression of uncertainty about OA diagnosis (n=1): an unusual abbreviation of 'probably' not specified to be excluded from the algorithm before the keyword 'terminology'. (NL: "mgl artrose" + ICPC code L15)

# SUPPLEMENTARY FILE 2.
## Length of available medical history

| Medical history in years | % of study sample (patients with or without knee OA participating in IPCI database between 2008-2019) | % of knee OA patients in the study cohort (patients with knee OA participating in IPCI database between 2008-2019) |
|---|---|---|
| 1 | 12.4 | 4.68 |
| 2 | 3.53 | 1.73 |
| 3 | 3.46 | 1.76 |
| 4 | 3.08 | 1.66 |
| 5 | 3.37 | 2.00 |
| 6 | 3.62 | 2.52 |
| 7 | 4.09 | 3.16 |
| 8 | 4.08 | 3.26 |
| 9 | 4.49 | 3.98 |
| 10 | 5.83 | 6.19 |
| 11 | 4.91 | 5.03 |
| 12 | 9.62 | 11.23 |
| 13 | 7.30 | 8.64 |
| 14 | 4.89 | 6.23 |
| 15 | 5.92 | 8.51 |
| 16 | 4.92 | 6.69 |
| 17 | 3.05 | 4.55 |
| 18 | 4.08 | 6.34 |
| 19 | 3.38 | 5.52 |
| 20 | 1.87 | 2.84 |
| 21 | 1.08 | 1.99 |
| 22 | 0.46 | 0.65 |
| 23 | 0.48 | 0.75 |
| 24 | 0.06 | 0.09 |
| **Median years (IQR)** | **12.5 (6.75, 7.21)** | **12.5 (6.75, 7.21)** |

The IPCI database is a dynamic cohort. This means that the database grew from 1 January 1996 by enrolment of general practices, but there are many general practices (and patients) that participated in the IPCI database later in time. The database included a sufficient number of patients and valid data-processing of medical information from 2008 onwards, and therefore, we chose a study period from 2008-2019. Information regarding the length of medical history available in IPCI database (i.e. from the moment of enrolment in IPCI database) varies between patients and practices. For example, for those patients moving from another country to

the Netherlands, there is no medical history available. To give an indication of the length of available medical history, we used the date of the first prescription ever in the medical history in the electronic health records. This date was used as a proxy for the starting point of the medical history, since the exact start of medical history is not available in the IPCI database. We calculated the time from the first prescription ever to the moment of patient enrolment in IPCI database to give an indication of the length of available medical history. If the time of patient enrolment in IPCI database was earlier than 1 January 2008 (start of the study period), the data from that time up to 1 January 2008 was used as medical history (i.e. period used to identify prevalent knee OA). In addition, to increase the reliability of the data, the first year a patient is part of the IPCI database was not included as new medical information and was included as part of medical history. It should be noted that since the first prescription ever was used as a proxy for the starting point of the medical history, it is possible that the actual length of medical history is longer than we presented, especially in those patient without any prescription recorded in their electronic health record. The median years of medical history was the whole study cohort and for knee OA patients only 12.5 years (IQR = 6.75, 7.21).

# SUPPLEMENTARY FILE 3.
## ICPC codes for comorbidities

| **Comorbidity** | **ICPC codes** |
|---|---|
| Hypertension | K86 Essential hypertension without organ damage<br>K87 Hypertension with organ damage / secondary hypertension<br>F83.02 Hypertensive retinopathy |
| Hyperlipidaemia | T93 Lipid Metabolism Disorders<br>- T93.01 Hypercholesterolemia<br>- T93.02 Hypertriglyceridemia<br>- T93.03 Mixed hyperlipidaemia<br>- T93.04 Familial hypercholesterolemia / lipidemia |
| Overweight | T82 Adiposity<br>T83 Obesity |
| Diabetes mellitus | T90 Diabetes mellitus |
| Myocardial infarction/ angina pectoris | K74 Angina pectoris<br>K75 Acute myocardial infarction<br>K76 Other / chronic ischemic heart disease |
| Transient ischaemic attacks/ stroke | K89 Transient ischaemic attacks<br>K90 Cerebrovascular accident |
| Peripheral arterial disease | K91 Atherosclerosis<br>K92.01 Intermittent claudication |
| Chronic Obstructive Pulmonary Disease | R95 Chronic Obstructive Pulmonary Disease |
| Asthma | R96 Asthma |
| Hip osteoarthritis | L89 Hip osteoarthritis |
| Spinal osteoarthritis | L84 Spinal osteoarthritis/spondylosis |

# SUPPLEMENTARY FILE 4.

## Point prevalence proportions and incidence rates of knee OA based on codified data and narrative data alone

**A. Point prevalence proportions of knee OA based on codified data versus narrative data alone**

| | Codified data | | | | Narrative data alone | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] |
| 2008 | 218867 | 6367 | 2.91 [2.84-2.98] | 2.88 [2.87-2.89] | 218867 | 6448 | 2.95 [2.87-3.02] | 2.92 [2.91-2.93] |
| 2009 | 334603 | 10573 | 3.16 [3.10-3.22] | 3.14 [3.13-3.15] | 334603 | 10238 | 3.06 [3.00-3.12] | 3.04 [3.03-3.05] |
| 2010 | 418845 | 14676 | 3.50 [3.45-3.56] | 3.47 [3.46-3.48] | 418845 | 13625 | 3.25 [3.20-3.31] | 3.23 [3.22-3.24] |
| 2011 | 529463 | 20414 | 3.86 [3.80-3.91] | 3.81 [3.80-3.82] | 529463 | 18419 | 3.48 [3.43-3.53] | 3.45 [3.44-3.46] |
| 2012 | 639336 | 26342 | 4.12 [4.07-4.17] | 4.09 [4.07-4.10] | 639336 | 23937 | 3.74 [3.70-3.79] | 3.72 [3.71-3.73] |
| 2013 | 578029 | 25686 | 4.44 [4.39-4.50] | 4.43 [4.42-4.45] | 578029 | 21651 | 3.75 [3.70-3.80] | 3.74 [3.72-3.75] |
| 2014 | 675460 | 32589 | 4.82 [4.77-4.88] | 4.81 [4.80-4.83] | 675460 | 27246 | 4.03 [3.99-4.08] | 4.02 [4.00-4.03] |
| 2015 | 767821 | 39471 | 5.14 [5.09-5.19] | 5.14 [5.12-5.15] | 767821 | 32728 | 4.26 [4.22-4.31] | 4.25 [4.23-4.26] |
| 2016 | 834741 | 45076 | 5.40 [5.35-5.45] | 5.37 [5.36-5.38] | 834741 | 38246 | 4.58 [4.54-4.63] | 4.55 [4.54-4.56] |
| 2017 | 859855 | 49188 | 5.72 [5.67-5.77] | 5.68 [5.66-5.69] | 859855 | 42474 | 4.94 [4.89-4.99] | 4.90 [4.88-4.91] |
| 2018 | 838538 | 50487 | 6.02 [5.97-6.07] | 5.94 [5.92-5.95] | 838538 | 44513 | 5.31 [5.26-5.36] | 5.23 [5.22-5.25] |
| 2019 | 767159 | 48221 | 6.29 [6.23-6.34] | 6.15 [6.14-6.17] | 767159 | 43719 | 5.70 [5.65-5.75] | 5.60 [5.58-5.61] |

**Notes.** Standardized point prevalence proportions are standardized for age and sex distribution of the total population from the Netherlands.

**B. Incidence rates of knee OA based on codified data versus narrative data alone**

| | Codified data | | | | Narrative data alone | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 203368 | 959 | 4.72 [4.42 - 5.02] | 4.88 [4.84 - 4.93] | 203443 | 892 | 4.38 [4.10 - 4.68] | 4.42 [4.38 - 4.46] |
| 2009 | 312074 | 1596 | 5.11 [4.87 - 5.37] | 5.32 [5.27 - 5.36] | 312528 | 1409 | 4.51 [4.28 - 4.75] | 4.55 [4.51 - 4.59] |
| 2010 | 391061 | 2092 | 5.35 [5.12 - 5.58] | 5.53 [5.49 - 5.58] | 392146 | 1931 | 4.92 [4.71 - 5.15] | 4.97 [4.93 - 5.01] |
| 2011 | 484030 | 2876 | 5.94 [5.73 - 6.16] | 6.17 [6.13 - 6.22] | 485842 | 2353 | 4.84 [4.65 - 5.04] | 4.89 [4.84 - 4.93] |
| 2012 | 590001 | 3446 | 5.84 [5.65 - 6.04] | 6.10 [6.05 - 6.14] | 592346 | 2877 | 4.86 [4.68 - 5.04] | 4.89 [4.85 - 4.93] |
| 2013 | 568111 | 3570 | 6.28 [6.08 - 6.49] | 6.60 [6.55 - 6.65] | 571909 | 2803 | 4.90 [4.72 - 5.09] | 4.95 [4.91 - 4.99] |
| 2014 | 624679 | 3801 | 6.08 [5.89 - 6.28] | 6.42 [6.37 - 6.47] | 629865 | 3213 | 5.10 [4.93 - 5.28] | 5.14 [5.10 - 5.18] |
| 2015 | 715390 | 3944 | 5.51 [5.34 - 5.69] | 5.84 [5.80 - 5.89] | 721969 | 3770 | 5.22 [5.06 - 5.39] | 5.28 [5.24 - 5.33] |
| 2016 | 784232 | 4501 | 5.74 [5.57 - 5.91] | 6.07 [6.02 - 6.11] | 791065 | 4242 | 5.36 [5.20 - 5.53] | 5.41 [5.36 - 5.45] |
| 2017 | 810453 | 4519 | 5.58 [5.41 - 5.74] | 5.89 [5.84 - 5.93] | 817176 | 4620 | 5.65 [5.49 - 5.82] | 5.71 [5.66 - 5.75] |
| 2018 | 784326 | 4295 | 5.48 [5.31 - 5.64] | 5.76 [5.72 - 5.80] | 790272 | 4555 | 5.76 [5.60 - 5.93] | 5.80 [5.75 - 5.84] |
| 2019 | 740085 | 4263 | 5.76 [5.59 - 5.94] | 6.04 [6.00 - 6.09] | 744949 | 4603 | 6.18 [6.00 - 6.36] | 6.21 [6.16 - 6.26] |

**Notes.** Standardized incidence rates are standardized for age and sex distribution of the total population from the Netherlands.

# SUPPLEMENTARY FILE 5.

Point prevalence proportions and incidence rates of knee OA based on codified data and narrative data alone, stratified by sex

## A. Point prevalence proportions of knee OA based on codified data and narrative data alone, stratified by sex

| | Codified knee OA | | | | | | | | Narratively diagnosed knee OA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | | Men | | | | Women | | | |
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] |
| 2008 | 105096 | 1954 | 1.86 [1.78-1.94] | 1.80 [1.79-1.81] | 113771 | 4413 | 3.88 [3.77-4.00] | 3.91 [3.89-3.92] | 105096 | 2470 | 2.35 [2.26-2.44] | 2.30 [2.28-2.31] | 113771 | 3978 | 3.50 [3.39-3.61] | 3.51 [3.50-3.53] |
| 2009 | 160451 | 3341 | 2.08 [2.01-2.15] | 2.02 [2.01-2.03] | 174152 | 7232 | 4.15 [4.06-4.25] | 4.20 [4.19-4.22] | 160451 | 3974 | 2.48 [2.40-2.55] | 2.42 [2.41-2.44] | 174152 | 6264 | 3.60 [3.51-3.69] | 3.62 [3.61-3.64] |
| 2010 | 201064 | 4674 | 2.32 [2.26-2.39] | 2.25 [2.24-2.27] | 217781 | 10002 | 4.59 [4.50-4.68] | 4.63 [4.61-4.65] | 201064 | 5325 | 2.65 [2.58-2.72] | 2.59 [2.58-2.61] | 217781 | 8300 | 3.81 [3.73-3.89] | 3.83 [3.81-3.85] |
| 2011 | 253594 | 6629 | 2.61 [2.55-2.68] | 2.54 [2.53-2.55] | 275869 | 13785 | 5.00 [4.91-5.08] | 5.02 [5.00-5.04] | 253594 | 7352 | 2.90 [2.83-2.97] | 2.84 [2.83-2.86] | 275869 | 11067 | 4.01 [3.94-4.09] | 4.03 [4.01-4.04] |
| 2012 | 306476 | 8743 | 2.85 [2.79-2.91] | 2.77 [2.76-2.79] | 332860 | 17599 | 5.29 [5.21-5.37] | 5.34 [5.32-5.36] | 306476 | 9716 | 3.17 [3.11-3.23] | 3.11 [3.09-3.12] | 332860 | 14221 | 4.27 [4.20-4.34] | 4.30 [4.28-4.31] |
| 2013 | 277068 | 8658 | 3.12 [3.06-3.19] | 3.06 [3.04-3.07] | 300961 | 17028 | 5.66 [5.57-5.74] | 5.74 [5.72-5.76] | 277068 | 8925 | 3.22 [3.15-3.29] | 3.17 [3.16-3.19] | 300961 | 12726 | 4.23 [4.16-4.30] | 4.27 [4.25-4.29] |
| 2014 | 324167 | 11159 | 3.44 [3.38-3.51] | 3.36 [3.35-3.38] | 351293 | 21430 | 6.10 [6.02-6.18] | 6.19 [6.17-6.21] | 324167 | 11280 | 3.48 [3.42-3.54] | 3.42 [3.40-3.43] | 351293 | 15966 | 4.54 [4.47-4.62] | 4.58 [4.56-4.60] |
| 2015 | 369044 | 13627 | 3.69 [3.63-3.76] | 3.61 [3.60-3.63] | 398777 | 25844 | 6.48 [6.40-6.56] | 6.58 [6.56-6.61] | 369044 | 13800 | 3.74 [3.68-3.80] | 3.68 [3.67-3.70] | 398777 | 18928 | 4.75 [4.68-4.81] | 4.78 [4.77-4.80] |
| 2016 | 401299 | 15756 | 3.93 [3.87-3.99] | 3.82 [3.80-3.84] | 433442 | 29320 | 6.76 [6.69-6.84] | 6.85 [6.83-6.87] | 401299 | 16125 | 4.02 [3.96-4.08] | 3.94 [3.93-3.96] | 433442 | 22121 | 5.10 [5.04-5.17] | 5.13 [5.11-5.15] |
| 2017 | 413127 | 17370 | 4.20 [4.14-4.27] | 4.08 [4.06-4.10] | 446728 | 31818 | 7.12 [7.04-7.20] | 7.20 [7.18-7.23] | 413127 | 17997 | 4.36 [4.29-4.42] | 4.27 [4.25-4.28] | 446728 | 24477 | 5.48 [5.41-5.55] | 5.50 [5.48-5.52] |
| 2018 | 402437 | 17938 | 4.46 [4.39-4.52] | 4.30 [4.29-4.32] | 436101 | 32549 | 7.46 [7.38-7.55] | 7.49 [7.47-7.52] | 402437 | 18849 | 4.68 [4.62-4.75] | 4.57 [4.55-4.59] | 436101 | 25664 | 5.88 [5.81-5.96] | 5.87 [5.85-5.89] |
| 2019 | 368332 | 17292 | 4.69 [4.62-4.77] | 4.51 [4.49-4.53] | 398827 | 30929 | 7.75 [7.67-7.84] | 7.73 [7.70-7.75] | 368332 | 18474 | 5.02 [4.94-5.09] | 4.88 [4.86-4.89] | 398827 | 25245 | 6.33 [6.25-6.41] | 6.28 [6.26-6.30] |

**Notes.** standardized point prevalence proportions are standardized for age.

## B. Incidence rates of knee OA based on codified data and narrative data alone, stratified by sex

| | Codified knee OA | | | | | | | Narratively diagnosed knee OA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | Men | | | | Women | | |
| Year | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 98715 | 331 | 3.35 [3.00 - 3.73] | 3.33 [3.28 - 3.38] | 104653 | 628 | 6.00 [5.54 - 6.49] | 6.36 [6.29 - 6.42] | 98244 | 380 | 3.87 [3.49 - 4.28] | 3.83 [3.78 - 3.88] | 105199 | 512 | 4.87 [4.45 - 5.31] | 4.97 [4.91 - 5.03] |
| 2009 | 151310 | 563 | 3.72 [3.42 - 4.04] | 3.71 [3.66 - 3.76] | 160764 | 1033 | 6.43 [6.04 - 6.83] | 6.84 [6.77 - 6.91] | 150719 | 551 | 3.66 [3.36 - 3.97] | 3.64 [3.58 - 3.69] | 161809 | 858 | 5.30 [4.95 - 5.67] | 5.42 [5.36 - 5.48] |
| 2010 | 189979 | 710 | 3.74 [3.47 - 4.02] | 3.73 [3.68 - 3.78] | 201082 | 1382 | 6.87 [6.52 - 7.24] | 7.25 [7.18 - 7.32] | 189388 | 792 | 4.18 [3.90 - 4.48] | 4.16 [4.11 - 4.22] | 202758 | 1139 | 5.62 [5.30 - 5.95] | 5.74 [5.67 - 5.80] |
| 2011 | 235101 | 993 | 4.22 [3.97 - 4.49] | 4.23 [4.17 - 4.28] | 248929 | 1883 | 7.56 [7.23 - 7.91] | 8.02 [7.95 - 8.10] | 234379 | 964 | 4.11 [3.86 - 4.38] | 4.10 [4.04 - 4.15] | 251463 | 1389 | 5.52 [5.24 - 5.82] | 5.63 [5.57 - 5.70] |
| 2012 | 286560 | 1226 | 4.28 [4.04 - 4.52] | 4.28 [4.23 - 4.34] | 303441 | 2220 | 7.32 [7.01 - 7.63] | 7.82 [7.75 - 7.90] | 285610 | 1199 | 4.20 [3.96 - 4.44] | 4.18 [4.13 - 4.24] | 306736 | 1678 | 5.47 [5.21 - 5.74] | 5.57 [5.51 - 5.63] |
| 2013 | 276124 | 1312 | 4.75 [4.50 - 5.02] | 4.79 [4.74 - 4.85] | 291987 | 2258 | 7.73 [7.42 - 8.06] | 8.32 [8.24 - 8.40] | 275689 | 1181 | 4.28 [4.04 - 4.54] | 4.28 [4.23 - 4.34] | 296220 | 1622 | 5.48 [5.21 - 5.75] | 5.59 [5.53 - 5.65] |
| 2014 | 304165 | 1318 | 4.33 [4.10 - 4.57] | 4.37 [4.32 - 4.43] | 320514 | 2483 | 7.75 [7.45 - 8.06] | 8.36 [8.29 - 8.44] | 303993 | 1366 | 4.49 [4.26 - 4.74] | 4.49 [4.43 - 4.54] | 325872 | 1847 | 5.67 [5.41 - 5.93] | 5.77 [5.70 - 5.83] |
| 2015 | 348926 | 1395 | 4.00 [3.79 - 4.21] | 4.06 [4.01 - 4.12] | 366464 | 2549 | 6.96 [6.69 - 7.23] | 7.54 [7.46 - 7.61] | 348777 | 1577 | 4.52 [4.30 - 4.75] | 4.52 [4.47 - 4.58] | 373192 | 2193 | 5.88 [5.63 - 6.13] | 6.01 [5.94 - 6.07] |
| 2016 | 382826 | 1719 | 4.49 [4.28 - 4.71] | 4.55 [4.49 - 4.60] | 401406 | 2782 | 6.93 [6.68 - 7.19] | 7.51 [7.44 - 7.59] | 382459 | 1750 | 4.58 [4.36 - 4.80] | 4.58 [4.52 - 4.63] | 408606 | 2492 | 6.10 [5.86 - 6.34] | 6.20 [6.14 - 6.27] |
| 2017 | 395642 | 1685 | 4.26 [4.06 - 4.47] | 4.30 [4.25 - 4.36] | 414811 | 2834 | 6.83 [6.58 - 7.09] | 7.40 [7.33 - 7.47] | 395020 | 1899 | 4.81 [4.59 - 5.03] | 4.80 [4.74 - 4.86] | 422156 | 2721 | 6.45 [6.21 - 6.69] | 6.57 [6.50 - 6.64] |
| 2018 | 382695 | 1628 | 4.25 [4.05 - 4.47] | 4.28 [4.23 - 4.34] | 401631 | 2667 | 6.64 [6.39 - 6.90] | 7.17 [7.10 - 7.24] | 381775 | 1897 | 4.97 [4.75 - 5.20] | 4.95 [4.89 - 5.01] | 408497 | 2658 | 6.51 [6.26 - 6.76] | 6.60 [6.54 - 6.67] |
| 2019 | 361403 | 1689 | 4.67 [4.45 - 4.90] | 4.72 [4.66 - 4.77] | 378682 | 2574 | 6.80 [6.54 - 7.07] | 7.31 [7.24 - 7.38] | 360270 | 1893 | 5.25 [5.02 - 5.50] | 5.23 [5.17 - 5.30] | 384679 | 2710 | 7.04 [6.78 - 7.32] | 7.14 [7.08 - 7.21] |

**Notes.** Standardized incidence rates are standardized for age.

# SUPPLEMENTARY FILE 6.

## Point prevalence proportions and incidence rates of knee OA based on a combination of codified and narrative data, stratified by sex

| | Point prevalence | | | | | | | | Incidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | | Men | | | | Women | | | |
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 105096 | 4424 | 4.21 [4.09-4.34] | 4.10 [4.08-4.11] | 113771 | 8391 | 7.38 [7.22-7.53] | 7.42 [7.40-7.44] | 96283 | 711 | 7.38 [6.85-7.37] | 7.44 [7.37-7.52] | 100826 | 1140 | 11.31 [10.66-12.28] | 12.38 [12.28-12.47] |
| 2009 | 160451 | 7315 | 4.56 [4.46-4.66] | 4.45 [4.43-4.46] | 174152 | 13496 | 7.75 [7.62-7.88] | 7.83 [7.80-7.85] | 147404 | 1114 | 7.56 [7.12-7.57] | 7.64 [7.57-7.72] | 154651 | 1891 | 12.23 [11.68-13.32] | 13.42 [13.32-13.52] |
| 2010 | 201064 | 9999 | 4.97 [4.88-5.07] | 4.85 [4.83-4.86] | 217781 | 18302 | 8.40 [8.28-8.53] | 8.46 [8.43-8.48] | 184781 | 1502 | 8.13 [7.72-8.16] | 8.23 [8.16-8.31] | 192980 | 2521 | 13.06 [12.56-14.13] | 14.23 [14.13-14.33] |
| 2011 | 253594 | 13981 | 5.51 [5.42-5.61] | 5.38 [5.36-5.40] | 275869 | 24852 | 9.01 [8.90-9.12] | 9.05 [9.02-9.07] | 228044 | 1957 | 8.58 [8.21-8.64] | 8.72 [8.64-8.80] | 238323 | 3272 | 13.73 [13.26-14.91] | 15.01 [14.91-15.11] |
| 2012 | 306476 | 18459 | 6.02 [5.94-6.11] | 5.88 [5.86-5.90] | 332860 | 31820 | 9.56 [9.45-9.67] | 9.63 [9.61-9.66] | 277135 | 2425 | 8.75 [8.41-8.82] | 8.90 [8.82-8.98] | 289678 | 3898 | 13.46 [13.04-14.69] | 14.79 [14.69-14.90] |
| 2013 | 277068 | 17583 | 6.35 [6.25-6.44] | 6.23 [6.21-6.25] | 300961 | 29754 | 9.89 [9.77-10.00] | 10.01 [9.98-10.04] | 266718 | 2493 | 9.35 [8.98-9.50] | 9.59 [9.50-9.67] | 278553 | 3880 | 13.93 [13.49-15.30] | 15.41 [15.30-15.51] |
| 2014 | 324167 | 22439 | 6.92 [6.83-7.01] | 6.78 [6.76-6.80] | 351293 | 37396 | 10.65 [10.54-10.75] | 10.77 [10.75-10.80] | 293136 | 2684 | 9.16 [8.81-9.30] | 9.38 [9.30-9.47] | 304956 | 4330 | 14.20 [13.78-15.62] | 15.72 [15.62-15.83] |
| 2015 | 369044 | 27427 | 7.43 [7.34-7.52] | 7.30 [7.27-7.32] | 398777 | 44772 | 11.23 [11.12-11.33] | 11.37 [11.34-11.40] | 335377 | 2972 | 8.86 [8.55-9.06] | 9.14 [9.06-9.22] | 347786 | 4742 | 13.63 [13.25-15.09] | 15.19 [15.09-15.29] |
| 2016 | 401299 | 31881 | 7.94 [7.86-8.03] | 7.76 [7.74-7.79] | 433442 | 51441 | 11.87 [11.77-11.97] | 11.98 [11.95-12.01] | 366790 | 3469 | 9.46 [9.15-9.66] | 9.75 [9.66-9.83] | 379409 | 5274 | 13.90 [13.53-15.35] | 15.46 [15.35-15.56] |
| 2017 | 413127 | 35367 | 8.56 [8.47-8.65] | 8.35 [8.32-8.37] | 446728 | 56295 | 12.60 [12.50-12.71] | 12.70 [12.67-12.73] | 377656 | 3584 | 9.49 [9.18-9.69] | 9.78 [9.69-9.86] | 390346 | 5555 | 14.23 [13.86-15.76] | 15.86 [15.76-15.96] |
| 2018 | 402437 | 36787 | 9.14 [9.05-9.23] | 8.87 [8.85-8.90] | 436101 | 58213 | 13.35 [13.24-13.46] | 13.36 [13.33-13.39] | 363919 | 3525 | 9.69 [9.37-9.88] | 9.96 [9.88-10.05] | 376074 | 5325 | 14.16 [13.78-15.65] | 15.76 [15.65-15.86] |
| 2019 | 368332 | 35766 | 9.71 [9.61-9.81] | 9.39 [9.36-9.41] | 398827 | 56174 | 14.08 [13.97-14.20] | 14.01 [13.98-14.04] | 342473 | 3582 | 10.46 [10.12-10.71] | 10.79 [10.71-10.88] | 352815 | 5284 | 14.98 [14.58-16.53] | 16.63 [16.53-16.74] |

**Notes.** Standardized point prevalence proportions and incidence rates are standardized for age.

# CHAPTER 3

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

Ilgin G. Arslan, Jurgen Damen, Marcel de Wilde, Jacoline J. van den Driest, Patrick J.E. Bindels, Johan van der Lei, Sita M.A. Bierma-Zeinstra, Dieuwke Schiphof

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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 1.76–1.95 times higher and increased from 4.03% in 2008 to 7.34% in 2019. The incidence was 1.83–2.41 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.

# 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.

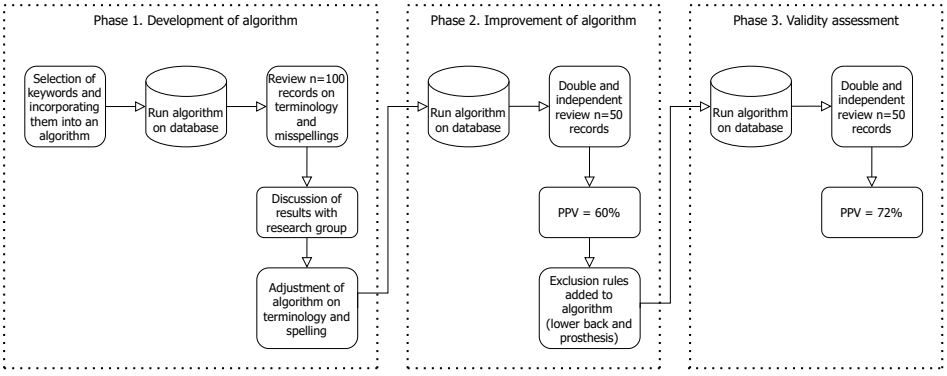



**FIGURE 1.** Workflow diagram for the development of the narrative data algorithm

**Outcomes**

PPVs were calculated as the proportion of patients who were confirmed as having hip OA, based on the information reported in the EHR. The annual lifetime prevalence was calculated 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. The entire retrospective record available for patients was used to estimate the prevalence. The annual incidence rate was calculated by the number of new cases between 1 January and 31 December (i.e. no previous diagnosis of hip OA) in each calendar year, divided by the number of person years at risk between 1 January and 31 December each calendar year. This at risk period is the period that a patient participated in the IPCI database without a recorded hip OA diagnosis until the moment of death, changing practice, hip OA diagnosis, or end of participation in the IPCI database. The entire retrospective record available for patients was used to exclude prior hip OA when estimating the incidence rates. Thus, patients with a hip OA diagnosis in their medical history (i.e. medical history before enrolment in the IPCI database or before 1 January 2008) were defined as prevalent cases. See Supplementary File 1 for more information regarding the medical history available for the study cohort. Prevalence and incidence estimates were calculated separately for: 1) patients with codified hip OA diagnosis defined as at least one ICPC code hip OA (i.e. L89), and 2) patients with narratively diagnosed hip OA according to the free-text algorithm without any record of codified hip OA in their EHR. Incidence and prevalence estimates were calculated stratified by sex. Further details of the study design are illustrated in 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 File 2 for the full list of ICPC-codes). This analysis was adjusted for age and sex.

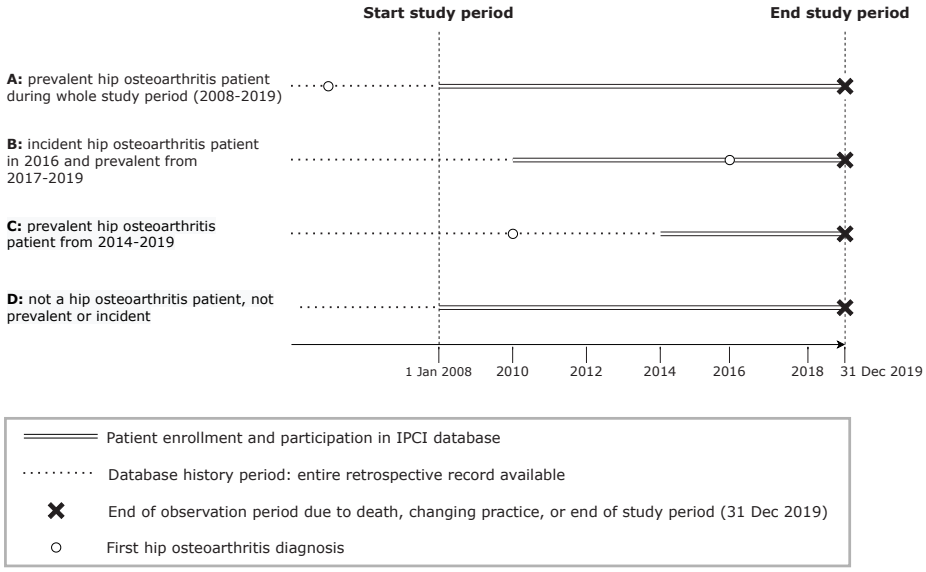



**FIGURE 2.** Details of the study design

**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.

### 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 File 3. 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 File 4, 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).

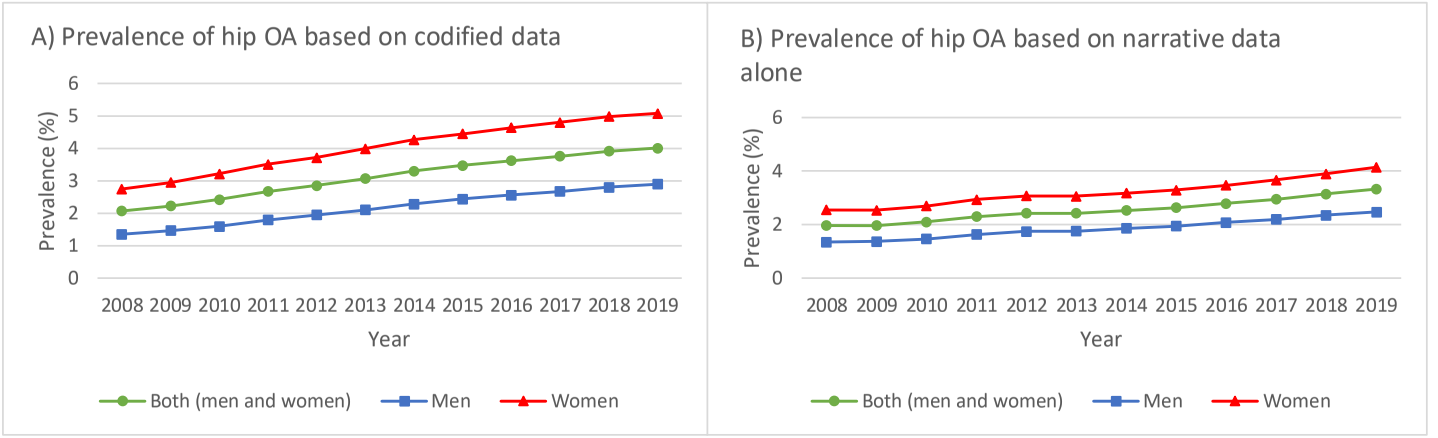
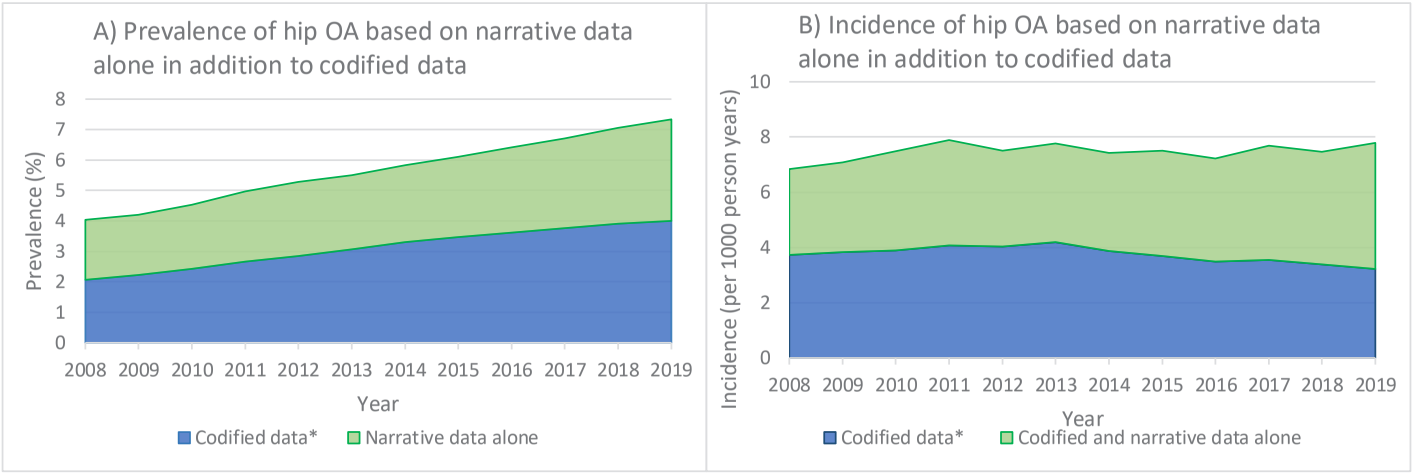



**FIGURE 3.** Standardized prevalence of hip OA based on codified data (A) and narrative data alone (B)




* 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

**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 |

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

### 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 File 4.

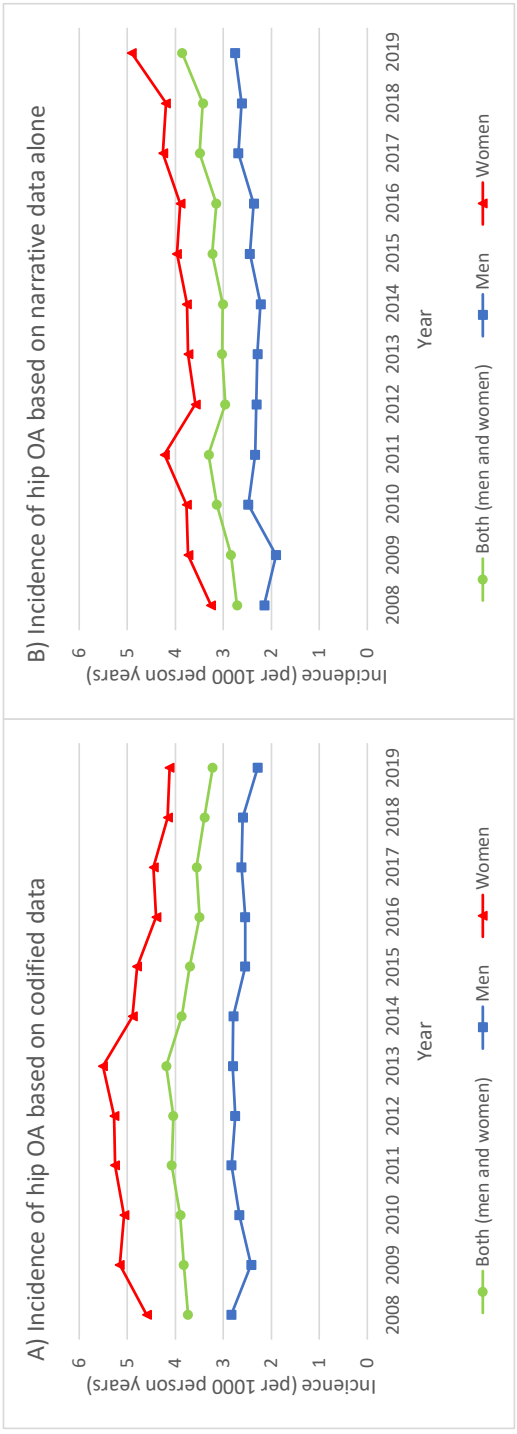



**FIGURE 5.** Standardized incidence of hip OA based on codified data (A) and narrative data alone (B)

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 File 5.

**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 File 6.

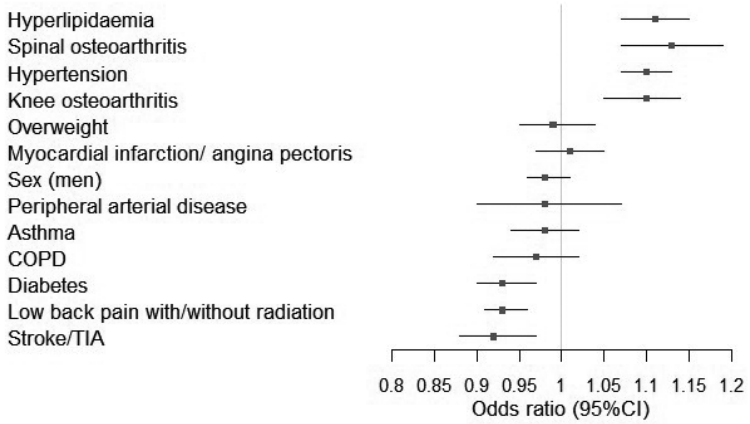



**FIGURE 6.** Characteristics associated with codified hip OA diagnosis among all hip OA patients (either codified diagnosed or narratively diagnosed without a hip OA code)

**Notes.** Full details are provided in Supplementary File 6.

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

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

Current healthcare policy on prevention and management is based on routine primary care data using codified data alone from EHRs. Findings from the current study and previous 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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# SUPPLEMENTARY FILE 1.
## Length of available medical history

| Medical history in years (first prescription ever to the moment of patient enrolment in IPCI database) | % of study sample (patients with or without hip OA participating in IPCI database between 2008-2019) | % of hip OA patients in the study cohort (patients with hip OA participating in IPCI database between 2008-2019) |
|---|---|---|
| 1 | 12.4 | 4.56 |
| 2 | 3.53 | 1.71 |
| 3 | 3.46 | 1.74 |
| 4 | 3.08 | 1.57 |
| 5 | 3.37 | 1.92 |
| 6 | 3.62 | 2.38 |
| 7 | 4.09 | 3.12 |
| 8 | 4.08 | 3.27 |
| 9 | 4.49 | 3.79 |
| 10 | 5.83 | 6.04 |
| 11 | 4.91 | 4.79 |
| 12 | 9.62 | 11.46 |
| 13 | 7.30 | 8.76 |
| 14 | 4.89 | 6.26 |
| 15 | 5.92 | 8.70 |
| 16 | 4.92 | 6.94 |
| 17 | 3.05 | 4.88 |
| 18 | 4.08 | 6.18 |
| 19 | 3.38 | 5.43 |
| 20 | 1.87 | 2.90 |
| 21 | 1.08 | 2.03 |
| 22 | 0.46 | 0.73 |
| 23 | 0.48 | 0.77 |
| 24 | 0.06 | 0.09 |
| **Median years (IQR)** | **12.5 (6.75, 7.21)** | **12.5 (6.75, 7.21)** |

To calculate the length of available medical history for people in the IPCI database, we used the same methods as an earlier published study examining the under-recording of knee OA.[1] The description of this methods is included below.

The IPCI database is a dynamic cohort. This means that the database grew from 1 January 1996 by enrolment of general practices, but there are many general practices (and patients) that

participated in the IPCI database later in time. The database included a sufficient number of patients and valid data-processing of medical information from 2008 onwards, and therefore, we chose a study period from 2008-2019. Information regarding the length of medical history available in IPCI database (i.e. from the moment of enrolment in IPCI database) varies between patients and practices. For example, for those patients moving from another country to the Netherlands, there is no medical history available. To give an indication of the length of available medical history, we used the date of the first prescription ever in the medical history in the electronic health records. This date was used as a proxy for the starting point of the medical history, since the exact start of medical history is not available in the IPCI database. We calculated the time from the first prescription ever to the moment of patient enrolment in IPCI database to give an indication of the length of available medical history. If the time of patient enrolment in IPCI database was earlier than 1 January 2008 (start of the study period), the data from that time up to 1 January 2008 was used as medical history (i.e. period used to identify prevalent hip OA). In addition, to increase the reliability of the data, the first year a patient is part of the IPCI database was not included as new medical information and was included as part of medical history. It should be noted that since the first prescription ever was used as a proxy for the starting point of the medical history, it is possible that the actual length of medical history is longer than we presented, especially in those patient without any prescription recorded in their electronic health record. The median years of medical history was the whole study cohort and for hip OA patients only 12.5 years (IQR = 6.75, 7.21).

[1] Arslan IG, Damen J, de Wilde M, et al. Incidence and prevalence of knee osteoarthritis using codified and narrative data from electronic health records: a population-based study. Arthritis Care Res (Hoboken). 2022.

# SUPPLEMENTARY FILE 2.
## ICPC codes for comorbidities

| **Comorbidity** | **ICPC codes** |
|---|---|
| Hypertension | K86 Essential hypertension without organ damage<br>K87 Hypertension with organ damage / secondary hypertension<br>F83.02 Hypertensive retinopathy |
| Hyperlipidaemia | T93 Lipid Metabolism Disorders<br>- T93.01 Hypercholesterolemia<br>- T93.02 Hypertriglyceridemia<br>- T93.03 Mixed hyperlipidaemia<br>- T93.04 Familial hypercholesterolemia / lipidemia |
| Overweight | T82 Adiposity<br>T83 Obesity |
| Diabetes mellitus | T90 Diabetes mellitus |
| Myocardial infarction/ angina pectoris | K74 Angina pectoris<br>K75 Acute myocardial infarction<br>K76 Other / chronic ischemic heart disease |
| Transient ischaemic attacks/ stroke | K89 Transient ischaemic attacks<br>K90 Cerebrovascular accident |
| Peripheral arterial disease | K91 Atherosclerosis<br>K92.01 Intermittent claudication |
| Chronic Obstructive Pulmonary Disease | R95 Chronic Obstructive Pulmonary Disease |
| Asthma | R96 Asthma |
| Fibromyalgia | L18.01 Fibromyalgia |
| Rheumatoid arthritis | L88 Rheumatoid arthritis |
| Knee osteoarthritis | L90 Knee osteoarthritis |
| Spinal osteoarthritis | L84 Spinal osteoarthritis/spondylosis |
| Low back pain | L03 Low back pain without radiation<br>L86 Low back pain with radiation |

# SUPPLEMENTARY FILE 3.

## Specifications of the algorithm to identify patients with hip OA based on narrative data

**Phase 1: development of the algorithm**

Patient was identified with narrative data when a combination of hip-word and osteoarthritis-word within 100 characters was found:

| Hip-word | Explanation | Alterations resulting from assessment of random 100 hits on terminology variations and misspellings of keywords |
|---|---|---|
| Heup | Translation into English: hip | None |
| Cox | Note: start of word 'coxartrose' (NL)<br>Translation to English: coxartrosis | None |
| ICPC code L13 | ICPC L13 is a codified diagnosis of hip complaints/symptoms | None |
| **Osteoarthritis-word** | **Explanation** | **Alterations resulting from the assessment of random 100 hits on terminology variations and misspellings of keywords** |
| Artro* | Stands for: artrose (NL)<br>Translation into English: osteoarthritis | Ingore: 'artrogeen' (NL)<br>Translation to English: artrogen |
| | | Ingore: 'artrotec' |
| | | Ingore when 'gon' appears immediately before 'artro', which makes: 'gonartrosis' |
| | | Ingore when 'haem' appears immediately before 'artro', which makes: 'haemartros' |
| | | Ignore: 'artrodese' (NL)<br>Translation to English: artrodesis |
| | | Ingore when 'panadol' appears immediately before 'artro', which makes: 'panadolartrose' |
| Arthro* | Stands for: arthrose (NL)<br>Translation into English: osteoarthritis | Ignore: 'arthrogeen' (NL)<br>Translation to English: artrogen |
| | | Ingore: 'arthrotec' |
| | | Ingore when 'gon' appears immediately before 'arthro', which makes: 'gonarthrosis' |
| | | Ingore when 'haem' appears immediately before 'arthro', which makes: 'haemarthros' |
| | | Ingore: 'arthrosator' |
| Slijt* | Stands for: slijtage (NL)<br>Translation into English: wear<br>Note: commonly used Dutch synonym for osteoarthritis | None |

| | | |
|---|---|---|
| Verslet* | Stands for: versleten (NL)<br>Translation into English: wear<br>Note: commonly used Dutch a synonym for osteoarthritis | None |
| Prothese | Translation into English: prosthesis | |
| THP | Abbreviation for: totale heup prothese (NL)<br>Translation into English: total hip replacement | Should appear in combination with a hip-word to ensure the validity of the THP word relating to the hip joint. |



Keywords were excluded when they presented in combination with terms of negation (e.g. 'not' or 'no'), relatives (e.g. 'father has', 'mother has'), patient's anxiety for having hip OA, and expressions of uncertainties regarding the hip OA diagnosis by the GP or clinicians from primary or secondary care (e.g. 'probably', 'differential diagnostics'). Additional alterations resulting from the assessment of random 100 patients: remove whole sentence when 'WRS' (Dutch abbreviation for probably), 'WAARSCHIJNLIJK' (Dutch word for probably), 'WRSCH' (Dutch abbreviation for probably), or 'MGL' (Dutch abbreviation for probably) appears before a word in the list for hip osteoarthritis.

**Phase 2: improvement of the algorithm**

We randomly selected 50 patients with narratively diagnosed hip OA without a record of codified hip OA (i.e. no ICPC code L89).These cases were then assessed on true and false positive cases for having hip OA through a blinded medical record review by two authors (IGA and JD) and consensus through discussion with the last author (DS). As a result, 20 out of 50 cases were assessed as false positive cases. This resulted into a positive predicted value (PPV) of 60%. Reasons for false positives and actions to improve the algorithm are summarized in Box 1.

**BOX 1.** Reasons for false positives (n=20) and actions to improve the algorithm

| Reason for false positive | Frequency | Action |
|---|---|---|
| Keyword 'prosthesis' in combination with keywords for the hip joint or codified hip complaints, and THP (abbreviation for total hip replacement) found after a hip fracture and not due to hip OA | 3 | Keywords 'prosthesis' and 'THP' excluded from the algorithm |
| Keywords for the hip joint or codified hip complaints in combination with OA in the lower back or sacroiliac joint, for example: "no degeneration of the hips, but osteoarthritis in the lower back" (NL: "geen slijtage in de heup, maar artrose in de lage rug") and linked the consultation to ICPC code L13 (i.e. hip complaints/ symptoms) | 5 | Exclusion of hip joint or codified hip complaints in combination with OA and the following Dutch terms for the lower back or sacroiliac joint:<br>- "lage rug"<br>- "lage rugpijn"<br>- "lage-rug"<br>- "lwk"<br>- "lumbale wervel kolom"<br>- "onder rug"<br>- "onderrug"<br>- "SI" |
| GP reported "osteoarthritis in the finger" (NL: artrose in de vinger) and accidentally linked the consultation to ICPC code L13 (i.e. hip complaints/symptoms) | 1 | Not possible to exclude from the algorithm |
| Terminology variations of negations. For example: 'nosigns of' instead of 'no signs of' (NL= 'geenaanwijzingen' instead of 'geen aanwijzingen') | 6 | Exclusion of hip joint or codified hip complaints in combination with the following variations of negation terms:<br>- "geenaanwijzingen"<br>- "uitsluiting" |
| Patient "wonders if there could be wear and tear in the hip" (NL: "vraagt zich af of er slijtage kan zijn van de heup") and GP concludes that the patient has no hip OA (NL: "geen afwijzingen normale heupen geen arthrose") | 1 | Not possible to exclude from the algorithm |
| Cardiologist reported accidentally 'hip OA in the past', whether the patient did not have any history of hip complaints in the EHR | 1 | Not possible to exclude from the algorithm |
| Unclear diagnosis of hip OA, for example: "osteoarthritis knees/hips +/-" (NL: "arthrose knien/heupen +/-" | 3 | Not possible to exclude from the algorithm |

**Phase 3: Validity assessment of the final algorithm**

We randomly selected 50 patients with narratively diagnosed hip OA without a codified record of hip OA (i.e. no ICPC code L89) from the revised algorithm. These cases were then assessed on true and false positive cases for having hip OA through a blinded medical record review by two authors (IGA and JD) and consensus through discussion with the last author (DS). As a result, 14 out of 50 cases were assessed as false positive cases. This resulted into a PPV of 72%. Reasons for false positives are summarized in Box 2.



**BOX 2.** Reasons for false positives (n=14) of the improved algorithm

| Reason for false positive | Frequency |
|---|---|
| Terminology variations of 'arthrodesis' (NL=arthrodese) where the algorithm detected the patient this term in combination with a keyword related to the hip joint | 1 |
| Variation of keywords related to OA in the lower back in combination with a keyword related to the hip joint or codified hip complaints, for example: "osteoarthritis in the lower back"(NL: "slijtage laag lumbaal") and linked the consultation to ICPC code L13 (i.e. hip complaints/symptoms) | 3 |
| Unclear diagnosis of hip OA, for example: "Reassurance about osteoarthritis" (NL: "geruststelling wat betreft artrose") and linked the consultation to ICPC code L13 | 4 |
| Terminology variations of 'COX' where the algorithm detected the patient this term in combination with a keyword related to the hip joint: "ARCOXIA" | 1 |
| Variation of keywords related to knee OA in combination with a keyword related to the hip joint or codified hip complaints: "osteoarthritis in the knees, hips nothing unusual" (NL: "knieen artrotisch heupen gb") | 2 |
| Hip OA as an incidental finding on X-ray to rule out a hip fracture after traumatic event | 3 |

**Summary of the final narrative data algorithm**

Patient was identified with narrative data when a combination of hip-word and osteoarthritis-word within 100 characters was found:

| Hip-word | Explanation | Additional rules |
|---|---|---|
| Heup | Translation into English: hip | - |
| Cox | Note: start of word 'coxartrose' (NL)<br>Translation to English: coxartrosis | - |
| ICPC code L13 | ICPC L13 is a codified diagnosis of hip complaints/symptoms | - |
| **Osteoarthritis-word** | **Explanation** | **Additional rules** |
| Artro* | Stands for: artrose (NL)<br>Translation into English: osteoarthritis | Ingore: 'artrogeen' (NL)<br>Translation to English: artrogen |
| | | Ingore: 'artrotec' |
| | | Ingore when 'gon' appears immediately before 'artro', which makes: 'gonartrosis' |
| | | Ingore when 'haem' appears immediately before 'artro', which makes: 'haemartros' |
| | | Ignore: 'artrodese' (NL)<br>Translation to English: artrodesis |
| | | Ingore when 'panadol' appears immediately before 'artro', which makes: 'panadolartrose' |
| Arthro* | Stands for: arthrose (NL)<br>Translation into English: osteoarthritis | Ignore: 'arthrogeen' (NL)<br>Translation to English: artrogen |
| | | Ingore: 'arthrotec' |
| | | Ingore when 'gon' appears immediately before 'arthro', which makes: 'gonarthrosis' |
| | | Ingore when 'haem' appears immediately before 'arthro', which makes: 'haemarthros' |
| | | Ingore: 'arthrosator' |
| Slijt* | Stands for: slijtage (NL)<br>Translation into English: wear<br>Note: commonly used Dutch synonym for osteoarthritis | - |
| Verslet* | Stands for: versleten (NL)<br>Translation into English: wear<br>Note: commonly used Dutch a synonym for osteoarthritis | - |

**Additional rules**

- Keywords were excluded when they presented in combination with terms of negation (e.g. 'not' or 'no'), relatives (e.g. 'father has', 'mother has'), patient's anxiety for having hip OA, and expressions of uncertainties regarding the hip OA diagnosis by the GP or clinicians from primary or secondary care (e.g. 'probably', 'differential diagnostics').
- Remove whole sentence when 'WRS' (Dutch abbreviation for probably), 'WAARSCHIJNLIJK' (Dutch word for probably), 'WRSCH' (Dutch abbreviation for probably), or 'MGL' (Dutch abbreviation for probably) appears before a word in the list for hip osteoarthritis.
- Exclusion of hip joint or codified hip complaints in combination with OA and the following Dutch terms for the lower back or sacroiliac joint:
  - "lage rug"
  - "lage rugpijn"
  - "lage-rug"
  - "lwk"
  - "lumbale wervel kolom"
  - "onder rug"
  - "onderrug"
  - "SI"

# SUPPLEMENTARY FILE 4.

## Prevalence and incidence estimates of hip OA based on codified data and narrative data alone

**A. Prevalence of hip OA based on codified data versus narrative data alone**

| | Codified data | | | | Narrative data alone | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] |
| 2008 | 218867 | 4580 | 2.09 [2.03-2.15] | 2.07 [2.06-2.08] | 218867 | 4339 | 1.98 [1.92-2.04] | 1.96 [1.96-1.97] |
| 2009 | 334603 | 7501 | 2.24 [2.19-2.29] | 2.23 [2.22-2.24] | 334603 | 6627 | 1.98 [1.93-2.03] | 1.97 [1.96-1.98] |
| 2010 | 418845 | 10263 | 2.45 [2.40-2.50] | 2.43 [2.42-2.44] | 418845 | 8871 | 2.12 [2.07-2.16] | 2.10 [2.09-2.11] |
| 2011 | 529463 | 14312 | 2.70 [2.66-2.75] | 2.67 [2.66-2.68] | 529463 | 12330 | 2.33 [2.29-2.37] | 2.30 [2.29-2.31] |
| 2012 | 639336 | 18421 | 2.88 [2.84-2.92] | 2.86 [2.85-2.87] | 639336 | 15668 | 2.45 [2.41-2.49] | 2.43 [2.42-2.44] |
| 2013 | 578029 | 17799 | 3.08 [3.03-3.12] | 3.07 [3.06-3.08] | 578029 | 14067 | 2.43 [2.39-2.47] | 2.43 [2.42-2.43] |
| 2014 | 675460 | 22351 | 3.31 [3.27-3.35] | 3.30 [3.29-3.31] | 675460 | 17159 | 2.54 [2.50-2.58] | 2.53 [2.52-2.54] |
| 2015 | 767821 | 26678 | 3.47 [3.43-3.52] | 3.47 [3.46-3.48] | 767821 | 20307 | 2.64 [2.61-2.68] | 2.64 [2.63-2.65] |
| 2016 | 834741 | 30414 | 3.64 [3.60-3.68] | 3.62 [3.61-3.63] | 834741 | 23451 | 2.81 [2.77-2.85] | 2.79 [2.78-2.80] |
| 2017 | 859855 | 32564 | 3.79 [3.75-3.83] | 3.76 [3.75-3.77] | 859855 | 25556 | 2.97 [2.94-3.01] | 2.95 [2.94-2.96] |
| 2018 | 838538 | 33299 | 3.97 [3.93-4.01] | 3.92 [3.90-3.93] | 838538 | 26758 | 3.19 [3.15-3.23] | 3.14 [3.13-3.15] |
| 2019 | 767159 | 31444 | 4.10 [4.05-4.14] | 4.01 [4.00-4.02] | 767159 | 26074 | 3.40 [3.36-3.44] | 3.33 [3.32-3.34] |

**Notes.** Standardized prevalence proportions are standardized for age and sex distribution of the total population from the Netherlands.

**B. Incidence rates of hip OA based on codified data versus narrative data alone**

| | Codified data | | | | Narrative data alone | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 205157 | 751 | 3.66 [3.40-3.93] | 3.74 [3.70-3.78] | 205542 | 552 | 2.69 [2.47-2.92] | 2.72 [2.68-2.75] |
| 2009 | 315111 | 1171 | 3.72 [3.51-3.94] | 3.82 [3.79-3.86] | 316054 | 882 | 2.79 [2.61-2.98] | 2.84 [2.81-2.87] |
| 2010 | 395383 | 1496 | 3.78 [3.59-3.98] | 3.90 [3.86-3.93] | 396799 | 1230 | 3.10 [2.93-3.28] | 3.14 [3.10-3.17] |
| 2011 | 489847 | 1935 | 3.95 [3.78-4.13] | 4.08 [4.04-4.11] | 491749 | 1605 | 3.26 [3.11-3.43] | 3.30 [3.27-3.34] |
| 2012 | 597691 | 2339 | 3.91 [3.76-4.08] | 4.04 [4.01-4.08] | 600392 | 1755 | 2.92 [2.79-3.06] | 2.96 [2.93-2.99] |
| 2013 | 576380 | 2315 | 4.02 [3.85-4.18] | 4.19 [4.15-4.23] | 580037 | 1729 | 2.98 [2.84-3.12] | 3.03 [2.99-3.06] |
| 2014 | 634653 | 2353 | 3.71 [3.56-3.86] | 3.87 [3.83-3.90] | 639735 | 1890 | 2.95 [2.82-3.09] | 3.01 [2.98-3.04] |
| 2015 | 727908 | 2562 | 3.52 [3.38-3.66] | 3.70 [3.66-3.74] | 734255 | 2321 | 3.16 [3.03-3.29] | 3.23 [3.19-3.26] |
| 2016 | 798842 | 2668 | 3.34 [3.21-3.47] | 3.49 [3.46-3.53] | 805820 | 2494 | 3.09 [2.97-3.22] | 3.15 [3.11-3.18] |
| 2017 | 827009 | 2818 | 3.41 [3.28-3.54] | 3.56 [3.52-3.59] | 834087 | 2870 | 3.44 [3.32-3.57] | 3.49 [3.45-3.52] |
| 2018 | 801449 | 2617 | 3.27 [3.14-3.39] | 3.39 [3.36-3.43] | 807950 | 2741 | 3.39 [3.27-3.52] | 3.42 [3.39-3.46] |
| 2019 | 757419 | 2358 | 3.11 [2.99-3.24] | 3.22 [3.19-3.25] | 762998 | 2924 | 3.83 [3.69-3.97] | 3.86 [3.82-3.89] |

**Notes.** Standardized incidence rates are standardized for age and sex distribution of the total population from the Netherlands.

# SUPPLEMENTARY FILE 5.

## Prevalence and incidence estimates of hip OA, stratified by sex

### A. Prevalence of hip OA based on codified data and narrative data alone, stratified by sex

| | Codified hip OA | | | | | | | | Narratively diagnosed hip OA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | | Men | | | | Women | | | |
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] |
| 2008 | 105096 | 1471 | 1.40 [1.33-1.47] | 1.35 [1.34-1.36] | 113771 | 3109 | 2.73 [2.64-2.83] | 2.75 [2.73-2.76] | 105096 | 1461 | 1.39 [1.32-1.46] | 1.35 [1.34-1.36] | 113771 | 2878 | 2.53 [2.44-2.62] | 2.55 [2.53-2.56] |
| 2009 | 160451 | 2430 | 1.51 [1.45-1.58] | 1.47 [1.46-1.48] | 174152 | 5071 | 2.91 [2.83-2.99] | 2.94 [2.93-2.96] | 160451 | 2252 | 1.40 [1.35-1.46] | 1.36 [1.35-1.37] | 174152 | 4375 | 2.51 [2.44-2.59] | 2.54 [2.53-2.55] |
| 2010 | 201064 | 3321 | 1.65 [1.60-1.71] | 1.60 [1.59-1.61] | 217781 | 6942 | 3.19 [3.11-3.26] | 3.21 [3.20-3.23] | 201064 | 3040 | 1.51 [1.46-1.57] | 1.47 [1.46-1.48] | 217781 | 5831 | 2.68 [2.61-2.75] | 2.70 [2.68-2.71] |
| 2011 | 253594 | 4694 | 1.85 [1.80-1.90] | 1.79 [1.78-1.80] | 275869 | 9618 | 3.49 [3.42-3.56] | 3.51 [3.49-3.52] | 253594 | 4260 | 1.68 [1.63-1.73] | 1.63 [1.62-1.64] | 275869 | 8070 | 2.93 [2.86-2.99] | 2.94 [2.93-2.95] |
| 2012 | 306476 | 6175 | 2.01 [1.96-2.07] | 1.95 [1.94-1.96] | 332860 | 12246 | 3.68 [3.61-3.74] | 3.71 [3.70-3.73] | 306476 | 5513 | 1.80 [1.75-1.85] | 1.75 [1.74-1.76] | 332860 | 10155 | 3.05 [2.99-3.11] | 3.08 [3.06-3.09] |
| 2013 | 277068 | 5969 | 2.15 [2.10-2.21] | 2.10 [2.09-2.11] | 300961 | 11830 | 3.93 [3.86-4.00] | 3.99 [3.97-4.01] | 277068 | 4985 | 1.80 [1.75-1.85] | 1.76 [1.75-1.77] | 300961 | 9082 | 3.02 [2.96-3.08] | 3.06 [3.04-3.07] |
| 2014 | 324167 | 7607 | 2.35 [2.29-2.40] | 2.29 [2.27-2.30] | 351293 | 14744 | 4.20 [4.13-4.27] | 4.27 [4.25-4.28] | 324167 | 6158 | 1.90 [1.85-1.95] | 1.86 [1.84-1.87] | 351293 | 11001 | 3.13 [3.07-3.19] | 3.17 [3.16-3.19] |
| 2015 | 369044 | 9231 | 2.50 [2.45-2.55] | 2.44 [2.43-2.46] | 398777 | 17447 | 4.38 [4.31-4.44] | 4.45 [4.43-4.47] | 369044 | 7340 | 1.99 [1.94-2.03] | 1.95 [1.94-1.96] | 398777 | 12967 | 3.25 [3.20-3.31] | 3.30 [3.28-3.31] |
| 2016 | 401299 | 10612 | 2.64 [2.59-2.70] | 2.56 [2.55-2.58] | 433442 | 19802 | 4.57 [4.51-4.63] | 4.63 [4.62-4.65] | 401299 | 8574 | 2.14 [2.09-2.18] | 2.08 [2.07-2.09] | 433442 | 14877 | 3.43 [3.38-3.49] | 3.47 [3.45-3.48] |
| 2017 | 413127 | 11414 | 2.76 [2.71-2.81] | 2.67 [2.66-2.68] | 446728 | 21150 | 4.73 [4.67-4.80] | 4.80 [4.78-4.82] | 413127 | 9323 | 2.26 [2.21-2.30] | 2.19 [2.18-2.20] | 446728 | 16233 | 3.63 [3.58-3.69] | 3.67 [3.65-3.68] |
| 2018 | 402437 | 11711 | 2.91 [2.86-2.96] | 2.80 [2.79-2.82] | 436101 | 21588 | 4.95 [4.88-5.02] | 4.98 [4.96-5.00] | 402437 | 9780 | 2.43 [2.38-2.48] | 2.35 [2.34-2.36] | 436101 | 16978 | 3.89 [3.83-3.95] | 3.90 [3.88-3.92] |
| 2019 | 368332 | 11136 | 3.02 [2.97-3.08] | 2.89 [2.88-2.91] | 398827 | 20308 | 5.09 [5.02-5.16] | 5.08 [5.06-5.10] | 368332 | 9467 | 2.57 [2.52-2.62] | 2.47 [2.46-2.49] | 398827 | 16607 | 4.16 [4.10-4.23] | 4.14 [4.13-4.16] |

**Notes.** Standardized prevalence proportions are standardized for age.

## B. Incidence of hip OA based on codified data and narrative data alone, stratified by sex

| | Codified hip OA | | | | | | | | Narratively diagnosed hip OA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | | Men | | | | Women | | | |
| Year | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 99224 | 286 | 2.88 [2.56-3.24] | 2.83 [2.79-2.88] | 105933 | 465 | 4.39 [4.00-4.81] | 4.60 [4.54-4.65] | 99268 | 216 | 2.18 [1.90-2.49] | 2.14 [2.10-2.18] | 106274 | 336 | 3.16 [2.83-3.52] | 3.26 [3.21-3.31] |
| 2009 | 152231 | 372 | 2.44 [2.20-2.71] | 2.42 [2.38-2.46] | 162880 | 799 | 4.91 [4.57-5.26] | 5.15 [5.09-5.21] | 152419 | 293 | 1.92 [1.71-2.16] | 1.90 [1.86-1.94] | 163635 | 589 | 3.60 [3.31-3.90] | 3.73 [3.68-3.79] |
| 2010 | 191339 | 515 | 2.69 [2.46-2.93] | 2.67 [2.62-2.71] | 204044 | 981 | 4.81 [4.51-5.12] | 5.06 [5.00-5.12] | 191618 | 480 | 2.50 [2.29-2.74] | 2.48 [2.44-2.52] | 205181 | 750 | 3.66 [3.40-3.93] | 3.76 [3.71-3.82] |
| 2011 | 236950 | 675 | 2.85 [2.64-3.07] | 2.83 [2.78-2.88] | 252897 | 1260 | 4.98 [4.71-5.27] | 5.26 [5.20-5.32] | 237356 | 560 | 2.36 [2.17-2.56] | 2.34 [2.30-2.38] | 254393 | 1045 | 4.11 [3.86-4.36] | 4.22 [4.17-4.27] |
| 2012 | 289072 | 800 | 2.77 [2.58-2.97] | 2.75 [2.71-2.80] | 308619 | 1539 | 4.99 [4.74-5.24] | 5.27 [5.21-5.33] | 289702 | 675 | 2.33 [2.16-2.51] | 2.31 [2.27-2.35] | 310690 | 1080 | 3.48 [3.27-3.69] | 3.58 [3.53-3.63] |
| 2013 | 278944 | 781 | 2.80 [2.61-3.00] | 2.80 [2.76-2.85] | 297436 | 1534 | 5.16 [4.90-5.42] | 5.51 [5.44-5.57] | 279889 | 643 | 2.30 [2.12-2.48] | 2.29 [2.25-2.33] | 300148 | 1086 | 3.62 [3.41-3.84] | 3.73 [3.68-3.78] |
| 2014 | 307615 | 853 | 2.77 [2.59-2.97] | 2.79 [2.74-2.83] | 327038 | 1500 | 4.59 [4.36-4.82] | 4.89 [4.83-4.95] | 309026 | 689 | 2.23 [2.07-2.40] | 2.22 [2.18-2.26] | 330709 | 1201 | 3.63 [3.43-3.84] | 3.76 [3.71-3.81] |
| 2015 | 353225 | 891 | 2.52 [2.36-2.69] | 2.55 [2.50-2.59] | 374683 | 1671 | 4.46 [4.25-4.68] | 4.80 [4.74-4.85] | 355123 | 869 | 2.45 [2.29-2.62] | 2.45 [2.40-2.49] | 379132 | 1452 | 3.83 [3.64-4.03] | 3.97 [3.92-4.02] |
| 2016 | 387944 | 984 | 2.54 [2.38-2.70] | 2.55 [2.50-2.59] | 410898 | 1684 | 4.10 [3.90-4.30] | 4.40 [4.34-4.45] | 389992 | 928 | 2.38 [2.23-2.54] | 2.36 2.32-2.41] | 415828 | 1566 | 3.77 [3.58-3.96] | 3.89 [3.84-3.94] |
| 2017 | 401588 | 1050 | 2.61 [2.46-2.78] | 2.62 [2.58-2.66] | 425421 | 1768 | 4.16 [3.96-4.35] | 4.45 [4.40-4.51] | 403672 | 1093 | 2.71 [2.55-2.87] | 2.69 [2.64-2.73] | 430415 | 1777 | 4.13 [3.94-4.33] | 4.25 [4.20-4.31] |
| 2018 | 388877 | 1010 | 2.60 [2.44-2.76] | 2.59 [2.55-2.64] | 412572 | 1607 | 3.90 [3.71-4.09] | 4.16 [4.11-4.21] | 390804 | 1033 | 2.64 [2.48-2.81] | 2.62 [2.57-2.66] | 417146 | 1708 | 4.09 [3.90-4.29] | 4.20 [4.14-4.25] |
| 2019 | 367768 | 842 | 2.29 [2.14-2.45] | 2.28 [2.24-2.32] | 389651 | 1516 | 3.89 [3.70-4.09] | 4.12 [4.07-4.17] | 369479 | 1031 | 2.79 [2.62-2.97] | 2.76 [2.71-2.80] | 393519 | 1893 | 4.81 [4.60-5.03] | 4.91 [4.85-4.97] |

**Notes.** Standardized incidence rates are standardized for age.

## C. Prevalence and incidence estimates of hip OA based on a combination of codified and narrative data, stratified by sex

| | Prevalence | | | | | | | | Incidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | Women | | | | Men | | | | Women | | | |
| Year | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Eligible people | Cases | Crude prevalence [95% CI] | Standardized prevalence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] | Person-years | Cases | Crude incidence [95% CI] | Standardized incidence [95% CI] |
| 2008 | 105096 | 2932 | 2.79 [2.69-2.89] | 2.70 [2.69-2.71] | 113771 | 5987 | 5.26 [5.13-5.40] | 5.29 [5.27-5.31] | 97814 | 502 | 5.13 [4.69-5.60] | 5.13 [5.06-5.19] | 103176 | 801 | 7.76 [7.24-8.32] | 8.45 [8.37-8.53] |
| 2009 | 160451 | 4682 | 2.92 [2.84-3.00] | 2.83 [2.82-2.85] | 174152 | 9446 | 5.42 [5.32-5.53] | 5.49 [5.47-5.50] | 150029 | 665 | 4.43 [4.10-4.78] | 4.46 [4.40-4.52] | 158595 | 1388 | 8.75 [8.30-9.22] | 9.57 [9.49-9.65] |
| 2010 | 201064 | 6361 | 3.16 [3.09-3.24] | 3.06 [3.05-3.08] | 217781 | 12773 | 5.87 [5.76-5.97] | 5.91 [5.89-5.93] | 188371 | 995 | 5.28 [4.96-5.62] | 5.32 [5.26-5.39] | 198365 | 1731 | 8.73 [8.32-9.15] | 9.53 [9.45-9.61] |
| 2011 | 253594 | 8954 | 3.53 [3.46-3.60] | 3.43 [3.41-3.44] | 275869 | 17688 | 6.41 [6.32-6.51] | 6.45 [6.42-6.47] | 232870 | 1235 | 5.30 [5.01-5.61] | 5.38 [5.32-5.44] | 245225 | 2305 | 9.40 [9.02-9.79] | 10.27 [10.19-10.36] |
| 2012 | 306476 | 11688 | 3.81 [3.74-3.88] | 3.70 [3.68-3.71] | 332860 | 22401 | 6.73 [6.64-6.82] | 6.79 [6.77-6.81] | 283740 | 1475 | 5.20 [4.94-5.47] | 5.27 [5.21-5.34] | 298814 | 2619 | 8.76 [8.43-9.11] | 9.64 [9.55-9.72] |
| 2013 | 277068 | 10954 | 3.95 [3.88-4.03] | 3.86 [3.85-3.88] | 300961 | 20912 | 6.95 [6.85-7.04] | 7.05 [7.03-7.07] | 273740 | 1424 | 5.20 [4.94-5.48] | 5.31 [5.25-5.38] | 287926 | 2620 | 9.10 [8.75-9.45] | 10.08 [10.00-10.16] |
| 2014 | 324167 | 13765 | 4.25 [4.18-4.32] | 4.14 [4.13-4.16] | 351293 | 25745 | 7.33 [7.24-7.42] | 7.44 [7.42-7.46] | 301618 | 1542 | 5.11 [4.86-5.37] | 5.26 [5.19-5.32] | 316316 | 2701 | 8.54 [8.22-8.87] | 9.48 [9.40-9.56] |
| 2015 | 369044 | 16571 | 4.49 [4.42-4.56] | 4.39 [4.37-4.41] | 398777 | 30414 | 7.63 [7.54-7.71] | 7.75 [7.72-7.77] | 346024 | 1760 | 5.09 [4.85-5.33] | 5.24 [5.18-5.31] | 361942 | 3123 | 8.63 [8.33-8.94] | 9.65 [9.57-9.74] |
| 2016 | 401299 | 19186 | 4.78 [ 4.71-4.85] | 4.64 [4.63-4.66] | 433442 | 34679 | 8.00 [7.92-8.09] | 8.10 [8.08-8.12] | 379440 | 1912 | 5.04 [4.82-5.27] | 5.17 [5.11-5.23] | 396123 | 3250 | 8.20 [7.92-8.49] | 9.18 [9.10-9.26] |
| 2017 | 413127 | 20737 | 5.02 [4.95-5.09] | 4.86 [4.84-4.88] | 446728 | 37383 | 8.37 [8.28-8.45] | 8.47 [8.44-8.49] | 392255 | 2143 | 5.46 [5.23-5.70] | 5.60 [5.54-5.66] | 409213 | 3545 | 8.66 [8.38-8.95] | 9.67 [ 9.59-9.75] |
| 2018 | 402437 | 21491 | 5.34 [5.27-5.41] | 5.15 [5.13-5.17] | 436101 | 38566 | 8.84 [8.76-8.93] | 8.88 [8.85-8.90] | 379130 | 2043 | 5.39 [5.16-5.63] | 5.51 [5.45-5.58] | 395663 | 3315 | 8.38 [8.10-8.67] | 9.31 [9.23-9.39] |
| 2019 | 368332 | 20603 | 5.59 [5.52-5.67] | 5.37 [5.35-5.39] | 398827 | 36915 | 9.26 [9.16-9.35] | 9.22 [9.20-9.25] | 358048 | 1873 | 5.23 [5.00-5.47] | 5.36 [5.30-5.42] | 372629 | 3409 | 9.15 [8.84-9.46] | 10.09 [10.01-10.17] |

**Notes.** Standardized prevalence and incidence estimates are standardized for age.

# SUPPLEMENTARY FILE 6.
## Characteristics associated with codified hip OA diagnosis

| | **Codified hip OA (n=63470)** | **Narratively diagnosed hip OA alone (n=54288)** | **Multivariable analysis OR (95%CI)** ***Codified diagnosis vs narrative diagnosis alone*** |
|---|---|---|---|
| Age at hip OA hit, mean (SD) | 68.2 (11.7) | 65.4 (12.8) | - |
| Men, n (%) | 21757 (34.3) | 19559 (36.0) | 0.98 [0.96 – 1.01] |
| Hypertension, n (%) | 21636 (34.1) | 15857 (29.2) | **1.10 [1.07 – 1.13]** |
| Hyperlipidaemia, n (%) | 7314 (11.5) | 5210 (9.60) | **1.11 [1.07 – 1.15]** |
| Overweight, n (%) | 3791 (5.97) | 3322 (6.12) | 0.99 [0.95 – 1.04] |
| Diabetes mellitus, n (%) | 7843 (12.4) | 6362 (11.7) | **0.93 [0.90 – 0.97]** |
| Myocardial infarction/ angina pectoris, n (%) | 6752 (10.6) | 5051 (9.30) | 1.01 [0.97 – 1.05] |
| Stroke/TIA, n (%) | 3828 (6.03) | 3043 (5.61) | **0.92 [0.88 – 0.97]** |
| Peripheral arterial disease, n (%) | 1289 (2.03) | 989(1.82) | 0.98 [0.90 – 1.07] |
| COPD, n (%) | 3887(6.12) | 3128 (5.76) | 0.97 [0.92 – 1.02] |
| Asthma, n (%) | 4865 (7.67) | 4251 (7.83) | 0.98 [0.94 – 1.02] |
| Knee osteoarthritis, n (%) | 7334 (11.6) | 5139 (9.47) | **1.10 [1.05 – 1.14]** |
| Spinal osteoarthritis, n (%) | 3901 (6.15) | 2672 (4.92) | **1.13 [1.07 – 1.19]** |
| Low back pain with or without radiation, n (%) | 15603 (24.6) | 13902 (25.6) | **0.93 [0.91 – 0.96]** |

**Abbreviations:** OR= odds ratio; CI= confidence interval

**Notes.** Bold estimates are statistically significant at 5% level. Prior to the multivariable regression analysis, we checked used a variance inflation factor (VIF) to assess collinearity of the independent variables in the model. No collinearity was observed, as the VIF of all independent variables was <5 (range 1.02 to 1.20). Box-Tidwell test and restricted cubic spline plot showed nonlinearity between the independent variable age and logit of the outcome. A model with linear splines with knots at 4 percentiles that produced the best model fit based on the Akaike information criterion was used.

# CHAPTER 5

## Quality indicators for knee and hip osteoarthritis care: a systematic review

Ilgin G. Arslan, Rianne M. Rozendaal, Marienke van Middelkoop, Saskia A.G. Stitzinger, Maarten-Paul van de Kerkhove, Vincent M.I. Voorbrood, Patrick J.E. Bindels, Sita M.A. Bierma-Zeinstra, Dieuwke Schiphof

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## ABSTRACT

**Objective:** To provide an overview of quality indicators (QIs) for knee and hip osteoarthritis (KHOA) care and to highlight differences in healthcare settings.

**Methods:** A database search was conducted in MEDLINE (PubMed), EMBASE, CINAHL, Web of Science, Cochrane CENTRAL and Google Scholar, OpenGrey and Prospective Trial Register, up to March 2020. Studies developing or adapting existing QI(s) for patients with osteoarthritis were eligible for inclusion. Included studies were categorized into healthcare settings. QIs from included studies were categorized into structure, process, and outcome of care. Within these categories, QIs were grouped into themes (e.g. physical therapy). Narrative synthesis was used to describe differences and similarities between healthcare settings.

**Results:** We included 20 studies with a total of 196 QIs mostly related to the process of care in different healthcare settings. Few studies included patients' perspectives. Rigorous methods for evidence synthesis to develop QIs were rarely used. Narrative analysis showed differences in QIs between healthcare settings with regard to exercise therapy, weight counselling, referral to laboratory tests, and 'do not do' QIs. Differences within the same healthcare setting were identified on radiographic assessment.

**Conclusion:** The heterogeneity in QIs emphasize the necessity to carefully select QIs for KHOA depending on the healthcare setting. This review provides an overview of QIs outlined to their healthcare settings to support healthcare providers and policy makers in selecting the contextually appropriate QIs to validly monitor the quality of KHOA care. We strongly recommend to review QIs against the most recent guidelines before implementing them into practice.

## BACKGROUND

Osteoarthritis (OA) is one of the leading musculoskeletal causes of global disability, mainly affecting the knees and the hips.[1] The prevalence has increased worldwide with 32% between 2005 to 2015 and is expected to increase even more with the ageing of the population and the rising obesity rate. This will become a challenge for the health systems globally.[2-4]

Despite the presence of numerous consistent guidelines for the management of knee and hip OA (KHOA) [5-9], clinical practice shows a low consistency with following these recommendations leading to suboptimal care.[10, 11] Therefore, routinely monitoring of feedback on quality of care has been made high priority.[12] Quality indicators (QIs) are measurable elements that can be used to assess the quality of care. These QIs can be related to the characteristics of material and human resources of the healthcare (i.e. the structures), activities undertaken in the delivered healthcare (i.e. the process), and the changes in health status resulting from the delivered healthcare (i.e. the outcomes).[13-15]

Although the evidence-based recommendations for the management of KHOA are internationally similar, clinical practice is context-dependent and therefore varies between countries. In the Netherlands, Scandinavian countries and the United Kingdom, the content of KHOA treatment depends on the healthcare setting. Non-surgical management of KHOA is largely provided in primary care. For patients who do not respond successfully to this approach, a referral to secondary care for surgical management is indicated.[5, 16] This distinction in healthcare settings is less pronounced in other countries such as the United States (US), where the first point of contact and access to orthopaedic care strongly depend on patients' health insurance status.[17, 18] Previous research has shown that QIs cannot simply be transferred between countries, due to structural and cultural differences of healthcare systems.[19] This has led to a variety of QIs for OA care.

Several systematic reviews have focused on QIs for OA in primary care.[20, 21] However, an overview of QIs that take into account the differences in healthcare settings and countries is lacking. Such an overview will support healthcare providers and policy makers in selecting the contextually appropriate QIs. This will enable them to validly monitor and provide feedback on the quality of care.

Therefore, the aim of this systematic review was to provide an up-to-date overview of QIs for KHOA in which we outline the healthcare settings and countries for which the QIs have been developed or adapted.

# METHODS

This systematic review was conducted and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[22] A protocol for conducting this systematic review was developed a priori and is available on request.

**Search methods for identification of studies**

An electronic database search was conducted by a trained medical librarian up to March 2020, using MEDLINE (PubMed), EMBASE, CINAHL, Web of Science, Cochrane CENTRAL and Google Scholar databases. For unpublished and ongoing studies, a similar search was conducted in OpenGrey and the Prospective Trial Register database. A range of search terms related to OA (e.g. osteoarthrit*, hip, knee) combined with indicator terms (e.g. quality*, indicator, process, structure) were used to identify studies. Full details of the search strategy are provided in Supplementary File 1. The electronic database search involved no restrictions on healthcare setting, country, language, study design and publication status. Reference lists of studies were manually searched recursively until no additional eligible publications were identified.

**Criteria for considering studies for this review**

***Type of studies***

Studies about development of QI(s) and adaptation of existing QI(s) for another context were included (e.g. cross-sectional studies, literature reviews and Delphi studies). Reviews that contained QIs which were already included from other studies were excluded, as were conference abstracts and studies written in languages other than English, Scandinavian, Dutch, Turkish and German. Studies published before January 2000 were excluded, since they may contain QIs that are more likely to be outdated and may therefore include treatment modalities that are no longer recommended. Studies focusing on patients with OA and other diseases (e.g. rheumatoid arthritis (RA)) were included if QIs about OA were presented separately.

***Type of QIs***

QIs for OA care, either specifically in the knees and hips or OA not related to specific sites, were extracted from the studies. QIs that measure post-surgical healthcare (e.g. after joint replacement) were excluded. Various types of individuals (e.g. patients, healthcare providers, or healthcare managers) could be involved in the adaptation or development process of the QIs, resulting in QIs from various perspectives of stakeholders.[13, 23] QIs from all types of perspectives were included in this review.

**Data collection and analysis**

All titles and abstracts were double and independently screened for their relevance (IGA plus DS or RR). Full-texts of potentially eligible studies were gathered and screened again by double independent review to check for their relevance (IGA plus DS or RR). Data from the included studies were extracted into a pre-tested data extraction form by one reviewer (IGA) and checked by another reviewer (DS or RR). The following data were extracted: general information about the study, healthcare setting, country, target population, involved joints (e.g. knee OA, hip OA, or any OA), perspective of QI(s), information of testing and implementation of the QI(s) if this was done in the study, and the full QI(s). Furthermore, methods of evidence synthesis and consensus method were extracted. An evidence synthesis using a systematic review and consensus method using a RAND Appropriateness Method or a Delphi method were considered as the most rigorous methods.[24, 25] Possible conflict of interest due to funding and non-adherence to the study protocol were extracted and considered as a source of bias. Disagreements in data collection were resolved by consensus and if necessary by the third reviewer. The extracted QIs were then categorized into three categories according to Donabedian, which conceptualizes quality of care through the structures, processes and outcomes of care (Supplementary File 2).[13, 14] Structure QIs refer to attributes of material and human resources used for providing care (e.g. percentage of specialists among all doctors). Process QIs reflect the activities undertaken in the delivered care (e.g. percentage of patients who are offered exercise therapy among all patients). Outcome QIs refer to changes in health status as a result of the delivered care (e.g. percentage of patients with functional improvement among all patients). Within these three categories, QIs were grouped in themes (e.g. QIs for medication, QIs for weight loss, etc.). For the purpose of narrative analysis, we categorized studies into healthcare settings, for example primary care setting or secondary care setting. Within each category and theme, differences and similarities between the healthcare settings were analysed and summarized. Authors of studies (n=3, response rate=100%) were contacted for additional information for the data collection and analysis.

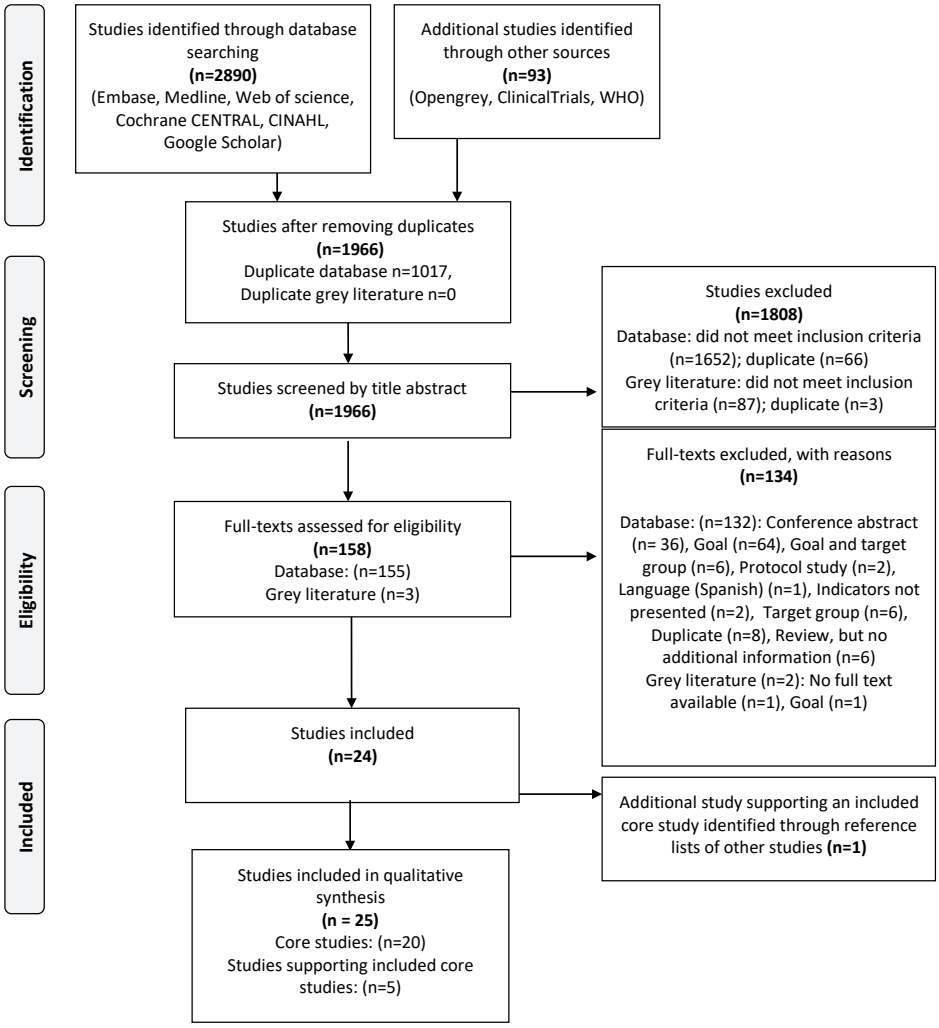


## RESULTS

**Results of the search**

The search strategy identified 1,966 studies, after removing duplicates (Figure 1). After screening on title and abstract, 1,808 studies were excluded. The remaining 158 studies were screened on full-texts, of which 24 studies were included. One additional study[26] was identified through reference lists of included studies. The main reasons for exclusion on full-text are listed

in Supplementary File 3. Of the 25 included studies, five studies[26-30] described the methods of other already included studies (i.e. core studies) in detail. We did not exclude these studies, but used them as supporting studies for data extraction and analyses, as they contained additional information not reported in the core studies.




From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta- Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

**FIGURE 1.** Flow chart for the selection of studies

**Characteristics of the studies included**

***Methods of development of QI(s) or adaptation of existing QI(s)***

The characteristics of the studies included are summarized in Table 1 and more detailed in Supplementary File 4. Only five out of 20 studies (25%) included an evidence synthesis for the QIs using a systematic review[31-35]. Consensus on QIs during the development phase was mostly done using a (modified) RAND Appropriateness Method[19, 31-34, 36-40] or Delphi method[41, 42]. The remaining studies used less rigorous methods[35, 43-46] or did not specify the methods[47, 48]. Four studies[36, 44-46] tested the reliability of the QIs. Eleven studies[19, 36, 37, 43, 44, 46-48] evaluated the feasibility of QIs in practice and three studies[34, 38, 39] through judgment by an expert panel. Although not every study reported information on conflict of interest, the reviewers judged most of the studies unlikely to have conflict of interest. No study protocols of the studies included were available, hence no judgement about adherence to the protocol could be made. All studies included QIs in the process of care category. Three studies[34, 35, 43] included QIs in the process and outcome category, and only one study[34] in all three categories. Information on healthcare perspectives of the QIs (i.e. types of individuals involved with the development/adaptation process of the QIs) was often not reported. Studies that reported the healthcare perspectives for developing QIs or adapting existing QIs mostly involved the perspectives of healthcare professionals[19, 34, 37-39, 44, 49] and researchers[43, 46, 50], and in a few cases the perspectives of patients[34, 35] and healthcare organizations[34]. QIs were often developed to measure the quality of care with data from paper or electronic records. Some studies[35, 38] developed QIs to measure the quality of care with data from patient or physiotherapist-reported forms[43, 44, 46] or a mixture of patients or proxy interviews and medical records[31, 33, 50].

**TABLE 1.** Characteristics of the studies included (n=20 studies)

| Study | Perspective of quality of care | Level of care | Proposed method of QI derivation | Evidence synthesis | Consensus method | Testing/ implementation |
|---|---|---|---|---|---|---|
| Asch 2004 [36] | NR | Process | Medical records | Literature review, not specified to be systematic | RAND approach/ modified Delphi method | Implemented in 12 Veterans Health Administration care systems and 12 US communities. Average reliability: presence of a condition (κ = 0.83), indicator eligibility (κ = 0.76), and indicator scoring (κ = 0.80) |
| Barber 2016 [34] | Healthcare professionals, organizational, and patients | Structure, process and outcome | NR | Integrative review including an update of an earlier conducted systematic review | Modified RAND-UCLA Appropriateness Method | Feasibility assessed by the expert panel during the Delphi rounds. |
| Blackburn 2016 [35] | Patients | Process and outcome | Patient-reported questionnaire | Used an earlier published systematic review[21] | Four discussion groups with the research team | Not tested/implemented |
| Broadbent 2008 [48] | NR | Process | Medical records | Used QIs of a published study(6), and of the National Primary Care Research and Development Centre. | NR | QIs implemented in 18 general practices in the UK |
| Doubova 2015 [37] | Healthcare professional | Process | Electronic health records | Literature review, not specified to be systematic | Modified RAND/UCLA Appropriateness Method | QIs implemented cross-sectional in four family medicine clinics in Mexico City |
| Grypdonck 2014 [49] | Healthcare professional | Process | NR | Literature review, not specified to be systematic | RAND-modified Delphi method | Not tested/implemented |
| Hardcastle 2015 [38] | Healthcare professional | Process | Patient interview surveys | Used QIs of an earlier published study[40] | Modified RAND/UCLA appropriateness method | Feasibility of the survey use assessed by an expert panel of clinicians |
| Jansen 2010 [43] | Researchers | Process and outcome | Physiotherapist self-reported recording forms | QIs were derived from the Dutch physiotherapy guideline on KHOA | Independent assessment of QIs by two authors | QIs implemented by 27 physical therapists who recorded patient and treatment characteristics of at least five consecutive patients. |

| | | | | | | |
|---|---|---|---|---|---|---|
| MacLean 2001 [31]: ACOVE-1 (supporting article: Shekelle 2001 [26]) | NR | Process | Medical records, administrative data and patient or proxy interview | Systematic review | Modified RAND/UCLA Appropriateness Method | Not tested/implemented. |
| MacLean 2004 [33]: ACOVE-2 (supporting article: Pencharz 2004 [29]) | NR | Process | Medical records, administrative data, and/or patient or proxy interview | Systematic review | Modified RAND/UCLA appropriateness method | Not tested/implemented |
| MacLean 2007 [32]: ACOVE-3 | Healthcare professionals | Process | Medical records, administrative data, and/or patient or proxy interview | Systematic review | Modified RAND/UCLA appropriateness method | Not tested/implemented |
| Marshall 2003 [19] | Healthcare professionals | Process | Electronic and paper records from the general practice | Literature review, not specified to be systematic | RAND/UCLA appropriateness method | Field-testing on 1600 randomly selected patient records in 16 general practices |
| Moore 2000 [39] | Healthcare professionals | Process | Medical records | Literature review, not specified to be systematic | RAND/UCLA appropriateness method | Feasibility of the QIs assessed by the expert panel |
| Østerås 2018 [46] (supporting article: Østerås 2013 [30]) | Researchers | Process | Patient self-reported questionnaire | Literature review, not specified to be systematic | Critical judgement by researchers and national and international colleagues that used the questionnaire in different settings | Feasibility of QIs assessed during 2010-2014 in a Norwegian OA cohort (V1). Revised version, the OA-QI v2, was then pilot-tested by 11 of the members in the Patient Research Partner Panel at Diakonhjemmet Hospital. Test-retest κ=0.38–0.85, exact agreement from 69–92%. The ICC for all 16 items was 0.89. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Peter 2013 [44] | Healthcare providers | Process | PT self-reported online questionnaire | QIs derived from the Dutch physiotherapy guideline on KHOA | Rating of recommendations of guideline by an expert panel of PTs | Pilot-tested by 15 PTs and three experts. Consecutively, pilot test done among expert (n= 51) and PTs (n=192) in the Netherlands. Test–retest reliability : ICC = 0.89. |
| Saliba 2004 [42] | NR | Process | Not reported | Adapted ACOVE-1 set for nursing homes | Modified Delphi process | Not tested/implemented |
| Smith 2007 [41] | NR | Process | Not reported | Adapted ACOVE-1 set for home-based care | Modified Delphi process | Not tested/implemented |
| Steel et al. (2004)[40] | NR | Process | Medical records | Adapted ACOVE-1 set for UK healthcare system | Modified RAND/UCLA appropriateness method | Not tested/implemented |
| Vanden-berghe 2004 [47] | NR | Process | Paper registration sheets or electronic patient records | NR | NR | QIs implemented cross-sectionally in the general practices in Belgium and compared between a pooled and restricted database. |
| Wierenga 2011 [45] | NR | Process | Medical records and a hospital information system | Adapted ACOVE-1 set for in-hospital pharmaceutical care | Expert panel review methods | Feasibility assessment with ten elderly patients. Reliability tested with ten randomly selected patients; κ = 0.88 (95%CI=0.75, 1.00); ICC= 0.80 (95%CI=0.63, 0.90). |

**Notes.** More information on the data-extraction and quality assessment for each study is provided in Supplementary File 3.

**Abbreviations:** ACOVE, Assessing Care of Vulnerable Elders; ICC, Intraclass Correlation Coefficient; KHOA, knee and hip osteoarthritis; NR, not reported; OA, osteoarthritis; PT, physiotherapist; RA, rheumatoid arthritis

*Healthcare settings*

Studies were categorized into five healthcare settings: primary care (n=10), secondary care (n=3), the entire spectrum of disciplines (n=8) and centralized intake care (n=1) (Table 2). Nine studies[19, 35, 37, 40, 41, 43, 44, 47, 48] developed QIs for primary care, mainly on healthcare in general practice and physiotherapy care. Three studies developed QIs for secondary care in the US[42], the Netherlands[45] and the UK[40]. We categorized eight studies as targeting the entire spectrum of disciplines, since they did not focus on a specific healthcare setting. Five of those[31-33, 36, 39] developed QIs for the healthcare system in the US, of which three[31-33] developed the Assessing Care of Vulnerable Elders (ACOVE) QI set. Of the remaining studies targeting the entire spectrum of disciplines, one study[49] was conducted in Belgium, one study[38] focused on UK private households and one study[46] on the Norwegian healthcare system. Another study[34] developed QIs for a relatively new and exceptional system in Canada; the centralized intake care. This system pools patients into a single queue, assesses the nature and urgency of referral and prioritizes the access to care based on this assessment.

**Narrative synthesis**

A total of 196 QIs were derived from the included studies. See Supplementary File 5 for a detailed description of the QIs with the actual wordings as stated in the original studies, grouped by category and theme.

*Quality indicators about the structure of care*

With respect to the structure of care, one study[34] developed three QIs for centralized intake care in Canada concerning the completion of appointments as scheduled, number of specialist providers participating in centralized intake and clinic capacity of the OA teams (Table 3).

**TABLE 2.** Included studies (n=20) categorized according to their healthcare setting

| Study | Target population | Country |
|---|---|---|
| | ***Primary care*** | |
| Blackburn 2016 [35] | Patients with OA in primary care setting | UK |
| Broadbent 2008 [48] | Patients with OA in general practice | UK |
| Doubova 2015 [37] | Patients with KHOA aged ≥19 in family medicine | Mexico |
| Jansen 2010 [43] | Patients with KHOA in PT care | The Netherlands |
| Marshall 2003 [19] | Patients with OA in general practice | UK |
| Peter 2013 [44] | Patients with KHOA in PT care | The Netherlands |
| Smith 2007 [41] | Housebound elderly patients in home-based primary care | US |
| Steel 2004 [40]* | People aged 65 and with OA in primary and secondary care | UK |
| Vandenberghe 2004 [47] | Patients with OA of aged ≥60 in general practice | Belgium |
| | ***Secondary care*** | |
| Saliba 2004 [42] | Institutionalized vulnerable elderly with OA in nursing homes | US |
| Steel 2004 [40]* | People aged 65 and with OA in primary and secondary care | UK |
| Wierenga 2011 [45] | Elderly hospitalized patients with OA from in-hospital pharmaceutical care | The Netherlands |
| | ***The entire spectrum of disciplines*** | |
| Asch 2004 [36] | Patients of outpatient and inpatient care for acute and chronic conditions and preventive care (including OA) | US |
| Grypdonck 2014 [49] | Patients with knee OA across the entire spectrum of disciplines | No country specified |
| Hardcastle 2015 [38] | People with OA aged ≥50 living in private households | UK |
| MacLean 2001 [31] | Vulnerable elderly with OA | US |
| MacLean 2004 [33] | Patients with OA | US |
| MacLean 2007 [32] | Vulnerable elderly with OA | US |
| Moore 2000 [39] | Patients with OA | US |
| Osteras 2018 [46] | Patients with OA | Norway |
| | ***Centralized intake care system*** | |
| Barber 2016 [34] | Patients with RA and/or OA in centralized intake care system | Canada |

*Steel 2004 [40] is listed twice in the table, as it focuses on 'primary care' and 'secondary care'.

**Abbreviations:** PT, physiotherapy

**TABLE 3.** Quality indicators on structure of care (n=3)

| Theme | Subtheme (number of QIs) | Healthcare setting and country |
|---|---|---|
| Musculoskeletal appointments | Musculoskeletal appointments completed as scheduled (n=1) | Centralized intake care system in Canada[34] |
| Healthcare providers involved | Specialist providers participating in centralized intake (n=1) | Centralized intake care system in Canada[34] |
| Estimation of clinic capacity | Ratio of patient flow to estimated clinic capacity of OA teams participating in centralized intake (n=1) | Centralized intake care system in Canada[34] |

***Quality indicators about the process of care***

Regarding the process of care, we identified QIs on 10 different themes (Table 4).

1. History taking and examination (n=32 QIs)

QIs on assessment of functional status and level of pain were most common and focused on all healthcare settings, except for centralized intake care. QIs on assessment for assistive devices, appliances and aids, and radiographic assessment also focused on the entire spectrum of disciplines, except for centralized intake care. Differences were seen in the indication for radiographic assessment; from offering an radiography to patients with incident hip OA to only offering a radiograph to patients with worsening complaints or patients who seem resistant to conservative treatment. QIs on diagnostic aspiration of the joint and examination of joint before drug use were less common and focused on the US only. QIs relating to history taking and health assessment to evaluate the given treatment were mainly described for (physiotherapy) primary care settings in Europe.

2. Education and information (n=22 QIs)

QIs on this theme related to information on the pathology of OA, treatment options and self-management and were similar between countries. Most QIs on this theme were developed for primary care (physiotherapy) in the Netherlands, but least for secondary care and healthcare in the US.

3. Exercise therapy (n=25 QIs)

QIs regarding exercise therapy were mostly developed for primary care on recommending and prescribing physiotherapy or specific exercises and were similar between countries. Three QIs focusing on the entire spectrum of disciplines were found regarding the frequency and regular evaluations of exercise therapy sessions, and regarding tailoring exercise therapy to patients goals.

4. Weight counselling (n=7)

QIs for advice on weight loss were developed for primary care and the entire spectrum of disciplines. Body Mass Index (BMI) threshold and frequency for advising patients to lose weight differed between QIs for the entire spectrum of disciplines in the US and QIs for family medicine in Mexico (>25 kg/m2 versus >27 kg/m2, and at least once in two years versus annually).

5. 'Do not do' QIs (n=3)

Two QIs for primary care (physiotherapy) in the Netherlands focused on recommending against massage and physical modalities other than Transcutaneous Electrical Nerve Stimulation. One QI for the entire spectrum of disciplines focused on not prescribing a brace for people with knee OA, except for patients with unicompartmental knee OA with axial deviation.

6. Pharmacological treatment (n=51)

Most of the pharmacological treatment QIs were developed for primary care. These QIs were consistent in their content and covered; 1) the use of paracetamol as first-line pharmacologic therapy, 2) prescribing a trial of maximum-dose paracetamol before changing to a different oral agent, 3) non-steroidal anti-inflammatory drugs (NSAIDs) prescription, 4) NSAID prescription concomitant with either misoprostol or proton-pump inhibitor and 5) informing/screening patients about the risks of medication use. One additional QIs for the entire spectrum of disciplines in Norway focused on the indication of injections[46]. Four QIs focused on not using several drug types, mainly focusing on primary care. One QI covered not using strong opioids and one QI not using chondroitin and glucosamine-chondroitin[49]. A Norwegian study[46] formulated a QI that offering stronger pain killers in OA patients (e.g. co-proxamol, co-dydramol, tramadol, co-codamol, dihydrocodeine, codeine) in case of no sufficient pain relief by paracetamol reflects better quality of care.

7. Referrals (n=26)

Four QIs were found regarding referral of patients to exercise therapy/programs/activities in all studies included in this study, except in studies focusing on Mexico and the US. From the three QIs that focused on referral for weight loss services, only one[33] defined a specific threshold for BMI for the referral to weight loss services (US healthcare). QIs regarding the referral to an orthopaedic surgeon when patients do not respond sufficiently to non-surgical therapy were similar in all studies. There was only one QI for family medicine in Mexico regarding referral to laboratory test to detect possible adverse events[37]. The remaining QIs (n=6) focused on centralized intake care in Canada[34], for example regarding the agreement of centralized intake suspected diagnosis of severe OA cases versus confirmed diagnosis of severe OA.

8. Indication of surgery (n=4)

Only two studies developed QIs on the indication for surgical treatment. One study for the entire spectrum of disciplines[49] developed QIs for indications for different types of surgical treatments for knee OA (i.e. joint replacement and arthroscopic interventions) and one study[34] for centralized intake care system in Canada regarding operating room time. QIs regarding indications for surgical treatment for hip OA are lacking. Remarkably, studies that focused on secondary care[40, 45] did not develop QIs for the indications for surgical treatment.

9. Documentation (n=6)

Six QIs were found on documentation of information on measures from physical examination for the entire spectrum of disciplines in the US[36, 39] and on patients' characteristics for primary care (physiotherapy) in the Netherlands[43].

10. Treatment frequency, duration, follow up, and aftercare (n=6)

Although not all QIs on this theme defined a specific threshold, three QIs for primary care (physiotherapy) in the Netherlands and one for the entire spectrum of disciplines in the US healthcare specified a threshold for treatment frequency (<12 consultations), duration (<6 weeks), and follow up (every six weeks). The study on primary care (physiotherapy) in the Netherlands[43] was also the only one that developed a QI for aftercare, for example regarding home exercise programmes.

**TABLE 4.** Quality indicators on process of care (n=182)

| Theme | Subtheme (number of QIs) | Healthcare setting and country |
|---|---|---|
| History taking and examination (n=32) | Regular assessment of functional status and pain (n=9) | - Primary care in the UK, US and Norway[40, 41, 46, 48]<br>- Secondary care in the UK and US [40, 42]<br>- The entire spectrum of disciplines in the US [31, 33, 50] |
| | Assessment for assistive devices, appliances, and aids (n=6) | The entire spectrum of disciplines in the US and Norway [33, 46, 50] |
| | Radiographic assessment (n=3) | The entire spectrum of disciplines in the US and one study with unspecified country [33, 39, 49] |
| | Diagnostic aspiration (n=4) | - Primary care in the US [41]<br>- Secondary care in the US[42]<br>- The entire spectrum of disciplines in the US and one study with unspecified country [31, 49] |
| | Inventory of health-related problems (n=4) | - Primary care; PT care in the Netherlands[44]<br>- The entire spectrum of disciplines in Norway[46] |
| | Examination of joint before drug treatment (n=2) | - Secondary care in the US [42]<br>- The entire spectrum of disciplines in the US [33] |
| | Health assessment for evaluation of treatment (n=4) | Primary care ; PT care in the Netherlands [44] |
| Education and information (n=22) | Information and advice concerning pathology of OA, lifestyle, and physical activity formulated in detail (n=9) | - Primary care; PT care in the Netherlands [44]<br>- The entire spectrum of disciplines in Norway[46] |
| | Information concerning joint protection and the use of aids (n=1) | - Primary care; PT care in the Netherlands[44] |
| | Advise about medication (n=1) | - Primary care in the UK [35] |
| | Information concerning pathology of OA, treatment, and self-management formulated in general (n=10) | - Primary care in the UK [35, 40, 48]<br>- Secondary care in the UK [40]<br>- The entire spectrum of disciplines in the US, Norway and one study with unspecified country [31, 33, 38, 46, 49] |
| | Information regarding resources and tools while waiting for appointment (n=1) | Centralized intake care system in Canada [34] |
| Exercise therapy (n=25) | Exercise therapy, recommendation/prescription for activities, of strengthening, aerobic exercises, and functional exercises body functions and walking exercises (n=4) | Primary care in the UK and PT care in the Netherlands [35, 44] |
| | Recommendation/prescription (n=15) | - Primary care in the US, UK, Mexico and PT care in the Netherlands [41 37, 40, 44]<br>- Secondary care in the US and UK [40, 42]<br>- The entire spectrum of disciplines in the US, UK and one study with unspecified country [31-33, 38, 49] |
| | Recommendation of exercise therapy formulated in general (n=2) | The entire spectrum of disciplines in the US[36, 39] |

| Theme | Subtheme (number of QIs) | Healthcare setting and country |
|---|---|---|
| | Combining exercise therapy with education/self-management interventions, frequency and evaluation, and tailoring exercise therapy to patients' goals (n=4) | The entire spectrum of disciplines, country not specified[49] |
| Weight counselling (n=7) | Advice about body weight and joint pain (n=7) | - Primary care in the UK and Mexico [35, 37]<br>- The entire spectrum of disciplines in the US, Norway and one study with unspecified country [33, 39, 46, 49] |
| 'Do not do' QIs (n=3) | No massage therapy, no prescription of a brace and no physical modalities other than TENS (n=3) | - Primary care; PT care in the Netherlands [43]<br>- The entire spectrum of disciplines; country not specified[49] |
| Pharmacological treatment (n=51) | Paracetamol as first-line pharmacologic therapy (n=16) | - Primary care in the US, UK, Belgium and Mexico[19, 37, 40, 41, 47, 48]<br>- Secondary care in the Netherlands, UK and US[40, 42, 45]<br>- The entire spectrum of disciplines in the US, UK, Norway and one study with unspecified country [31-33, 36, 38, 39, 46, 49] |
| | Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent (n=7) | - Primary care in the UK and US[40, 41, 48]<br>- Secondary care in the US, UK and the Netherlands [40, 42, 45]<br>- The entire spectrum of disciplines in the US[31, 33] |
| | Prescription of NSAIDs and concomitant with either misoprostol or proton-pump inhibitor (n=15) | - Primary care in the UK, Belgium and Mexico[19, 37, 47, 48]<br>- The entire spectrum of discipline in the US and one study with unspecified country [31, 49, 50] |
| | Informing patients about risks of medication use and screening for side effects (n=8) | - Primary care in the US and UK [41, 48]<br>- The entire spectrum of disciplines in the US and Norway[31, 32, 46] |
| | Injection (n=1) | The entire spectrum of disciplines in Norway[46] |
| | No medication use of several drug types, i.e. chondroitin and glucosamine-chondroitin and strong pain killers such as opioids (n=4) | - Primary care in Belgium [47]<br>- The entire spectrum of disciplines in the US and Norway [46, 49] |
| Referrals (n=26) | Exercise therapy/programs/ activities (n=5) | - Primary care in the UK [35]<br>- The entire spectrum of disciplines in Norway and one study with unspecified country[46, 49] |
| | Weight loss services (n=3) | - Primary care in the UK [35]<br>- The entire spectrum of disciplines in the US and Norway[33, 46] |
| | Orthopaedic surgeon (n=8) | - Primary care in the UK[19, 40, 48]<br>- Secondary care in the UK[40]<br>- The entire spectrum of disciplines in the US and Norway[31-33, 38, 46] |
| | Laboratory tests (n=1) | Primary care in Mexico[37] |
| | Centralized intake care specific QIs, e.g. time from referral to appointment (n=9) | Centralized intake care system in Canada [34] |

| Theme | Subtheme (number of QIs) | Healthcare setting and country |
|---|---|---|
| Indications for surgical treatment (n=4) | Indication for knee replacement (n=1) | The entire spectrum of disciplines; country not specified[49] |
| | Unicompartmental knee replacement (n=1) | The entire spectrum of disciplines; country not specified[49] |
| | No arthroscopic interventions of the knee (n=1) | The entire spectrum of disciplines; country not specified [49] |
| | Operating room time (n=1) | Centralized intake care system in Canada [34] |
| Documentation (n=6) | Symptoms, limitations in daily activities, systemic or inflammatory disease, physical examination, and use and effectiveness of treatment (n=3) | The entire spectrum of disciplines in the US[36, 39] |
| | Presence of systemic or inflammatory disease, and joint trauma or surgery (n=1) | The entire spectrum of disciplines in the US[39] |
| | Problem areas and patient profile (n=2) | Primary care; PT care in the Netherlands [43] |
| Follow up, treatment frequency, duration and aftercare (n=6) | Follow up review (n=2) | - The entire spectrum of disciplines in the US [39]<br>- Centralized intake care system in Canada [34] |
| | Treatment frequency, number of sessions and duration of treatment episode (n=3) | Primary care; PT care in the Netherlands [43] |
| | Aftercare (e.g. home exercise programme) (n=1) | Primary care; PT care in the Netherlands [43] |

**Abbreviations:** PT, physiotherapy; TENS, Transcutaneous electrical nerve stimulation

*Quality indicators at outcome level of care*

QIs at outcome level of care included experiences and satisfaction with healthcare (n=6), pain and functional capacity (n=3), and achievement of treatment goals (n=1) (Table 5). The QIs on satisfaction and experiences of healthcare providers and patients were mostly developed for centralized intake care in Canada. The QIs on the other themes were developed for primary care (physiotherapy) in the Netherlands[43]. For most of the QIs on outcome level of care, the threshold reflecting high or low quality of care was not specified (e.g. QI: "the extent to which the treatment goals were achieved"[43]).

**TABLE 5.** Quality indicators on outcome of care (n=11)

| Theme | Subtheme (number of QIs) | Healthcare setting and country |
|---|---|---|
| Experiences and satisfaction with healthcare (n=6) | Healthcare providers' and patients' experiences (n=4) | Centralized intake care system in Canada [34] |
| | Patients' satisfaction (n=2) | - Primary care in the UK and PT care in the Netherlands [35, 43] |
| Pain and functional capacity (n=4) | Level of pain and functional capacity (n=3) | Primary care; PT care in the Netherlands[43] |
| Achievement of treatment goals (n=1) | The extent to which the treatment goals were achieved (n=1) | Primary care; PT care in the Netherlands[43] |

**Abbreviations:** PT, physiotherapy; UK, United Kingdom

## DISCUSSION

This systematic review provides an overview of 20 studies including a total number of 196 QIs for KHOA care for a variety of healthcare settings. Rigorous methods for evidence synthesis to develop QIs were rarely used in the included studies. Adequate reporting on the perspective of healthcare, the proposed method of measurement (e.g. medical records) and threshold of the QIs was lacking. QIs were mainly developed from the perspective of healthcare professionals and researchers, while a patient perspective is limited. Narrative analysis showed that most healthcare settings and countries contain QIs on the following themes with largely similar content: 1) examination of functional status and pain, 2) education and information, 3) exercise therapy, 4) referral to exercise therapy/programs/activities, 5) and pharmacological treatment regarding paracetamol, NSAID and risks of medication use. For example regarding the use of paracetamol as first-line pharmacologic therapy and prescribing a trial of maximum-dose paracetamol before changing to a different oral agent. Some differences in the content of QIs occur due to the health care system, i.e. QIs about exercise therapy, weight counselling, referral to laboratory tests and 'do not do' QIs (mainly described for physiotherapy care in the Netherlands). Nevertheless, differences in the content of QIs occurred within the same healthcare setting with regard to indications for radiographic assessment of the joint.

Studies in the current review included mostly QIs that were related to the process of care. An explanation therefore could be that the studies included developed QIs or adapted existing QIs for quality of care improvement purposes. Process measures offer a roadmap for improving care or list the actions required to eventually improve outcomes for quality improvement purposes. In contrast, outcome measures are mainly developed for public reporting and accountability purposes through feedback on quality of care in order to stimulate quality improvement rather than specific actions to improve the quality of care.[51] Another

explanation might be that outcome measures in OA care mainly focus on reduction in pain and functional improvement. These outcome measures are not easy to capture within daily practice as a process of care. In contrast, for example, blood tests to measure disease activity of RA are captured as a process of care for patients with RA, which makes it easier to evaluate this measure as an outcome of care. However, the low number of QIs on structure of care remains unclear. Most QIs on outcome level were developed in the physiotherapy care in the Netherlands. These QIs are derived from the Dutch KHOA guidelines for physiotherapy with great focus on the outcomes of therapy.

This study identified differences within themes of QIs, which can be explained by differences between healthcare settings and countries. First, QIs for physiotherapy care in the Netherlands strongly focused on inventory of health-related problems, education and information, and exercise therapy. This is likely explained by the fact that the management of KHOA in physiotherapy care focuses on non-surgical and non-pharmacological management, containing the interventions these QIs include. Also, these QIs have been formulated in more detail, for example regarding the specific content of self-management (e.g. coping style with health problems). This may be due to the great focus on informing, advising and self-management in the Dutch KHOA guidelines for physiotherapy where these QIs are derived from. Second, QIs for centralized intake care in Canada[34] is a healthcare setting that aims to prioritise access to care for patients with KHOA with great focus on the structure of care. This is reflected by the fact that this study was the only one that included structure QIs. Third, QIs on pharmacological treatment were mainly described in studies about primary care setting. This is likely explained by the fact that primary care focuses on non-surgical treatment, containing pharmacological and non-pharmacological therapy, compared to secondary care. Altogether, the differences that this systematic review identified between QIs emphasize the heterogeneity of QIs for KHOA depending on the healthcare setting.

This systematic review did however identify differences which could not be fully explained by healthcare setting. These QIs concerned laboratory test in case of an NSAID prescription for ≥6 months to detect possible adverse events, a BMI threshold and frequency for advising patients to lose weight, and specific indications for radiographic assessment for KHOA. For example, two studies focusing on healthcare in the US described different indications, one describing that patients with incident hip OA should be offered an anteroposterior radiograph[39] and another describing that patients with worsening complaints of KHOA accompanied by progressive decrease in activities should receive a radiograph within three months[33]. However, this difference might be explained by the year of the study, which may indicate how up-to-date of the content of the QI is. The study describing that patients with worsening complaints should receive a radiograph[33] was published more recently (i.e. 2004) and is in line with the

current evidence[52] compared to the study that recommends a radiograph for patients with incident hip OA[39] (i.e. 2000). Another remarkable finding was that QIs on pharmacological treatment are consistent in the use of paracetamol as first-line pharmacologic therapy and prescribing NSAIDs after a trial of maximum-dose paracetamol. However, recent guidelines do not recommend the use of paracetamol and the use of topical NSAIDs instead of paracetamol is strongly recommended.[8] QIs about pharmacological treatment might be mostly influenced by guidelines and need to be up-to-date with the most recent guidelines. In addition, more agreement and uniformly formulated QIs within similar healthcare settings on these themes are needed to enhance uniform requirements for quality of care.

Of some frequently used treatments for OA, very little is described in QIs. For example, only one of 196 identified QIs focussed on the prescription of opioids. Furthermore, QIs regarding injections, not prescribing chondroitin and glucosamine-chondroitin and indications for surgical treatment for hip OA are scarce. Also, there is currently an overuse of imaging to diagnose KHOA, while guidelines recommend to diagnose KHOA clinically.[5-7, 53] However, none of the studies focusing on primary care included QIs on imaging, while in these countries, the diagnosis and management of OA is mainly provided in primary care with GPs as the gatekeepers. Supplementing current QI sets, especially for primary care, with QIs on imaging may be helpful in reducing the overuse of imaging for the diagnosis of OA. In addition, although evidence shows the benefits of treatment tailored to patients' preferences for satisfaction with treatment, uptake, and effectiveness of treatment[54], QIs relating to patients' preferences are scarce. QIs mainly represented the perspective of healthcare professionals, while the perspectives of patients are just as important [55], as they are the service users of healthcare.[56] Hence, future research on development of QIs on these themes is needed.

This systematic review was restricted to studies that developed QIs or adapted existing QIs. A previously published review[21] on QIs for primary care for OA also included studies that evaluated the feasibility and reliability of existing QIs. We did not include these studies, while it may provide valuable information for the application of the QIs. We recommend for future research to evaluate implementation studies on the feasibility, validity and reliability of QI-sets in this review to add more guidance for the use of the QIs. Another limitation of this study may be that our literature search was not restricted on the date of publication, since our aim was to provide an extensive overview of the evidence. However, QIs from old studies may no longer apply to the current healthcare. Another limitation may be that we did not assess the quality of the included studies due to the absence of a quality assessment tool for studies developing QIs. To compensate the lack of such a tool, we presented the evidence synthesis and consensus method used in the included studies, which provided some information about the quality of the studies. Furthermore, we evaluated QIs from the literature using the Donabedian structure-

process-outcome framework. However, other healthcare frameworks could have yielded other differences between healthcare settings and within the same healthcare settings. For example, the framework put forth by the Institute of Medicine, including the following six domains of quality of care: safe, effective, patient-centered, timely, efficient and equitable.[57] Lastly, our literature search did not include a search for websites for QIs in current use in quality or pay for performance programs for specific hospitals or health care systems (e.g. US National Quality Forum[58] and UK National Institute for Health & Clinical Excellence[59]).

Previously published reviews[20, 21, 34, 35, 60, 61] focused on QIs specific healthcare settings (e.g. primary care and centralized intake care systems), or perspectives (e.g. patients' perspectives). To our knowledge, this is the first systematic review that provides a comprehensive overview of QIs for KHOA outlining the differences and similarities between healthcare settings. This demonstrates the importance of selecting the contextually appropriate QIs to validly monitor the quality of care for KHOA.

## CONCLUSIONS

This review showed considerable differences between QIs depending on their healthcare settings. Furthermore, this review provides an overview of QIs outlined to their healthcare settings to support healthcare providers and policy makers in selecting the contextually appropriate QIs to validly monitor the quality of care for KHOA. However, we strongly recommend to review QIs against the most recent guidelines before implementing them into practice, especially QIs regarding pharmacological treatment. Furthermore, more adequate reporting of studies, rigorous methods of development of QIs and a greater variety of perspectives of stakeholders is needed. In addition, more uniformly formulated within the same healthcare settings and on several areas and up-to-date QIs are needed.

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# SUPPLEMENTARY FILE 1.
## Search strategy

**Embase**

('knee osteoarthritis'/de OR 'hip osteoarthritis'/de OR osteoarthritis/de OR (osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* NEAR/3 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) NEAR/6 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*)):ab,ti) AND ('health care quality'/de OR 'total quality management'/de OR (((qualit* OR process OR performance* OR structure* OR outcome* ) NEAR/3 (indicator* OR parameter*)) OR ((qualit*) NEAR/3 (care OR healthcare ) NOT 'quality of life')):ab,ti)

**Medline (Ovid)**

(Osteoarthritis, Knee/ OR Osteoarthritis, Hip/ OR osteoarthritis/ OR (osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* ADJ3 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) ADJ6 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*)).ab,ti.) AND (Quality of Health Care/ OR Total Quality Management/ OR Quality Indicators, Health Care/ OR (((qualit* OR process OR performance* OR structure* OR outcome* ) ADJ3 (indicator* OR parameter*)) OR ((qualit*) ADJ3 (care OR healthcare ) NOT quality of life)).ab,ti.)

**CINAHL EBSCOhost**

(MH Osteoarthritis, Knee OR MH Osteoarthritis, Hip OR MH osteoarthritis OR TI (osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* N2 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) N5 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*)) OR AB (osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* N2 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) N5 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*))) AND (MH Quality of Health Care OR MH Quality Improvement OR TI (((qualit* OR process OR performance* OR structure* OR outcome* ) N2 (indicator* OR parameter*)) OR ((qualit*) N2 (care OR healthcare) NOT quality of life)) OR AB (((qualit* OR process OR performance* OR structure* OR outcome*) N2 (indicator* OR parameter*)) OR ((qualit*) N2 (care OR healthcare ) NOT quality of life)))

**Cochrane CENTRAL**

((osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* NEAR/3 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) NEAR/6 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*)):ab,ti) AND ((((qualit* OR process OR

performance* OR structure* OR outcome* ) NEAR/3 (indicator* OR parameter*)) OR ((qualit*) NEAR/3 (care OR healthcare ) NOT 'quality of life')):ab,ti)

**Web of science**

TS=(((osteoarthrit* OR osteo-arthrit* OR osteoarthros* OR osteo-arthros* OR (degenerat* NEAR/2 (joint-disease* OR arthrit*)) OR ((knee OR hip OR knees OR hips) NEAR/5 (arthrosis* OR arthroses* OR arthrot* OR oa)) OR (oa AND rheuma*))) AND ((((qualit* OR process OR performance* OR structure* OR outcome* ) NEAR/2 (indicator* OR parameter*)) OR ((qualit*) NEAR/2 (care OR healthcare ) NOT "quality of life"))))

**Google scholar**

osteoarthritis|"osteo|degenerative arthritis|arthrosis|joint"|osteoarthrosis|"knee|hip|knees|hips arthrosis|arthroses|oa" "quality|process|performance|structure|outcome indicator|indicators|parameter|parameters"|"quality*care|healthcare"

**Google**

osteoarthritis|"osteo|degenerative arthritis|arthrosis|joint"|osteoarthrosis|"knee|hip|knees|hips arthrosis|arthroses|oa" "quality|process|performance|structure|outcome indicator|indicators|parameter|parameters"|"quality*care|healthcare" file-type:pdf

**Open Grey**

(osteoarthritis OR "degenerative arthritis") AND (quality ) AND (indicator OR indicators OR parameter OR parameters)

**Clinicaltrials.gov**

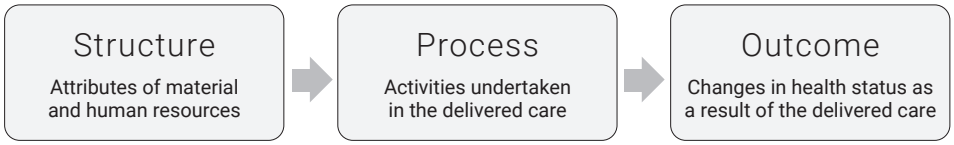
(osteoarthritis OR "degenerative arthritis") AND (quality ) AND (indicator OR indicators OR parameter OR parameters)

**WHO ictrp**

osteoarthritis AND quality AND indicator* OR osteoarthritis AND quality AND parameter* OR "degenerative arthritis" AND quality AND indicator* OR "degenerative arthritis" AND quality AND parameter*

## SUPPLEMENTARY FILE 2.

Donabedian's structure-process-outcome quality of care model



# SUPPLEMENTARY FILE 3.
## Reasons of excluded studies on full text

**Duplicate (n=8)**

1. Edwards, J. J. (2017). Quality indicators for the care of osteoarthritis in general practice: identification, synthesis, and implementation, core.ac.uk.
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**Conference abstract (n=35)**

1. Blackburn, S. J., et al. (2014). "Patients and researchers sometimes think alike: Patient involvement in the development of quality indicators for osteoarthritis care." Ann Rheum Dis 73.
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7. Dziedzic, K., et al. (2016). “Joint implementation of guidelines for osteoarthritis in Western Europe: JIGSAW-E.” Physiotherapy 102: e138-e139.
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**Goal (n=64)**


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**Goal and target group (n=6)**

1. Black, N. and C. Jenkinson (2009). “How can patients’ views of their care enhance quality improvement?” BMJ (Online) 339(7714): 202-205.
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**Protocol study (n=2)**

1. Dziedzic, K. S., et al. (2014). “Implementing the NICE osteoarthritis guidelines: a mixed methods study and cluster randomised trial of a model osteoarthritis consultation in primary care--the Management of OsteoArthritis In Consultations (MOSAICS) study protocol.” Implement Sci **9**: 95.
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**Language (Spanish) (n=1)**

1. Olry de Labry Lima, A., et al. (2017). "[Identification of health outcome indicators in Primary Care. A review of systematic reviews] Spanish." Rev. calid. asist. 32(5): 278-288.

**QIs not presented (n=2)**

1. Johansen, I., et al. (2019). "A quality indicator set for use in rehabilitation team care of people with rheumatic and musculoskeletal diseases; development and pilot testing." BMC Health Serv. Res. 19.
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**Target group (n=6)**

1. Braun, J., et al. (2016). "Cornerstones of quality assurance in medicine in Germany. Important impulse for the situation in treatment of rheumatism." Z. Rheumatol. 75(2): 203-212.
2. Gnanadesigan, N. and C. Fung (2007). "Quality indicators for screening and prevention in vulnerable elders." Journal of the American Geriatrics Society.
3. Kerr, E. A., et al. (2000). Quality of care for general medical conditions: a review of the literature and quality indicators. dtic.mil.
4. MacLean, C. H., et al. (2000). "Quality of care for patients with rheumatoid arthritis." Jama.
5. Saag, K. G., et al. (2004). "Measuring quality in arthritis care: The arthritis foundation's quality indicator set for analgesics." Arthritis Care Res 51(3): 337-349.
6. Westby, M. D., et al. (2018). "Development of quality indicators for hip and knee arthroplasty rehabilitation." Osteoarthritis Cartilage 26(3): 370-382.

**Reviews with no additional information about development, testing or implementation (feasibility) of QIs (n=6)**

1. Edwards, J.J., et al. (2015). " Quality indicators for the primary care of osteoarthritis: a systematic review." Ann Rheum Dis. 2015 Mar;74(3):490-8.
2. Falck, L., et al. (2019). "Toward Standardized Monitoring of Patients With Chronic Diseases in Primary Care Using Electronic Medical Records: Systematic Review." JMIR Med. Inf. 7(2): 136-148.
3. Hochberg, M. C. (2007). "Quality measures in osteoarthritis." Clin Exp Rheumatol 25(6 SUPPL. 47): S102-S106.
4. Petrosyan, Y., et al. (2017). "Quality indicators for care of osteoarthritis in primary care settings: a systematic literature review."

5. Petrosyan, Y. (2017). The quality of care among older adults with diabetes comorbid with other chronic conditions, tspace.library.utoronto.ca
6. Strömbeck, B., et al. (2013). "Health care quality indicators on the management of rheumatoid arthritis and osteoarthritis: A literature review." Rheumatology 52(2): 382-390.

**Grey literature excluded on goal (n=1)**

1. Quality of Care for Knee and Hip Osteoarthritis in Elderly Patients (QSAMISA). URL: https://clinicaltrials.gov/ct2/show/NCT04170218?cond=%28osteoarthritis+OR+%22degenerative+arthritis%22%29+AND+%28quality+%29+AND+%28indicator+OR+indicators+OR+parameter+OR+parameters%29&sfpd_s=10%2F12%2F2018&sfpd_e=04%2F07%2F2020&draw=2&rank=1

# SUPPLEMENTARY FILE 4.
## Characteristics of included studies

### Asch et al.(1)

| **General information** | |
|---|---|
| Year | 2004 |
| Target population | Patient of a spectrum of outpatient and inpatient care (that is, screening, diagnosis, treatment, and follow-up) for acute and chronic conditions and preventive care processes representing the leading causes of morbidity, death, and health care use among older male patients (including patients with OA). |
| Setting/context/ health system | US Veterans Health Administration (VHA) health care systems |
| Study design | RAND approach/ modified Delphi method and cross-sectional comparison to evaluate quality of care. |
| Perspective of quality of care | Not specified. |
| Level of care of quality indicators | Process level of care |
| Proposed method of measurement of QIs | Medical records |
| Evidence synthesis | Review of national guidelines and the medical literature, but not systematically. |
| Consensus method | RAND approach/modified Delphi method. |
| Implementation of QIs | Asch et al.(1) implemented the QIs between 1997 and 2000 in 12 VHA health care systems and 12 communities in the US. |
| Testing of QIs | Quote: "Charts were reabstracted charts for 4% of the participants selected at random. According to the κ statistic, average reliability in the national sample was substantial to almost perfect at 3 levels: presence of a condition (κ = 0.83), indicator eligibility (κ = 0.76), and indicator scoring (κ = 0.80)" |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| Providers caring for patients with symptoms of hip or knee osteoarthritis should recommend exercise programs at least once in 2 years. |
| Patients with a new diagnosis of osteoarthritis who wish to take medication for joint symptoms should be offered a trial of acetaminophen. |
| Providers caring for patients with symptoms of osteoarthritis should document all of the following at least once in 2 years: the location of symptoms and/or the presence or absence of limitations in daily activities. |

*Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

### Barber et al.(2)

| General information | |
|---|---|
| Year | 2015 |
| Target population | Rheumatoid arthritis (RA) patients and OA patients (patients with moderate to severe OA who required either surgical (total hip or knee arthroplasty) or nonsurgical management (requiring specialist consultation)). |
| Setting/context/ health system | Centralize intake care system in Canada. |
| Study design | Stakeholder meetings, literature review and Delphi rounds: a modification of the RAND-UCLA Appropriateness Method. |
| Perspective of quality of care | Healthcare professionals, organizational and patients. |
| Level of care of quality indicators | Structure, process, and outcome level of care |
| Proposed method of measurement of QIs | Not reported. |
| Evidence synthesis | Integrative review including an update of a systematic review of the literature conducted by the European Musculoskeletal Conditions Surveillance and Information Network in two literature databases (MEDLINE and Embase) to identify all existing performance measures for OA and RA. |
| Consensus method | Stakeholder meetings and Delphi rounds: a modification of the RAND-UCLA Appropriateness Method. |
| Implementation of QIs | Assessment of feasibility (i.e. how likely it is that the information required to report on the indicator will be available in the health system) done by an expert panel during the Delphi rounds. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators* |
|---|
| Time from OA referral receipt to referral completion for initially incomplete referrals. |
| Time from receipt of complete OA referral to musculoskeletal appointment. |
| Distribution of OA referrals in each urgency category (as scored using the Western Canada Waiting List referral tool). |
| Percentage of OA referrals triaged as highest urgency based on high Western Canada Waiting List priority criteria scores seen within Wait Time Alliance benchmarks. |
| Percentage of referrals rejected or redirected when received at centralized intake. |
| Percentage of OA referrals received with complete information. |
| Percentage of OA referrals scored using Western Canada Waiting List priority referral criteria. |
| Number of referrals received through centralized intake. |
| Agreement of centralized intake suspected diagnosis of severe OA cases (e.g., patients who are candidates for hip or knee joint replacements) versus confirmed diagnosis of severe OA. |
| Percentage of patients who receive information regarding resources and tools available for management while waiting for first musculoskeletal specialty contact. |
| Operating room time for arthroplasty surgeons in Alberta. |
| Percentage of specialist providers participating in centralized intake. |

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| Musculoskeletal specialty care provider experience with centralized intake. |
| Administrative staff and allied health professional experience with centralized intake. |
| Referring clinician's experience with centralized intake. |
| Percentage of musculoskeletal appointments completed as scheduled. |
| Ratio of patient flow to estimated clinic capacity of OA teams participating in centralized intake. |
| Patient experience with centralized intake. |

*Note: QIs for OA specific and OA + rheumatoid arthritis were extracted (thus; QIs for only RA were excluded)

### Blackburn et al.(3)

| **General information** | |
|---|---|
| Year | 2017 |
| Target population | Patients with OA. |
| Setting/context/ health system | Primary care in the UK. |
| Study design | Discussion meetings with a literature review. |
| Perspective of quality of care | Patients. |
| Level of care of quality indicators | Process and outcome level of care |
| Proposed method of measurement of QIs | Patient-reported questionnaire. Intended for use in the Management of OSteoArthritis In ConsultationS (MOSAICS) study, which developed and evaluated a new model of supported self-management of OA to implement the NICE guidelines. |
| Evidence synthesis | The authors used information from an earlier published systematic review(4), but did not conduct a literature review. |
| Consensus method | Four discussion groups with the research team to develop QIs. |
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| You have been offered information or advice on exercise or activity to help with your joint problem. |
| You have received advice about body weight and joint pain. |
| You have received advice and support on how you might help yourself to manage or deal with your joint problem. |
| You have been offered advice about medications (to relieve joint pain). |
| You have been offered a referral to an exercise or activity program for your joint problem. |
| You have been offered a referral for physiotherapy for your joint problem. |
| You have received a referral for weight loss services. |
| You have been given a follow-up review of your joint problem. |
| You are satisfied with the overall quality of the consultation with his/her GP for OA. |

*Note: Two QIs were developed regarding postoperative treatment of osteoarthritis. With respect to the exclusion criteria of our review, these QIs were excluded, thus not presented in this overview.

### Broadbent et al.(5)

| General information | |
|---|---|
| Year | 2008 |
| Target population | Patients with OA. |
| Setting/context/ health system | Primary care: UK general practice. |
| Study design | Development of indicators and retrospective observational study. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care |
| Proposed method of measurement of QIs | Medical records. |
| Evidence synthesis | The authors included QIs that were based on the following sources: NICE; RAND health indicators adapted by an independent expert panel including British GPs for the UK (Steel et al.(6)), and Quality Indicators for General Practice developed at the National Primary Care Research and Development Centre. |
| Consensus method | Not reported. |
| Implementation of QIs | Broadbent et al.(5) implemented the QIs in eighteen general practices in the UK. |
| Testing of QIs | Not done. |
| Conflict of interest | Unclear: Nicholas Steel was funded by a Primary Care Researcher Development Award from the UK National Coordinating Centre for Research Capacity Development (RDA03/21). Unclear whether this organisation has its certain interests or benefits with this study. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators |
|---|
| The percentage of patients with symptomatic osteoarthritis, whose notes contain a record that they have been offered education regarding the natural history, treatment, and self-management of the disease at least once. |
| The percentage of patients in whom oral pharmacological therapy was initiated to treat osteoarthritis, whose notes contain a record that they were offered paracetamol first (unless contraindicated). |
| The percentage of patients with osteoarthritis treated with an NSAID, whose notes contain a record that ibuprofen (or a cox-2 inhibitor) has been considered for first-line treatment (unless contraindicated or intolerant) |
| The percentage of patients in whom oral pharmacological therapy was changed from paracetamol to a different oral agent, whose notes contain a record that they were offered a trial of maximum-dose paracetamol. |
| The percentage of patients with osteoarthritis treated with an NSAID, whose notes contain a record that they have been advised of the gastrointestinal and renal risks associated with this drug. |
| The percentage of patients with osteoarthritis regularly treated with an NSAID, whose notes contain a record that they have been asked about gastrointestinal symptoms within the previous 12 months. |
| The percentage of patients with severe symptomatic osteoarthritis of the knee or hip that has failed to respond to non-pharmacological and pharmacological therapy, whose notes contain a record that they were offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. |

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| The percentage of patients treated for symptomatic osteoarthritis, whose notes contain a record that they have been assessed for functional status in the last year. |
| The percentage of patients treated for symptomatic osteoarthritis, whose notes contain a record that they have been assessed for degree of pain in the last year. |

**Doubova et al.(7)**

| **General information** | |
|---|---|
| Year | 2015 |
| Target population | Patients with knee and hip OA older than 19. |
| Setting/context/ health system | Primary care: family medicine in Mexico. |
| Study design | Modified version of RAND-UCLA method (development of indicators) and a cross-sectional analysis (of quality-of-care provided for patients with osteoarthritis). |
| Perspective of quality of care | Healthcare professional. |
| Level of care of quality indicators | Process level of care |
| Proposed method of measurement of QIs | Electronic health records. |
| Evidence synthesis | Literature review of scientific evidence in the following databases: Medline, Ovid, Cochrane Library, National Guideline Clearinghouse, CMA Infobase: Clinical Practice Guidelines, TRIP database, Institute for Clinical System Improvement, ACP Guideline website, American Academy of Family Physicians, NHS Evidence - National Library of Guidelines and IMSS-Clinical Guidelines. The literature search and review was performed by one researcher. No systematic review. |
| Consensus method | Modified version of the RAND/UCLA Appropriateness Method |
| Implementation of QIs | Doubova et al.(7) implemented the QIs in four family medicine clinics in Mexico City. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators** |
|---|
| (Patients with knee/hip OA who have documented recommendations for general aerobic and/or muscle strengthening exercise at least once per year, unless contraindicated (e.g. significant heart failure)/ Total number of patients with KHOA without contraindications for general aerobic exercise) * 100 |
| (Overweight (BMI ≥27 kg/m2) patients with KHOA who have documented nutritional counselling provided by the Nutrition and Dietary Service and/or who were encouraged by their family physician at least one time per year to lose weight/ Total number of overweight patients with KHOA) * 100 |
| (Patients with newly diagnosed of KHOA who received prescription of acetaminophen as initial oral analgesic, unless* contraindicated/ Total number of patients with recent diagnosis of KHOA) * 100 |
| (Patients aged 65 years or older with KHOA and one of the following comorbidities (history of peptic ulcer disease or gastrointestinal bleeding, chronic kidney disease, cardiac insufficiency and/or those receiving anticoagulant or glucocorticoids) who receive NSAID prescription/ Total number of patients aged 65 years or older with KHOA and one of the previously mentioned comorbidities)* 100 |

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| (Patients with KHOA and high risk for gastrointestinal complications who received NSAID prescription concomitant with either misoprostol or a proton-pump inhibitor/ Total number of patients with KHOA and high risk of gastrointestinal complications who received NSAIDs) * 100 |
| (Patients with KHOA and with NSAID prescription for 6 months or longer who were referred for the following laboratory tests (blood count, serum creatinine and liver enzymes) at least once in the previous 12 months / Total number of patients with KHOA and with NSAID prescription for 6 months or longer) * 100 |

* Note: originally, this quality indicator formulated instead of 'unless' the word 'otherwise'. In order to present the indicator in the similar way as the other indicators of this study and make the interpretation easier, we contacted the author of this study and changed the word 'otherwise' into 'unless' with the authors permission.

### Grypdonck et al.(8)

| **General information** | |
|---|---|
| Year | 2014 |
| Target population | Patients with knee OA. |
| Setting/context/ health system | The entire spectrum of disciplines involved in knee OA care. |
| Study design | RAND-modified Delphi method. |
| Perspective of quality of care | Healthcare professional. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Literature was searched in PubMed, Embase, and the World Wide Web (English and Dutch) for existing guidelines and sets of quality indicators. Unclear whether this was done systematically. |
| Consensus method | RAND-modified Delphi method. |
| Proposed method of measurement of QIs | Not identified. |
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | Unclear. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators** |
|---|
| If a patient has knee OA, then exercise therapy should be prescribed, including at least muscle strengthening, aerobic exercises and functional exercises, and combined with range of motion exercises in case of range of motion restrictions. |
| If a patient with knee OA is following exercise therapy, then the content and intensity of the exercise program should be tailored to the patient's individual goals in terms of limitations of activity and restrictions of participation. |
| If a patient with knee OA is following exercise therapy, then the treatment sessions should be spread over longer periods with lower frequencies in the later stages of the exercise program to facilitate the transition from exercise therapy to independent exercising and maintaining sufficient level of physical activity. |
| If a patient with knee OA is following exercise therapy, then he/she should be referred to regular community exercise and sports activities after a period of supervised exercise. |
| If a patient with knee OA is following exercise therapy, then regular evaluations by the physiotherapist are necessary. To make the switchover from a supervised to an autonomous program, an evaluation session should be performed every 3 months in the first year, every 6 months in the second year, and once per year afterward. |

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| If a patient with knee OA is following exercise therapy, then the exercise therapy should be combined with education/self-management interventions to improve patients' mental and physical performance and to alleviate pain. |
| If a patient with knee OA is overweight, then he/she should be encouraged to lose weight and maintain his/her weight at a lower level. |
| If a patient has knee OA, he/she should be given information access and education about the objectives of treatment and the importance of changes in lifestyle, exercise, pacing of activities, weight reduction, and other measures to unload the damaged joints. |
| If a patient has knee OA, then acetaminophen up to 3 g/day should be used as the initial oral analgesic. |
| If a patient has knee OA and there is no adequate response on acetaminophen, or there is severe pain and/or inflammation, then oral NSAID should be used. |
| If a patient has knee OA, then chondroitin and glucosamine-chondroitin combination products should not be used. |
| If NSAID are used in a patient with knee OA, then they should be used intermittently (max 3 weeks sustained use) and at the lowest effective dose. |
| If a patient with knee OA and a history of bleeding gastric ulcers has a need for NSAID, then either a COX-2 selective agent or a non-selective NSAID with coprescription of a proton pump inhibitor/misoprostol should be used instead of a non-selective NSAID. |
| If a patient with knee OA has heart failure grade 2–4, ischemic heart disease, or renal insufficiency with a GFR < 40 ml/min, then NSAID should not be used. In case of other cardiovascular risk factors (e.g., hypertension, …), NSAID should be used with caution. |
| If a patient has knee OA, then strong opioids (oxymorphone, oxycodone, fentanyl, morphine sulfate) should not be used. |
| If a patient has symptomatic knee OA, then he/she has to be referred to a physical therapist for instruction of the patient in appropriate exercises, for motivation of the patient to implement exercise and adhere to exercise, and to evaluate performance. |
| If a patient with knee OA is not obtaining adequate pain relief and functional improvement, then he/she should be considered for joint replacement. |
| If a patient has unicompartmental knee OA, then a unicompartmental knee replacement should be considered. |
| If a patient has knee OA, then arthroscopic interventions are not recommended. Coexisting meniscal lesions should not be treated. Only in case of locking of the knee from a large meniscal fragment or a loose body or an extension loss from an anterior anvil osteophyte is arthroscopic treatment indicated. |
| If a patient is clinically diagnosed with knee OA and suffering from pain resistant to conservative treatment with acetaminophen and/or NSAID, then a radiography (weight-bearing, semiflexed PA, plus lateral and skyline view) of the symptomatic knee should be taken for the morphological assessment and grading of knee OA (especially to detect unicompartmental OA, for which treatment modalities may differ). CT and MRI scan should not be used. |
| If a patient with knee OA has a recurrent clinically evident effusion, then he/she should be further assessed (with aspiration and analysis of synovial fluid) in order to differentiate from inflammation caused by other arthritis. |
| If a patient has knee OA, then a brace should not be prescribed (except in unicompartmental knee OA with axial deviation). |

### Hardcastle et al.(9)

| General information | |
|---|---|
| Year | 2015 |
| Target population | People with OA aged 50 years or older living in private households in England. |
| Setting/context/ health system | UK health system. |
| Study design | Adaptation of QIs by a modified RAND/UCLA appropriateness method and quality measurement using face-to-face interviews. |
| Perspective of quality of care | Healthcare professional. |
| Level of care of quality indicators | Process level of care |
| Evidence synthesis | Authors used QIs of Steel et al.(6); only difference is that they took a subset that would be feasible for surveys and adapted the age from 65 into 50. |
| Consensus method | Modified RAND/UCLA appropriateness method. |
| Proposed method of measurement of QIs | Patient interview surveys. |
| Implementation of QIs | Assessment for feasibility of survey use by an expert panel of clinicians. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators* |
|---|
| IF an ambulatory person aged ≥ 50 years has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 3 months and has no contraindications to exercise and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise programme should have been prescribed at least once. |
| IF an ambulatory person aged ≥ 50 years has a diagnosis of symptomatic osteoarthritis, THEN education regarding the natural history, treatment and self-management of the disease should be offered at least once. |
| IF oral pharmacological therapy is initiated to treat osteoarthritis among people aged ≥ 50 years, THEN paracetamol should be the first drug used, unless there is a contraindication to use. |
| IF a person aged ≥ 50 years with severe symptomatic osteoarthritis of the knee or hip has failed to respond to non-pharmacological and pharmacological therapy, THEN the patient should be offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. |

*Note: The presented QIs were developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

**Jansen et al. (10)**

| **General information** | |
|---|---|
| Year | 2013 |
| Target population | Patients with knee and/or hip OA. |
| Setting/context/ health system | Physiotherapy care in the Netherlands. |
| Study design | Prospective cohort study. |
| Perspective of quality of care | Researchers; list of QIs was made by the authors of this article. |
| Level of care of quality indicators | Process and outcome level of care. |
| Evidence synthesis | No literature review performed in the study. QIs were derived from the Dutch physiotherapy guideline on hip and knee OA. |
| Consensus method | The process and outcome indicators were formulated by one authors, and independently assessed by two other authors. The process indicators were derived from the key recommendations in the guidelines. Not reported were the outcome indicators come from. |
| Proposed method of measurement of QIs | Physiotherapist self-reported recording forms. Not reported whether this was online or on paper. |
| Implementation of QIs | 27 physical therapists recorded patient and treatment characteristics of at least five consecutive patients with knee and hip osteoarthritis. Problems with filling in/the use of the form were discussed afterwards. |
| Testing of QIs | Not done. |
| Conflict of interest | Unclear: this study was funded by a grant from the Royal Dutch Society of Physical Therapy (KNGF), however, no statement has been made regarding their involvement with the conduct of the study and interpretation and reporting of the results. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators** |
|---|
| Problem areas recorded (i.e. inflammation, pain, impairments of function, activity limitations, participation restrictions, and passive coping behaviour) (benchmark >90%) |
| Patient profile recording according to the Dutch physiotherapy guidelines (benchmark >90%) |
| Measurements of the VAS for severity of pain and Algofunctional Index measurements at baseline, at 6 weeks and at the end of the treatment episode (benchmark >90%) |
| Information and advice (benchmark >90%) |
| Exercise therapy for body functions (benchmark >90%) |
| Exercise therapy for activities (benchmark >90%) |
| No massage therapy (benchmark <10%) |
| No use of physical modalities other than TENS (e.g. pulsed shortwave) (benchmark <10%) |
| Aftercare (e.g. home exercise programme, follow up consultation, advice to participate in community based or sport programmes) (benchmark >90%) |
| VAS for severity of pain decrease of more than 25% |
| Algofunctional index decrease of more than 25% |
| The extent to which the treatment goals were achieved* |
| Number of sessions lower than 12 |

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| Duration of treatment episode less than 6 weeks |
| Treatment frequency * |
| Patients satisfaction with treatment* |
| Global perceived effect either for pain or for restrictions in daily activities (5 point Likert scale)* |

* No specific threshold reported in the article; QIs are developed based on the Dutch physiotherapy guideline and further information on thresholds is documented in the recommendations of this guideline.

### MacLean et al.(11) (ACOVE-1)

| **General information** | |
|---|---|
| Year | 2001 |
| Target population | Vulnerable elders with OA. |
| Setting/context/ health system | US health system. |
| Study design | Systematic review and RAND/UCLA Appropriateness Method. |
| Perspective of quality of carePerspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Systematic review. |
| Consensus method | Modified RAND/UCLA Appropriateness Method. |
| Proposed method of measurement of QIs | Medical records, administrative data, and/or patient or proxy interview. |
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators** |
|---|
| IF an ambulatory vulnerable elder is newly diagnosed with osteoarthritis of the knee, has no contraindication to exercise, and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 3 months of diagnosis BECAUSE such programs improve functional status and reduce pain. |
| IF an ambulatory vulnerable elder has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 12 months, has no contraindication to exercise, and is physically and mentally able to exercise, THEN there should be evidence that a directed or supervised strengthening or aerobic exercise program was prescribed at least once since the time of diagnosis BECAUSE such programs improve functional status and reduce pain. |
| IF an ambulatory vulnerable elder is diagnosed with symptomatic osteoarthritis THEN education regarding the natural history, treatment, and self-management of the disease should be offered at least once within 6 months of diagnosis BECAUSE such education produces improvements in physical functioning and pain. |
| IF a patient COX has had a diagnosis of symptomatic osteoarthritis for 12 months or longer THEN there should be evidence that the patient was offered education regarding the natural history, treatment, and selfmanagement of the disease at least once since the time of diagnosis BECAUSE such education produces improvements in physical functioning and pain. |

| |
|---|
| IF oral pharmacologic therapy is initiated to treat osteoarthritis in a vulnerable elder, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use, BECAUSE this agent is as effective in treating osteoarthritis as other oral agents, and it is less toxic. |
| IF oral pharmacologic therapy for osteoarthritis in a vulnerable elder is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age and comorbid conditions) BECAUSE acetaminophen, in adequate doses, is as effective in treating osteoarthritis as other oral agents, and it is less toxic. |
| IF a patient is treated with a COX nonselective nonsteroidal anti-inflammatory drug (NSAID), THEN there should be evidence that the patient was advised of the risk for gastrointestinal bleeding associated with these drugs BECAUSE this risk is substantial. |
| IF a vulnerable elder is older than 75 years of age, is treated with warfarin, or has a history of peptic ulcer disease or gastrointestinal bleeding, AND is being treated with a COX nonselective NSAID, THEN he or she should be offered concomitant treatment with either misoprostol or a proton-pump inhibitor BECAUSE this will substantially reduce the risk for NSAID-induced gastrointestinal bleeding. |
| IF a vulnerable elder with severe symptomatic osteoarthritis of the knee or hip has failed to respond to nonpharmacologic and pharmacologic therapy and has no contraindication to surgery, THEN the patient should be referred to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless a contraindication to surgery is documented BECAUSE hip and knee replacements markedly improve function and quality of life by reducing pain and/or improving range of motion. |
| IF a vulnerable elder is diagnosed with symptomatic osteoarthritis, THEN his or her functional status and the degree of pain should be assessed annually BECAUSE this information is necessary to direct therapeutic decisions. |
| IF a vulnerable elder has monoarticular joint pain associated with redness, warmth, or swelling AND the patient also has an oral temperature greater than 38.0 °C and does not have a previously established diagnosis of pseudogout or gout, THEN a diagnostic aspiration of the painfully swollen red joint should be performed that day BECAUSE this sign–symptom complex is common with joint infection, and it requires treatment that is different than that for osteoarthritis. |

### MacLean et al.(12) (ACOVE-2)

| **General information** | |
|---|---|
| Year | 2004 |
| Target population | Individuals with OA. |
| Setting/context/ health system | US health system. |
| Study design | Comprehensive literature review and modified RAND/UCLA Appropriateness Method. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Systematic review. |
| Consensus method | Modified RAND/UCLA appropriateness method. |
| Proposed method of measurement | Medical records, administrative data, and/or patient or proxy interview. |
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators |
|---|
| IF an ambulatory patient has had a diagnosis of symptomatic osteoarthritis of the knee or hip for >3 months AND has no contraindication to exercise and is physically and mentally able to exercise, THEN a directed or supervised muscle strengthening or aerobic exercise program should have been prescribed at least once and reviewed at least once per year. |
| IF an individual is overweight (as defined by body mass index of ≥27 kg/m2), THEN the individual should be advised to lose weight annually. |
| IF a patient has symptomatic osteoarthritis of the knee or hip and is overweight (as defined by body mass index of ≥27 kg/m2), THEN the patient should be advised to lose weight at least annually AND the benefit of weight loss on the symptoms of osteoarthritis should be explained to the patient. |
| IF a patient has had a diagnosis of symptomatic osteoarthritis of the knee or hip for >3 months, THEN education about the natural history, treatment, and self-management of osteoarthritis should have been given or recommended at least once. |
| IF a nonnarcotic pharmacologic therapy is initiated to treat osteoarthritis pain of mild or moderate severity, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use. |
| IF oral pharmacologic therapy for osteoarthritis is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age/comorbidities). |
| IF a patient with severe symptomatic osteoarthritis of the knee or hip has failed to respond to nonpharmacologic and pharmacologic therapy, THEN the patient should be offered referral to an orthopedic surgeon. |
| IF a patient has hip or knee osteoarthritis AND has worsening complaints accompanied by a progressive decrease in activities AND no previous radiograph during the preceding 3 months, THEN a knee or hip radiograph should be performed within 3 months. |
| IF a patient has symptomatic osteoarthritis of the knee or hip and has been overweight (as defined by body mass index of ≥27 kg/m2) for >3 years, THEN the patient should receive referral to a weight loss program. |
| IF a patient is begun on a drug treatment for joint pain, arthritis, or arthralgia, THEN evidence that the affected joint was examined should be documented. |
| IF a patient is diagnosed with symptomatic osteoarthritis of the knee or hip, THEN his or her pain should be assessed annually and when new to a practice. |
| IF a patient is diagnosed with symptomatic osteoarthritis of the knee or hip, THEN his or her functional status should be assessed annually and when new to a practice. |
| IF a patient has had symptomatic osteoarthritis of the hip or knee and reports difficulty walking to accomplish activities of daily living for >3 months, THEN the patient's walking ability should be assessed for need of ambulatory assistive devices. |
| IF a patient has a diagnosis of osteoarthritis and reports difficulties with nonambulatory activities of daily living, THEN the patient's functional ability with problem tasks should be assessed for need of nonambulatory assistive devices to aid with problem tasks. |

### MacLean et al.(13) (ACOVE-3)

| General information | |
|---|---|
| Year | 2007 |
| Target population | Vulnerable elders: These are community-dwelling individuals aged 65 and older who are at greater risk of death or functional decline over a 2-year period. |
| Setting/context/ health system | US health system. |

| | |
|---|---|
| Study design | Systematic review and modified RAND/UCLA Appropriateness Method. |
| Perspective of quality of care | Healthcare professionals. |
| Level of care of quality indicators | Process level of care |
| Evidence synthesis | Systematic review. |
| Consensus method | Modified RAND/UCLA appropriateness method. |
| Proposed method of measurement of QIs | Medical records, administrative data, and/or patient or proxy interview. |
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| IF an ambulatory vulnerable elder (VE) has symptomatic OA of the knee or hip for longer than 3 months and is able to exercise, THEN a directed or supervised muscle strengthening or aerobic exercise program should be recommended and activity reviewed annually. |
| IF a VE is started on pharmacological therapy to treat OA, THEN acetaminophen should be tried first. |
| IF a VE is prescribed chronic high-dose acetaminophen (≥3 g/d) or a VE with liver disease is prescribed chronic acetaminophen, THEN he or she should be advised of the risk of liver toxicity, BECAUSE these risks are greater with high doses of acetaminophen and when underlying liver disease is present. |
| IF a VE is prescribed an NSAID (non- selective or selective), THEN GI bleeding risks should be discussed and documented. |
| IF a VE is prescribed daily aspirin (including low-dose,<325mg/d), THEN GI bleeding risks should be discussed and documented, BECAUSE selective NSAIDs, non-selective NSAIDs, and aspirin increase the risk of bleeding. |
| IF a VE with a risk factor for GI bleeding (aged ≥75, peptic ulcer disease, history of GI bleeding, warfarin use, chronic glucocorticoid use) is treated with a nonselective NSAID, THEN he or she should be treated concomitantly with misoprostol or a proton pump inhibitor (PPI). |
| IF a VE with two or more risk factors for GI bleeding (aged ≥75, peptic ulcer disease, history of GI bleeding, warfarin use, chronic glucocorticoid use) is treated with daily aspirin, THEN he or she should be treated concomitantly with either misoprostol or a PPI, BECAUSE this will reduce the risk of GI bleeding. |
| IF a VE has severe symptomatic OA of the knee or hip despite nonsurgical therapy, THEN a referral to an orthopedic surgeon should be made. |
| IF a VE has symptomatic OA of the knee or hip, THEN pain should be assessed when new to a primary care or musculoskeletal disease practice and annually. |
| IF a VE has symptomatic OA of the knee or hip, functional status should be assessed when new to a primary care or musculoskeletal disease practice and annually, BECAUSE this information should direct therapeutic decisions. |
| IF a VE has symptomatic OA of the hip or knee and has difficulty walking that makes activities of daily living difficult for longer than 3 months, THEN the need for ambulatory assistive devices should be assessed. |
| IF a VE has symptomatic OA and has difficulty with nonambulatory activities of daily living, THEN the need for activity of daily living assistive devices should be assessed. |
| IF a VE is obese (body mass index (BMI) ≥30kg/m2), THEN he or she should be advised annually to lose weight, BECAUSE weight loss reduces the risk of developing symptomatic knee and hip OA. |

*Note: The presented QIs were developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

### Marshall et al. (14)

| General information | |
|---|---|
| Year | 2003 |
| Target population | Patients with osteoarthritis. |
| Setting/context/ health system | General practices in the UK healthcare system. |
| Study design | Literature review, RAND/UCLA Appropriateness Method, and field-testing of indicators using electronic and paper records in general practices. |
| Perspective of quality of care | Healthcare professionals. |
| Level of care of quality indicators | Process level of care |
| Evidence synthesis | Literature review; not systematically. |
| Consensus method | RAND/UCLA appropriateness method. |
| Proposed method of measurement of QIs | Electronic and paper records from the general practice. |
| Implementation of QIs | Field-testing on 1600 randomly selected patient records in 16 general practices belonging to two demographically contrasting English Primary Care Trusts. |
| Testing of QIs | Unclear, reliability of QIs was tested for diseases other than OA in this study. |
| Conflict of interest | No conflict of interest |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators |
|---|
| Patients with a new diagnosis of osteoarthritis who wish to take medication for joint symptoms should be offered a trial of paracetamol if not already tried. |
| If NSAIDs are considered, Ibuprofen should be considered for first line treatment unless contraindicated or intolerant. |
| Patients with osteoarthritis prescribed oral NSAIDs who are at high risk of gastrointestinal side effects (past history of dyspepsia or known peptic ulcer) should be considered for a co-prescription of PPIs, H2 antagonists or Misoprolol, unless contraindicated or intolerant |
| Patients with severe symptomatic osteoarthritis of the knee or hip who have failed to respond to conservative therapy should be offered referral to an orthopaedic surgeon for consideration of joint replacement. |

*Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

### Moore et al.(15)

| General information | |
|---|---|
| Year | 2000 |
| Target population | Patients with osteoarthritis. |
| Setting/context/ health system | US healthcare system. |
| Study design | Literature review and RAND/UCLA Appropriateness Method. |
| Perspective of quality of care | Healthcare professionals. |

| | |
|---|---|
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Literature review: reviewed relevant textbooks and review articles in MEDLINE with a basic strategy.<br>No systematic review. |
| Consensus method | RAND/UCLA appropriateness method. |
| Proposed method of measurement of QIs | Medical records. |
| Implementation of QIs | Assessment for feasibility of the QIs was done by the expert panel. |
| Testing of QIs | Not done. |
| Conflict of interest | Unclear. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

**Quality indicators**

| |
|---|
| Providers caring for patients with symptoms of OA should document all of the following at least once in 2 years:<br>a. the location of symptoms;<br>b. the presence or absence of limitations in daily activities;<br>c. the presence or absence of a history or symptoms of systemic or inflammatory disease;<br>d. the use and effectiveness of treatment modalities. |
| Providers caring for patients with incident symptoms of OA should document at least one of the following:<br>• the presence or absence of a history of any systemic or inflammatory disease that may mimic OA;<br>• the presence or absence of any current symptoms of systemic or inflammatory disease that may mimic OA;<br>• the presence or absence of a history of joint trauma or surgery. |
| Providers caring for patients with symptoms of OA should document the following for any one affected joint at least once in 2 years:<br>a. the presence or absence of effusion;<br>b. the presence or absence of bony enlargement;<br>c. the presence or absence of tenderness;<br>d. the presence or absence of limitations in range of motion. |
| Patients with incident symptoms of hip OA should be offered an anteroposterior film of the affected hip. |
| Patients with a new diagnosis of OA who wish to take medication for joint symptoms should be offered a trial of acetaminophen. |
| Providers caring for patients with symptoms of hip or knee OA should recommend both of the following at least once in 2 years:<br>a. exercise programs for persons with hip or knee OA;<br>b. weight loss among persons with knee OA and a BMI >25. |
| Patients receiving care for symptoms of OA should be seen in follow-up at least every 6 months. |

### Østerås et al.(16)

| General information | |
|---|---|
| Year | 2018 |
| Target population | Patients with OA. |
| Setting/context/ health system | Norwegian healthcare system. |
| Study design | Longitudinal, observational cohort study |
| Perspective of quality of care | Researchers: QIs were developed and assessed by researchers. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Literature review, no systematic review.<br>Quote: "Studies reporting QIs for OA care published between 2000 and 2010 were identified via structured searches of 4 electronic databases (Medline, Embase, CINAHL, and AMED) using the search terms quality of health care, standards of care, quality indicators (Health Care), performance indicator, guidelines (Standards), osteoarthritis, degenerative arthritis, and arthritis care. The searches resulted in 565 potentially relevant articles. The first author (NØ) screened titles and abstracts, and 26 articles were read in full text." (Osteras 2013) |
| Consensus method | Revised the QI questionnaire of Østerås et al. (2013) which was developed through critical judgement by researchers working within rheumatology and having experience with questionnaire design. During 2010-2014 the first author (NØ) systematically collected and registered feedback from national and international colleagues that used the questionnaire in different settings. The experiences were critically reviewed and discussed. Thereafter, the expert group and patient research partners collaborated on developing a revised version. |
| Proposed method of measurement of QIs | Patient self-reported questionnaire. |
| Implementation of QIs | Feasibility of QIs V1 was assessed using patient questionnaires from 359 persons in a Norwegian OA cohort. The revised version, the OA-QI v2, was then pilot-tested by 11 of the members in the Patient Research Partner Panel at Diakonhjemmet Hospital, who had no comments on the wording revisions that were done. |
| Testing of QIs | Questionnaire test-retest κ=0.38–0.85, % exact agreement from 69–92%. The ICC for all 16 items was 0.89. |
| Conflict of interest | Unclear. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| Quality indicators |
|---|
| Have you been given information about osteoarthritis from a health professional? |
| Have you been given information about different treatment alternatives? |
| Have you been given information about how you can self-manage the disease? |
| Have you been given information about the importance of physical activity and exercise? |
| Have you been advised to lose weight, if you are overweight? |
| If you use anti-inflammatory medications, have you been given information about the effects and possible side-effects of this medication? (e.g. ibuprofen (Nurofen, Brufen), diclofenac (Voltarol), naproxen (Naprosyn),celecoxib (Celebrex)) |

| |
|---|
| Have you been referred or offered a referral to a health professional who can advise you about physical activity and exercise? |
| Have you been referred or offered a referral to someone who can help you to lose weight, if you are overweight? |
| If you are severely troubled by your osteoarthritis, and exercise and medication do not help, have you been referred or offered a referral for an assessment for operation? (e.g. joint replacement) |
| If you have problems with daily activities, have these problems been assessed by a health professional? |
| If you have problems with walking, has your need for a walking aid been assessed? (e.g. stick, crutch or walker) |
| If you have problems related to other daily activities, has your need for appliances and aids been assessed? (e.g. splints, assistive technology for cooking or personal hygiene, a special chair) |
| If you have joint pain, has it been assessed by a health professional? |
| If you have joint pain, was paracetamol the first medication that was recommended? |
| If you have prolonged severe joint pain, which is not relieved sufficiently by paracetamol, have you been offered stronger pain killing medications? (e.g. co-codamol, codeine, tramadol, co-proxamol, co-dydramol, dihydrocodeine) |
| If you have experienced an acute deterioration of your symptoms, have you been given or offered a steroid injection? |

**Peter et al.(17)**

| **General information** | |
|---|---|
| Year | 2013 |
| Target population | Patients with knee and/or hip OA. |
| Setting/context/ health system | Physiotherapy care in the Netherlands. |
| Study design | Expert panel methods and cross-sectional implementation of the QI-questionnaire. |
| Perspective of quality of care | Healthcare providers |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | No literature review performed in the study. QIs were derived from the Dutch physiotherapy guideline on hip and knee OA. |
| Consensus method | Rating of recommendations of guideline by an expert panel of physical therapists in primary and secondary care with respect to its potential contribution to quality of care, acceptability and measurability for daily practice. The resulting recommendations were transformed to quality indicators. |
| Proposed method of measurement of QIs | Physiotherapist self-reported online questionnaire. |
| Implementation of QIs | The QI-questionnaire was pilot-tested with respect to clarity and completeness by 15 PTs working in primary care and three experts in the development of tests. Consecutively, a pilot test was also done among expert (n= 51) and general (n = 134) PTs and 58 PTs who were considered to be neither expert nor general PTs in the Netherlands. |
| Testing of QIs | All participating PTs were sent a hyperlink to the online version of the questionnaire by email. Participants were invited to complete the questionnaire at two different time points, within seven days, to determine the test–retest reliability. ICC was 0.89, meaning that the QI-questionnaire was found to be reliable. |

| | |
|---|---|
| Conflict of interest | Unclear. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators** |
|---|
| Inventory of health-related problems according to the International Classification of Functioning, Disability and Health (ICF) |
| Assessing the presence of personal and environmental problems in so far as these relate to the limitations in activities and restrictions in participation |
| Assessing the presence of hip and knee OA-specific 'red flags' |
| Treating patients with strengthening of muscles |
| Treating patients with improving of aerobic capacity |
| Treating patients with walking exercises |
| Treating patients with functional exercises |
| Providing information concerning knowledge and understanding of OA of the hip and/or knee} |
| Providing information concerning the consequences for the patient's functional performance in terms of movements, activities and participation} |
| Providing information concerning the relationship between burden and tolerance level |
| Providing information concerning the way a patient copes with health problems |
| Providing information concerning what constitutes an active and healthy lifestyle (in terms of exercise and nutrition/overweight |
| Providing information concerning behavioural change (regarding physical activity) |
| Providing information concerning joint protection and the use of aids |
| Evaluating treatment with the recommended measurement instruments |
| Evaluating treatment with the combination of a questionnaire and a performance test |
| Evaluating treatment with a patient-specific complaint list |
| Evaluating treatment with the Timed Up and Go test (TUG) |

* Note: One QI was developed regarding postoperative treatment of knee and hip osteoarthritis. With respect to the exclusion criteria of our review, this QI was excluded, thus not presented in this overview.

### Saliba et al.(18)

| **General information** | |
|---|---|
| Year | 2004 |
| Target population | Institutionalized vulnerable elders (including patient with OA). |
| Setting/context/ health system | Secondary care: nursing homes in the US. |
| Study design | Modified Delphi process. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | No literature review. Adapted the ACOVE-1 set for the use in nursing homes in the US. |
| Consensus method | Modified Delphi process. |

| | |
|---|---|
| Proposed method of measurement of QIs | Not specified. |
| Implementation of QIs | Not cone. |
| Testing of QIs | Not done. |
| Conflict of interest | Unclear. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| IF an ambulatory NH resident is newly diagnosed with symptomatic osteoarthritis of the knee and has no contraindication to exercise and is physically and mentally able to exercise THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 1 month of diagnosis. |
| IF an ambulatory NH resident has a diagnosis of symptomatic knee osteoarthritis for >3 months, has no contraindication to exercise, and is physically and mentally able to exercise THEN there should be evidence that a directed or supervised strengthening or aerobic exercise program was prescribed at least once since the time of diagnosis. |
| IF a non-OTC drug is newly prescribed to treat new joint pain THEN evidence that the affected joint was examined should be documented within 4 weeks. |
| IF oral pharmacologic therapy is initiated to treat osteoarthritis THEN acetaminophen should be the first drug used. |
| IF oral pharmacologic therapy for symptomatic osteoarthritis is changed from acetaminophen to a different oral agent THEN there should be evidence that the NH resident has had a trial of maximum dose acetaminophen (suitable for age and comorbid conditions). |
| IF a NH resident has a new joint pain that is reported to the primary care provider THEN the joint and periarticular structures should be examined within 1 month or there should be documentation that the problem has resolved. |
| IF a NH resident has monoarticular joint pain associated with redness, warmth, and/or swelling and the patient also has an oral temperature >38.0°C, and does not have a previously established diagnosis of pseudogout or gout THEN a diagnostic aspiration of the painfully swollen red joint should be performed that day. |

* Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

### Smith et al.(19)

| **General information** | |
|---|---|
| Year | 2007 |
| Target population | Home-based primary care patients (including patients with OA). |
| Setting/context/ health system | Primary care to homebound seniors in the US. |
| Study design | A modified Delphi process. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | No literature review. Adapted the ACOVE-1 set for the use in home-based primary care in the US. |
| Consensus method | Modified Delphi process. |
| Proposed method of measurement of QIs | Not specified. |

| | |
|---|---|
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| IF an ambulatory homebound patient is newly diagnosed with osteoarthritis of the knee, has no contraindication to exercise, and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 3 months of diagnosis. |
| IF an ambulatory homebound patient has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 12 months and is physically and mentally able to exercise, THEN there should be evidence that a physical therapy evaluation for focused strengthening exercises was prescribed at least once since the time of diagnosis. |
| IF oral pharmacologic therapy is initiated to treat osteoarthritis in a homebound patient, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use |
| IF oral pharmacologic therapy for osteoarthritis in a homebound patient is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age and comorbid conditions). |
| IF a patient is treated with a COX-nonselective NSAID, THEN there should be evidence that the patient was advised of the risk for gastrointestinal bleeding, as well as cardiovascular risk associated with these drugs. |
| IF a homebound patient is diagnosed with symptomatic osteoarthritis, THEN his or her functional status and the degree of pain should be assessed at each visit. |
| IF a homebound patient has monoarticular joint pain associated with redness, warmth, or swelling AND the patient also has an oral temperature greater than 38.0 °C and does not have a previously established diagnosis of pseudogout or gout, THEN diagnostic aspiration of the painfully swollen, red joint should be performed that day. |

*Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

### Steel et al.(6)

| **General information** | |
|---|---|
| Year | 2004 |
| Target population | Older adults (people aged 65 years and older in England) (including patients with OA). |
| Setting/context/ health system | Primary and secondary care in the UK. |
| Study design | Modified RAND/UCLA appropriateness method. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | No literature review. Adapted the ACOVE-1 set for use in UK healthcare system (translation from US to UK). |
| Consensus method | Modified RAND/UCLA appropriateness method. |
| Proposed method of measurement of QIs | Medical records. |

| | |
|---|---|
| Implementation of QIs | Not done. |
| Testing of QIs | Not done. |
| Conflict of interest | No conflict of interest. |
| Adherence to the protocol | Unclear: no protocol published/reported. |

| **Quality indicators*** |
|---|
| IF an ambulatory person aged 65 or older has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 3 months and has no contraindications to exercise and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise programme should have been prescribed at least once. |
| IF an ambulatory person aged 65 or older has a diagnosis of symptomatic osteoarthritis, THEN education regarding the natural history, treatment and self-management of the disease should be offered at least once. |
| IF oral pharmacological therapy is initiated to treat osteoarthritis among people aged 65 or older, THEN paracetamol should be the first drug used, unless there is a contraindication to use. |
| IF oral pharmacological therapy for osteoarthritis is changed from paracetamol to a different oral agent among people aged 65 or older, THEN the patient should have had a trial of maximum dose paracetamol (suitable for age/co-morbidities). |
| IF a person aged 65 or older with severe symptomatic osteoarthritis of the knee or hip has failed to respond to non- pharmacological and pharmacological therapy, THEN the patient should be offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. |
| IF a person aged 65 or older is treated for symptomatic osteoarthritis, THEN functional status and degree of pain should be assessed at least annually. |

* Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.



### VandenBerghe et al.(20)

| **General information** | |
|---|---|
| Year | 2004 |
| Target population | Patients with osteoarthritis of 60 years or above in Belgium. |
| Setting/context/ health system | General practice in Belgium (primary care) |
| Study design | Cross-sectional study. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | Unclear: method of derivation of QIs not described. Only described that the QIs originate from guidelines, but not specified which guidelines. |
| Consensus method | Unclear: method of derivation of QIs not described. |
| Proposed method of measurement of QIs | Either on paper registration sheets (paper group) or through an extraction of data from the electronic patient record (EPR group) by GPs |
| Testing of QIs | The quality indicators were implemented in Belgium in 2001 and 2003 in the general practices and data were compared between a pooled database (consultations and home visits) and a restricted database (after removal of home visits). |

| | |
|---|---|
| Conflict of interest | Not done. |
| Adherence to the protocol | Unclear: no statement regarding conflict of interest has been made in the article. |
| Testing of QIs | Unclear: no protocol published/reported. |

**Quality indicators**

| |
|---|
| Patients with a drug prescription for osteoarthritis in the past month (numerator)/ all patients with osteoarthritis (denominator) |
| Patients who were prescribed paracetamol (numerator)/ all patients with a drug prescription for osteoarthritis in the past month (denominator) |
| Patients which were prescribed an NSAID (numerator)/ all patients with a drug prescription for osteoarthritis in the past month (denominator) |
| Patients who were prescribed a coxib (numerator)/ all patients who received an NSAID for osteoarthritis in the past month (denominator) |
| Patients who received a repeated prescription/ all patients who received an NSAID for osteoarthritis in the past month (denominator) |

### Wierenga et al.(21)

| **General information** | |
|---|---|
| Year | 2011 |
| Target population | Elderly hospitalized patients in the Netherlands (including patients with OA). |
| Setting/context/ health system | Dutch in-hospital pharmaceutical care; secondary care. |
| Study design | Expert panel review methods. |
| Perspective of quality of care | Not reported/specified. |
| Level of care of quality indicators | Process level of care. |
| Evidence synthesis | No literature review. Adapted the ACOVE-1 set for use in Dutch in-hospital pharmaceutical care. |
| Consensus method | Expert panel review methods. |
| Proposed method of measurement of QIs | Medical records and a hospital information system. |
| Testing of QIs | Assessment for feasibility was done by the expert panel with ten preselected elderly patients who had experienced a long hospital stay, multiple co-morbidities and geriatric problems. |
| Conflict of interest | Quote: "The inter-rater agreement (reliability) was determined based on three pharmacists' (YB, JK, MT) assessment of the quality of care of ten randomly selected patients (different to those used for the improvement of the QI phrasing)."<br>κ = 0.88 (95%CI=0.75, 1.00)<br>ICC= 0.80 (95%CI=0.63, 0.90) |
| Adherence to the protocol | No conflict of interest. |
| Testing of QIs | Unclear: no protocol published/reported. |

**Quality indicators***

| |
|---|
| IF oral pharmacological therapy is initiated to treat osteoarthritis in an elder, THEN paracetamol (acetaminophen) should be the first drug used, UNLESS there is a documented contra-indication. |
| IF oral pharmacological therapy for osteoarthritis in an elder is changed from paracetamol (acetaminophen) to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum dose of paracetamol (suitable for age and co-morbid conditions. |

*Note: The presented QIs are developed for a broader spectrum of patient than only OA patient. For the current review, only the indicators regarding OA were extracted.

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# SUPPLEMENTARY FILE 5.

## Quality indicators per category and theme

| Theme | Quality indicator | Author | OA in the knee, hip, or not related to specific sites | Healthcare setting |
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| **Structure** | | | | |
| Musculoskeletal appointments | Percentage of musculoskeletal appointments completed as scheduled | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Healthcare providers involved | Percentage of specialist providers participating in centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Estimation of clinic capacity | Ratio of patient flow to estimated clinic capacity of OA teams participating in centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| **Process: history taking and examination** | | | | |
| Regular assessment of functional status | The percentage of patients treated for symptomatic osteoarthritis, whose notes contain a record that they have been assessed for functional status in the last year. | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Regular assessment of pain | The percentage of patients treated for symptomatic osteoarthritis, whose notes contain a record that they have been assessed for degree of pain in the last year. | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Regular assessment of pain | IF a VE has symptomatic OA of the knee or hip, THEN pain should be assessed when new to a primary care or musculoskeletal disease practice and annually. | MacLean et al. (2007) | Hip/knee OA | US healthcare system |
| Regular assessment of pain | If you have joint pain, has it been assessed by a health professional? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Regular assessment of pain and functional status | IF a vulnerable elder is diagnosed with symptomatic osteoarthritis, THEN his or her functional status and the degree of pain should be assessed annually BECAUSE this information is necessary to direct therapeutic decisions. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |

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| Regular assessment of pain and functional status | IF a patient is diagnosed with symptomatic osteoarthritis of the knee or hip, THEN his or her pain should be assessed annually and when new to a practice. | MacLean et al. (2004) | Hip/knee OA | US healthcare system |
| Regular assessment of pain and functional status | IF a homebound patient is diagnosed with symptomatic osteoarthritis, THEN his or her functional status and the degree of pain should be assessed at each visit. | Smith et al. (2007) | OA not related to specific sites | Home-based primary care setting in the US |
| Regular assessment of pain and functional status | IF a person aged 65 or older is treated for symptomatic osteoarthritis, THEN functional status and degree of pain should be assessed at least annually. | Steel et al. (2004) | OA not related to specific sites | Primary and secondary care setting in the UK |
| Regular assessment of pain and functional status | IF a NH resident has a new joint pain that is reported to the primary care provider THEN the joint and periarticular structures should be examined within 1 month or there should be documentation that the problem has resolved. | Saliba et al. (2004) | OA not related to specific sites | Nursing homes in the US |
| Assessment for aid | If you have problems with walking, has your need for a walking aid been assessed? (e.g. stick, crutch or walker) | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Assessment for appliances and aids | If you have problems related to other daily activities, has your need for appliances and aids been assessed? (e.g. splints, assistive technology for cooking or personal hygiene, a special chair) | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Assessment for assistive devices | IF a VE has symptomatic OA of the hip or knee and has difficulty walking that makes activities of daily living (ADLs) difficult for longer than 3 months, THEN the need for ambulatory assistive devices should be assessed, BECAUSE these devices will improve walking and help maintain function and independence. | MacLean et al. (2007) | Knee OA | US healthcare system |
| Assessment for assistive devices | IF a VE has symptomatic OA and has difficulty with nonambulatory ADLs, THEN the need for ADL assistive devices should be assessed, BECAUSE such devices will help to maintain function and independence. | MacLean et al. (2007) | Knee OA | US healthcare system |

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| Assessment for assistive devices | IF a patient has had symptomatic osteoarthritis of the hip or knee and reports difficulty walking to accomplish activities of daily living for 3 months, THEN the patient's walking ability should be assessed for need of ambulatory assistive devices. | MacLean et al. (2004) | Knee/hip OA | US healthcare system |
| Assessment for assistive devices | IF a patient has a diagnosis of osteoarthritis and reports difficulties with nonambulatory activities of daily living, THEN the patient's functional ability with problem tasks should be assessed for need of nonambulatory assistive devices to aid with problem tasks. | MacLean et al. (2004) | OA not related to specific sites | US healthcare system |
| Radiographs | Patients with incident symptoms of hip OA should be offered an anteroposterior film of the affected hip. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Radiographs | IF a patient has hip or knee osteoarthritis AND has worsening complaints accompanied by a progressive decrease in activities AND no previous radiograph during the preceding 3 months, THEN a knee or hip radiograph should be performed within 3 months. | MacLean et al. (2004) | Hip/knee OA | US healthcare system |
| Radiograph | If a patient is clinically diagnosed with knee OA and suffering from pain resistant to conservative treatment with acetaminophen and/or NSAID, then a radiography (weight-bearing, semiflexed PA, plus lateral and skyline view) of the symptomatic knee should be taken for the morphological assessment and grading of knee OA (especially to detect unicompartmental OA, for which treatment modalities may differ). CT and MRI scan should not be used. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Diagnostic aspiration | IF a vulnerable elder has monoarticular joint pain associated with redness, warmth, or swelling AND the patient also has an oral temperature greater than 38.0 °C and does not have a previously established diagnosis of pseudogout or gout, THEN a diagnostic aspiration of the painfully swollen red joint should be performed that day BECAUSE this sign–symptom complex is common with joint infection, and it requires treatment that is different than that for osteoarthritis. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |

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| Diagnostic aspiration | IF a NH resident has monoarticular joint pain associated with redness, warmth, and/or swelling and the patient also has an oral temperature >38.0°C, and does not have a previously established diagnosis of pseudogout or gout<br>THEN a diagnostic aspiration of the painfully swollen red joint should be performed that day. | Saliba et al. (2004) | OA not related to specific sites | Nursing homes in the US |
| Diagnostic aspiration | IF a homebound patient has monoarticular joint pain associated with redness, warmth, or swelling AND the patient also has an oral temperature greater than 38.0 °C and does not have a previously established diagnosis of pseudogout or gout, THEN diagnostic aspiration of the painfully swollen, red joint should be performed that day. | Smith et al. (2007) | OA not related to specific sites | Home-based primary care setting in the US |
| Diagnostic aspiration | If a patient with knee OA has a recurrent clinically evident effusion, then he/she should be further assessed (with aspiration and analysis of synovial fluid) in order to differentiate from inflammation caused by other arthritis. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Inventory of health-related problems | Inventory of health-related problems according to the International Classification of Functioning, Disability and Health (ICF) | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Inventory of health-related problems | Assessing the presence of personal and environmental problems in so far as these relate to the limitations in activities and restrictions in participation | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Inventory of health-related problems | If you have problems with daily activities, have these problems been assessed by a health professional? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Inventory of health-related problems | Assessing the presence of hip and knee OA-specific 'red flags' | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Examination of joint before drug treatment | IF a non-OTC drug is newly prescribed to treat new joint pain THEN evidence that the affected joint was examined should be documented within 4 weeks | Saliba et al. (2004) | OA not related to specific sites | Nursing homes in the US |
| Examination of joint before drug treatment | IF a patient is begun on a drug treatment for joint pain, arthritis, or arthralgia, THEN evidence that the affected joint was examined should be documented. | MacLean et al. (2004) | OA not related to specific sites | US healthcare system |

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| Evaluating treatment | Evaluating treatment with the recommended measurement instruments | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Evaluating treatment | Evaluating treatment with the combination of a questionnaire and a performance test | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Evaluating treatment | Evaluating treatment with a patient-specific complaint list | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Evaluating treatment | Evaluating treatment with the Timed Up and Go test (TUG) | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| **Process: education and information** | | | | |
| Information and advice | Information and advice (benchmark >90%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning knowledge and understanding of OA | Providing information concerning knowledge and understanding of OA of the hip and/or knee | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning development of disease | Have you been given information about osteoarthritis from a health professional? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Information concerning consequences for on functional performance | Providing information concerning the consequences for the patient's functional performance in terms of movements, activities and participation | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning relationship between burden and tolerance level | Providing information concerning the relationship between burden and tolerance level | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning coping style with health problems | Providing information concerning the way a patient copes with health problems | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning active and healthy lifestyle | Providing information concerning what constitutes an active and healthy lifestyle (in terms of exercise and nutrition/overweight) | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning behavioural change | Providing information concerning behavioural change (regarding physical activity) | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |
| Information concerning joint protection and the use of aids | Providing information concerning joint protection and the use of aids | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands. |

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| Advice about using medications to relieve joint pain | You have been offered advice about medications (to relieve joint pain) | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Information concerning treatment, and self-management | If a patient has knee OA, he/she should be given information access and education about the objectives of treatment and the importance of changes in lifestyle, exercise, pacing of activities, weight reduction, and other measures to unload the damaged joints. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Information about self-management for OA | You have received advice and support on how you might help yourself to manage or deal with your joint problem | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Information concerning pathology of OA, treatment, and self-management | The percentage of patients with symptomatic osteoarthritis, whose notes contain a record that they have been offered education regarding the natural history, treatment, and self-management of the disease at least once. | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Information pathology of OA, treatment, and self-management | IF an ambulatory person aged ≥ 50 years has a diagnosis of symptomatic osteoarthritis, THEN education regarding the natural history, treatment and self-management of the disease should be offered at least once. | Hardcastle et al. (2015) | OA not related to specific sites | UK healthcare system |
| Information concerning pathology of OA, treatment, and self-management | IF an ambulatory vulnerable elder is diagnosed with symptomatic osteoarthritis THEN education regarding the natural history, treatment, and self-management of the disease should be offered at least once within 6 months of diagnosis BECAUSE such education produces improvements in physical functioning and pain. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |
| Information concerning pathology of OA, treatment, and self-management | IF a patient COX has had a diagnosis of symptomatic osteoarthritis for 12 months or longer THEN there should be evidence that the patient was offered education regarding the natural history, treatment, and selfmanagement of the disease at least once since the time of diagnosis BECAUSE such education produces improvements in physical functioning and pain. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |

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| Information concerning pathology of OA, treatment, and self-management | IF a patient has had a diagnosis of symptomatic osteoarthritis of the knee or hip for >3 months, THEN education about the natural history, treatment, and self-management of osteoarthritis should have been given or recommended at least once. | MacLean et al. (2004) | knee/hip OA | US healthcare system |
| Information concerning pathology of OA, treatment, and self-management | IF an ambulatory person aged 65 or older has a diagnosis of symptomatic osteoarthritis, THEN education regarding the natural history, treatment and selfmanagement of the disease should be offered at least once. | Steel et al. (2004) | OA not related to specific sites | Primary and secondary care setting in the UK |
| Information concerning treatment options | Have you been given information about different treatment alternatives? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Information concerning how to live with the disease | Have you been given information about how you can self-manage the disease? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Information concerning importance of physical activity and exercise | Have you been given information about the importance of physical activity and exercise? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Information regarding resources and tools available for management while waiting | Percentage of patients who receive information regarding resources and tools available for management while waiting for first musculoskeletal specialty contact. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| **Process: exercise therapy** | | | | |
| Exercise therapy for activities | Exercise therapy for activities (benchmark >90%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Exercise therapy for body functions | Exercise therapy for body functions (benchmark >90%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Walking exercises | Treating patients with walking exercises | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Strengthening exercises | Treating patients with strengthening of muscles. | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |

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| Strengthening or aerobic exercises | IF an ambulatory person aged ≥ 50 years has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 3 months and has no contraindications to exercise and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise programme should have been prescribed at least once. | Hardcastle et al. (2015) | OA not related to specific sites | UK healthcare system |
| Strengthening or aerobic exercises | IF an ambulatory vulnerable elder is newly diagnosed with osteoarthritis of the knee, has no contraindication to exercise, and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 3 months of diagnosis BECAUSE such programs improve functional status and reduce pain. | MacLean et al. (2001) | Knee OA | US healthcare system |
| Strengthening or aerobic exercises | IF an ambulatory vulnerable elder has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 12 months, has no contraindication to exercise, and is physically and mentally able to exercise, THEN there should be evidence that a directed or supervised strengthening or aerobic exercise program was prescribed at least once since the time of diagnosis BECAUSE such programs improve functional status and reduce pain. | MacLean et al. (2001) | Knee OA | US healthcare system |
| Strengthening or aerobic exercises | IF an ambulatory VE has symptomatic OA of the knee or hip for longer than 3 months and is able to exercise, THEN a directed or supervised muscle strengthening or aerobic exercise program should be recommended and activity reviewed annually, BECAUSE directed or supervised exercise programs improve functional status and reduce pain. | MacLean et al. (2007) | Knee and hip OA | US healthcare system |
| Strengthening or aerobic exercises | IF an ambulatory patient has had a diagnosis of symptomatic osteoarthritis of the knee or hip for >3 months AND has no contraindication to exercise and is physically and mentally able to exercise, THEN a directed or supervised muscle strengthening or aerobic exercise program should have been prescribed at least once and reviewed at least once per year. | MacLean et al. (2004) | Knee/hip OA | US healthcare system |

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| Strengthening or aerobic exercises | IF an ambulatory NH resident is newly diagnosed with symptomatic osteoarthritis of the knee and has no contraindication to exercise and is physically and mentally able to exercise THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 1 month of diagnosis | Saliba et al. (2004) | Knee OA | Nursing homes in the US |
| Strengthening or aerobic exercises | IF an ambulatory NH resident has a diagnosis of symptomatic knee osteoarthritis for >3 months, has no contraindication to exercise, and is physically and mentally able to exercise THEN there should be evidence that a directed or supervised strengthening or aerobic exercise program was prescribed at least once since the time of diagnosis | Saliba et al. (2004) | Knee OA | Nursing homes in the US |
| Strengthening or aerobic exercises | IF an ambulatory homebound patient is newly diagnosed with osteoarthritis of the knee, has no contraindication to exercise, and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise program should be prescribed within 3 months of diagnosis. | Smith et al. (2007) | Knee OA | Home-based primary care setting in the US |
| Strengthening or aerobic exercises | IF an ambulatory person aged 65 or older has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 3 months and has no contraindications to exercise and is physically and mentally able to exercise, THEN a directed or supervised strengthening or aerobic exercise programme should have been prescribed at least once. | Steel et al. (2004) | Knee OA | Primary and secondary care setting in the UK |
| Strengthening or aerobic exercises | IF an ambulatory homebound patient has had a diagnosis of symptomatic osteoarthritis of the knee for longer than 12 months and is physically and mentally able to exercise, THEN there should be evidence that a physical therapy evaluation for focused strengthening exercises was prescribed at least once since the time of diagnosis. | Smith et al. (2007) | Knee OA | Home-based primary care setting in the US |

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| Strengthening or aerobic exercises | (Patients with knee/hip OA who have documented recommendations for general aerobic and/or muscle strengthening exercise at least once per year, unless contraindicated (e.g. significant heart failure)/ Total number of patients with KHOA without contraindications for general aerobic exercise) * 100: the higher, the better the quality of care | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| Strengthening, aerobic, and functional exercises | If a patient has knee OA, then exercise therapy should be prescribed, including at least muscle strengthening, aerobic exercises and functional exercises, and combined with range of motion exercises in case of range of motion restrictions. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Improving aerobic capacity | Treating patients with improving of aerobic capacity | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Functional exercises | Treating patients with functional exercises | Peter et al. (2013) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Exercise therapy | Providers caring for patients with symptoms of hip or knee OA should recommend both of the following at least once in 2 years: exercise programs for persons with hip or knee OA. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Exercise therapy | Providers caring for patients with symptoms of hip or knee osteoarthritis should recommend exercise programs at least once in 2 years. | Asch et al. (2004) | Knee/hip OA | US healthcare system |
| Advice on exercise or activities | You have been offered information or advice on exercise or activity to help with your joint problem | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Exercise therapy tailored to patients' goals | If a patient with knee OA is following exercise therapy, then the content and intensity of the exercise program should be tailored to the patient's individual goals in terms of limitations of activity and restrictions of participation. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Frequency of exercise therapy sessions | If a patient with knee OA is following exercise therapy, then the treatment sessions should be spread over longer periods with lower frequencies in the later stages of the exercise program to facilitate the transition from exercise therapy to independent exercising and maintaining sufficient level of physical activity. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |

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| Regular evaluations of exercise therapy | If a patient with knee OA is following exercise therapy, then regular evaluations by the physiotherapist are necessary. To make the switchover from a supervised to an autonomous program, an evaluation session should be performed every 3 months in the first year, every 6 months in the second year, and once per year afterward. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Combining exercise therapy with education/ self-management interventions | If a patient with knee OA is following exercise therapy, then the exercise therapy should be combined with education/self-management interventions to improve patients' mental and physical performance and to alleviate pain. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| **Process: weight counselling** | | | | |
| Advice about body weight and joint pain | You have received advice about body weight and joint pain | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Advice to lose weight | (Overweight (BMI ≥27 kg/m2) patients with KHOA who have documented nutritional counselling provided by the Nutrition and Dietary Service and/or who were encouraged by their family physician at least one time per year to lose weight/ Total number of overweight patients with KHOA) * 100: the higher, the better the quality of care | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| Advice to lose weight | If a patient with knee OA is overweight, then he/she should be encouraged to lose weight and maintain his/her weight at a lower level. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Advice to lose weight | IF an individual is overweight (as defined by body mass index of >27 kg/m2), THEN the individual should be advised to lose weight annually. | MacLean et al. (2004) | OA not related to specific sites | US healthcare system |
| Advice to lose weight | IF a patient has symptomatic osteoarthritis of the knee or hip and is overweight (as defined by body mass index of >27 kg/m2), THEN the patient should be advised to lose weight at least annually AND the benefit of weight loss on the symptoms of osteoarthritis should be explained to the patient. | MacLean et al. (2004) | Knee/hip OA | US healthcare system |

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| Advice to lose weight | Providers caring for patients with symptoms of hip or knee OA should recommend weight loss among persons with knee OA and a BMI >25 following at least once in 2 years. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Advice to lose weight | Have you been advised to lose weight, if you are overweight? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| **Process: 'do not do' QIs** | | | | |
| No massage therapy | No massage therapy (benchmark <10%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| No physical modalities | No use of physical modalities other than TENS (e.g. pulsed shortwave) (benchmark <10%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| No brace prescription | If a patient has knee OA, then a brace should not be prescribed (except in unicompartmental knee OA with axial deviation). | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| **Process: pharmacological treatment** | | | | |
| Paracetamol as first-line pharmacologic therapy | Patients who were prescribed paracetamol (numerator)/ all patients with a drug prescription for osteoarthritis in the past month (denominator) | VandenBerghe et al. (2004) | OA not related to specific sites | General practice in Belgium (primary care) |
| Paracetamol as first-line pharmacologic therapy | Patients with a new diagnosis of osteoarthritis who wish to take medication for joint symptoms should be offered a trial of paracetamol if not already tried. | Marshall et al. (2003) | OA not related to specific sites | General practices in the UK health care systems |
| Paracetamol as first-line pharmacologic therapy | Patients with a new diagnosis of OA who wish to take medication for joint symptoms should be offered a trial of acetaminophen. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacological therapy is initiated to treat osteoarthritis among people aged ≥ 50 years, THEN paracetamol should be the first drug used, unless there is a contraindication to use. | Hardcastle et al. (2015) | OA not related to specific sites | UK healthcare system |
| Paracetamol as first-line pharmacologic therapy | Patients with a new diagnosis of osteoarthritis who wish to take medication for joint symptoms should be offered a trial of acetaminophen. | Asch et al. (2004) | OA not related to specific sites | US healthcare system |

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| Paracetamol as first-line pharmacologic therapy | The percentage of patients in whom oral pharmacological therapy was initiated to treat osteoarthritis, whose notes contain a record that they were offered paracetamol first (unless contraindicated) | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacologic therapy is initiated to treat osteoarthritis in a vulnerable elder, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use, BECAUSE this agent is as effective in treating osteoarthritis as other oral agents, and it is less toxic. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |
| Paracetamol as first-line pharmacologic therapy | IF a VE is started on pharmacological therapy to treat OA, THEN acetaminophen should be tried first, BECAUSE acetaminophen achieves pain relief comparable to that of an NSAID (nonselective and selective) for many patients and is associated with a lower burden of common serious adverse events. | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| Paracetamol as first-line pharmacologic therapy | IF a nonnarcotic pharmacologic therapy is initiated to treat osteoarthritis pain of mild or moderate severity, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use. | MacLean et al. (2004) | OA not related to specific sites | US healthcare system |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacologic therapy is initiated to treat osteoarthritis THEN acetaminophen should be the first drug used | Saliba et al. (2004) | OA not related to specific sites | Nursing homes in the US |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacologic therapy is initiated to treat osteoarthritis in a homebound patient, THEN acetaminophen should be the first drug used, unless there is a documented contraindication to use | Smith et al. (2007) | OA not related to specific sites | Home-based primary care setting in the US |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacological therapy is initiated to treat osteoarthritis among people aged 65 or older, THEN paracetamol should be the first drug used, unless there is a contraindication to use. | Steel et al. (2004) | OA not related to specific sites | Primary and secondary care setting in the UK |
| Paracetamol as first-line pharmacologic therapy | IF oral pharmacological therapy is initiated to treat osteoarthritis in an elder, THEN paracetamol (acetaminophen) should be the first drug used, UNLESS there is a documented contra-indication. | Wierenga et al. (2011) | OA not related to specific sites | Dutch in-hospital pharmaceutical care |

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| Paracetamol as first-line pharmacologic therapy | If you have joint pain, was paracetamol the first medication that was recommended? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Paracetamol as first-line pharmacologic therapy | (Patients with newly diagnosed of KHOA who received prescription of acetaminophen as initial oral analgesic, otherwise contraindicated/ Total number of patients with recent diagnosis of KHOA) * 100: the higher, the better the quality of care | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| Paracetamol as first-line pharmacologic therapy | If a patient has knee OA, then acetaminophen up to 3 g/ day should be used as the initial oral analgesic. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | The percentage of patients in whom oral pharmacological therapy was changed from paracetamol to a different oral agent, whose notes contain a record that they were offered a trial of maximum-dose paracetamol | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacologic therapy for osteoarthritis in a vulnerable elder is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age and comorbid conditions) BECAUSE acetaminophen, in adequate doses, is as effective in treating osteoarthritis as other oral agents, and it is less toxic. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacologic therapy for osteoarthritis is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age/comorbidities). | MacLean et al. (2004) | OA not related to specific sites | US healthcare system |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacologic therapy for symptomatic osteoarthritis is changed from acetaminophen to a different oral agent THEN there should be evidence that the NH resident has had a trial of maximum dose acetaminophen (suitable for age and comorbid conditions) | Saliba et al. (2004) | OA not related to specific sites | Nursing homes in the US |

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| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacologic therapy for osteoarthritis in a homebound patient is changed from acetaminophen to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum-dose acetaminophen (suitable for age and comorbid conditions). | Smith et al. (2007) | OA not related to specific sites | Home-based primary care setting in the US |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacological therapy for osteoarthritis is changed from paracetamol to a different oral agent among people aged 65 or older, THEN the patient should have had a trial of maximum dose paracetamol (suitable for age/co-morbidities). | Steel et al. (2004) | OA not related to specific sites | Primary and secondary care setting in the UK |
| Trial of maximum-dose acetaminophen before changing from acetaminophen to different oral agent | IF oral pharmacological therapy for osteoarthritis in an elder is changed from paracetamol (acetaminophen) to a different oral agent, THEN there should be evidence that the patient has had a trial of maximum dose of paracetamol (suitable for age and co-morbid conditions. | Wierenga et al. (2011) | OA not related to specific sites | Dutch in-hospital pharmaceutical care |
| NSAID prescription | Patients which were not prescribed an NSAID (numerator)/ all patients with a drug prescription for osteoarthritis in the past month (denominator) | VandenBerghe et al. (2004) | OA not related to specific sites | General practice in Belgium (primary care) |
| NSAID prescription | Patients who were prescribed a coxib (numerator)/ all patients who received an NSAID for osteoarthritis in the past month (denominator) | VandenBerghe et al. (2004) | OA not related to specific sites | General practice in Belgium (primary care) |
| NSAID prescription | Patients who did not received a repeated prescription/ all patients who received an NSAID for osteoarthritis in the past month (denominator) | VandenBerghe et al. (2004) | OA not related to specific sites | General practice in Belgium (primary care) |
| NSAID prescription | If NSAIDs are considered, Ibuprofen should be considered for first line treatment unless contraindicated or intolerant. | Marshall et al. (2003) | OA not related to specific sites | General practices in the UK health care systems. |
| NSAID prescription | The percentage of patients with osteoarthritis treated with an NSAID, whose notes contain a record that ibuprofen (or a cox-2 inhibitor) has been considered for first-line treatment (unless contraindicated or intolerant) | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |

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| NSAID prescription | (Patients aged 65 years or older with KHOA and one of the following comorbidities (history of peptic ulcer disease or gastrointestinal bleeding, chronic kidney disease, cardiac insufficiency and/or those receiving anticoagulant or glucocorticoids) who receive NSAID prescription/ Total number of patients aged 65 years or older with KHOA and one of the previously mentioned comorbidities)* 100= the lower, the better the quality of care | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| NSAID prescription | If a patient has knee OA and there is no adequate response on acetaminophen, or there is severe pain and/or inflammation, then oral NSAID should be used. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| NSAID prescription | If NSAID are used in a patient with knee OA, then they should be used intermittently (max 3 weeks sustained use) and at the lowest effective dose. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| NSAID prescription | If a patient with knee OA has heart failure grade 2–4, ischemic heart disease, or renal insufficiency with a GFR < 40 ml/min, then NSAID should not be used. In case of other cardiovascular risk factors (e.g., hypertension, …), NSAID should be used with caution. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | Patients with osteoarthritis prescribed oral NSAIDs who are at high risk of gastrointestinal side effects (past history of dyspepsia or known peptic ulcer) should be considered for a co-prescription of PPIs, H2 antagonists or Misoprolol, unless contraindicated or intolerant | Marshall et al. (2003) | OA not related to specific sites | General practices in the UK health care systems. |
| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | (Patients with KHOA and high risk for gastrointestinal complications who received NSAID prescription concomitant with either misoprostol or a proton-pump inhibitor/ Total number of patients with KHOA and high risk of gastrointestinal complications who received NSAIDs) * 100= the higher, the better the quality of care. | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | If a patient with knee OA and a history of bleeding gastric ulcers has a need for NSAID, then either a COX-2 selective agent or a non-selective NSAID with coprescription of a proton pump inhibitor/misoprostol should be used instead of a non-selective NSAID. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |

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| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | IF a VE with a risk factor for GI bleeding (aged ≥75, peptic ulcer disease, history of GI bleeding, warfarin use, chronic glucocorticoid use) is treated with a nonselective NSAID, THEN he or she should be treated concomitantly with misoprostol or a proton pump inhibitor (PPI) | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | IF a VE with two or more risk factors for GI bleeding (aged ≥75, peptic ulcer disease, history of GI bleeding, warfarin use, chronic glucocorticoid use) is treated with daily aspirin, THEN he or she should be treated concomitantly with either misoprostol or a PPI, BECAUSE this will reduce the risk of GI bleeding. | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| NSAID prescription concomitant with either misoprostol or proton-pump inhibitor | IF a vulnerable elder is older than 75 years of age, is treated with warfarin, or has a history of peptic ulcer disease or gastrointestinal bleeding, AND is being treated with a COX nonselective NSAID, THEN he or she should be offered concomitant treatment with either misoprostol or a proton-pump inhibitor BECAUSE this will substantially reduce the risk for NSAID-induced gastrointestinal bleeding. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |
| Informing patients about risks of medication use | IF a patient is treated with a COX nonselective nonsteroidal anti-inflammatory drug (NSAID), THEN there should be evidence that the patient was advised of the risk for gastrointestinal bleeding associated with these drugs BECAUSE this risk is substantial. | MacLean et al. (2001) | OA not related to specific sites | US healthcare system |
| Informing patients about risks of medication use | IF a patient is treated with a COX-nonselective NSAID, THEN there should be evidence that the patient was advised of the risk for gastrointestinal bleeding, as well as cardiovascular risk associated with these drugs. | Smith et al. (2007) | OA not related to specific sites | Home-based primary care setting in the US |
| Informing patients about risks of medication use | The percentage of patients with osteoarthritis treated with an NSAID, whose notes contain a record that they have been advised of the gastrointestinal and renal risks associated with this drug | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |
| Screening patients for risks of medication use | The percentage of patients with osteoarthritis regularly treated with an NSAID, whose notes contain a record that they have been asked about gastrointestinal symptoms within the previous 12 months | Broadbent et al. (2008) | OA not related to specific sites | Primary care in the UK general practice |

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| Informing patients about risks of medication use | If you use anti-inflammatory medications, have you been given information about the effects and possible side-effects of this medication? (e.g. ibuprofen (Nurofen, Brufen), diclofenac (Voltarol), naproxen (Naprosyn),celecoxib (Celebrex)) | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Informing patients about risks of medication use | IF aVE is prescribed chronic high-dose acetaminophen (≥3 g/d) or a VE with liver disease is prescribed chronic acetaminophen, THEN he or she should be advised of the risk of liver toxicity, BECAUSE these risks are greater with high doses of acetaminophen and when underlying liver disease is present. | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| Informing patients about risks of medication use | IF a VE is prescribed an NSAID (non- selective or selective), THEN GI bleeding risks should be discussed and documented | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| Informing patients about risks of medication use | IF a VE is prescribed daily aspirin (including low-dose,<325mg/d), THEN GI bleeding risks should be discussed and documented, BECAUSE selective NSAIDs, non-selective NSAIDs, and aspirin increase the risk of bleeding. | MacLean et al. (2007) | OA not related to specific sites | US healthcare system |
| Corticosteroid injection | If you have experienced an acute deterioration of your symptoms, have you been given or offered a steroid injection? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Drug prescription | Patients without a drug prescription for osteoarthritis in the past month (numerator)/ all patients with osteoarthritis (denominator) | VandenBerghe et al. (2004) | OA not related to specific sites | General practice in Belgium (primary care) |
| Chondroitin and glucosamine-chondroitin | If a patient has knee OA, then chondroitin and glucosamine-chondroitin combination products should not be used. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Opioids | If a patient has knee OA, then strong opioids (oxymorphone, oxycodone, fentanyl, morphine sulfate) should not be used. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Offering stronger pain killers (e.g., co-proxamol, co-dydramol, tramadol, co-codamol, dihydrocodeine, codeine) | If you have prolonged severe joint pain, which is not relieved sufficiently by paracetamol, have you been offered stronger pain killing medications? (e.g. co-codamol, codeine, tramadol, co-proxamol, co-dydramol, dihydrocodeine) | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |

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| **Process: referral** | | | | |
| Referral to exercise or activity programmes | You have been offered a referral to an exercise or activity programme for your joint problem. | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Referral to physiotherapy | You have been offered a referral for physiotherapy for your joint problem. | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Referral to a physical therapist | If a patient has symptomatic knee OA, then he/she has to be referred to a physical therapist for instruction of the patient in appropriate exercises, for motivation of the patient to implement exercise and adhere to exercise, and to evaluate performance. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Referral for physical activity and exercise therapy | Have you been referred or offered a referral to a health professional who can advise you about physical activity and exercise? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Referral to regular community exercise and sports activities after a period of supervised exercise. | If a patient with knee OA is following exercise therapy, then he/she should be referred to regular community exercise and sports activities after a period of supervised exercise. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Referral to weight loss services | You have received a referral for weight loss services. | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Referral to weight loss services | IF a patient has symptomatic osteoarthritis of the knee or hip and has been overweight (as defined by body mass index of ≥27 kg/m2 for >3 years), THEN the patient should receive referral to a weight loss program. | MacLean et al. (2004) | Hip/knee OA | US healthcare system |
| Referral to weight loss services | Have you been referred or offered a referral to someone who can help you to lose weight, if you are overweight? | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Referral to an orthopaedic surgeon | IF a vulnerable elder with severe symptomatic osteoarthritis of the knee or hip has failed to respond to non-pharmacologic and pharmacologic therapy and has no contraindication to surgery, THEN the patient should be referred to an orthopedic surgeon to be evaluated for total joint replacement within 6 months unless a contraindication to surgery is documented BECAUSE hip and knee replacements markedly improve function and quality of life by reducing pain and/or improving range of motion. | MacLean et al. (2001) | Knee/hip OA | US healthcare system |

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| Referral to an orthopaedic surgeon | IF a VE has severe symptomatic OA of the knee or hip despite nonsurgical therapy, THEN a referral to an orthopedic surgeon should be made, BECAUSE joint surgery may reduce pain and improve functional status and quality of life. | MacLean et al. (2007) | Hip/knee OA | US healthcare system |
| Referral to an orthopaedic surgeon | Patients with severe symptomatic osteoarthritis of the knee or hip who have failed to respond to conservative therapy should be offered referral to an orthopaedic surgeon for consideration of joint replacement. | Marshall et al. (2003) | OA not related to specific sites | General practices in the UK health care systems. |
| Referral to an orthopaedic surgeon | IF a patient with severe symptomatic osteoarthritis of the knee or hip has failed to respond to nonpharmacologic and pharmacologic therapy, THEN the patient should be offered referral to an orthopedic surgeon. | MacLean et al. (2004) | Hip/knee OA | US healthcare system |
| Referral to an orthopaedic surgeon | IF a person aged ≥ 50 years with severe symptomatic osteoarthritis of the knee or hip has failed to respond to non-pharmacological and pharmacological therapy, THEN the patient should be offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. | Hardcastle et al. (2015) | OA not related to specific sites | UK healthcare system |
| Referral to an orthopaedic surgeon | IF a person aged 65 or older with severe symptomatic osteoarthritis of the knee or hip has failed to respond to non- pharmacological and pharmacological therapy, THEN the patient should be offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. | Steel et al. (2004) | Hip/knee OA | Primary and secondary care setting in the UK |
| Referral to an orthopaedic surgeon | The percentage of patients with severe symptomatic osteoarthritis of the knee or hip that has failed to respond to non-pharmacological and pharmacological therapy, whose notes contain a record that they were offered referral to an orthopaedic surgeon to be evaluated for total joint replacement within 6 months unless surgery is contraindicated. | Broadbent et al. (2008) | Hip/knee OA | Primary care in the UK general practice |

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| Referral to an orthopaedic surgeon | If you are severely troubled by your osteoarthritis, and exercise and medication do not help, have you been referred or offered a referral for an assessment for operation? (e.g. joint replacement) | Østerås et al. (2018) | OA not related to specific sites | Norwegian healthcare system |
| Referral for laboratory tests | (Patients with KHOA and with NSAID prescription for 6 months or longer who were referred for the following laboratory tests (blood count, serum creatinine and liver enzymes) at least once in the previous 12 months / Total number of patients with KHOA and with NSAID prescription for 6 months or longer) * 100: the higher, the better the quality of care. | Doubova et al. (2015) | Knee/hip OA | Primary care setting; family medicine in Mexico |
| Referral time | Time from OA referral receipt to referral completion for initially incomplete referrals. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Referral time | Time from receipt of complete OA referral to musculoskeletal appointment. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| QI specifically regarding Western Canada Waiting List | Distribution of OA referrals in each urgency category (as scored using the Western Canada Waiting List referral tool). | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| QI specifically regarding Western Canada Waiting List | Percentage of OA referrals triaged as highest urgency based on high Western Canada Waiting List priority criteria scores seen within Wait Time Alliance benchmarks . | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| QI specifically regarding Western Canada Waiting List | Percentage of OA referrals scored using Western Canada Waiting List priority referral criteria. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Referrals to centralized intake care rejected or redirected | Percentage of referrals rejected or redirected when received at centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Referral with complete information | Percentage of OA referrals received with complete information. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Referral received through centralized intake care | Number of referrals received through centralized intake | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |

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| Agreement of severe OA in candidates for joint replacement | Agreement of centralized intake suspected diagnosis of severe OA cases (e.g., patients who are candidates for hip or knee joint replacements) versus confirmed diagnosis of severe OA. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care in Canada |
| **Process: indication for surgery** | | | | |
| Indication for knee replacement | If a patient with knee OA is not obtaining adequate pain relief and functional improvement, then he/she should be considered for joint replacement. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Indication for unicompartmental knee replacement | If a patient has unicompartmental knee OA, then a unicompartmental knee replacement should be considered. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| No arthroscopic interventions | If a patient has knee OA, then arthroscopic interventions are not recommended. Coexisting meniscal lesions should not be treated. Only in case of locking of the knee from a large meniscal fragment or a loose body or an extension loss from an anterior anvil osteophyte is arthroscopic treatment indicated. | Grypdonck et al. (2014) | Knee OA | Entire spectrum of disciplines |
| Operating room time | Operating room time for arthroplasty surgeons in Alberta. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| **Process: documentation** | | | | |
| Documentation of symptoms, limitations in daily activities, systemic or inflammatory disease, and use and effectiveness of treatment ≥once in 2 years | Providers caring for patients with symptoms of OA should document all of the following at least once in 2 years:<br>a. the location of symptoms;<br>b. the presence or absence of limitations in daily activities;<br>c. the presence or absence of a history or symptoms of systemic or inflammatory disease;<br>d. the use and effectiveness of treatment modalities. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Documentation of symptoms, limitations in daily activities ≥once in 2 years | Providers caring for patients with symptoms of osteoarthritis should document all of the following at least once in 2 years: the location of symptoms and/or the presence or absence of limitations in daily activities. | Asch et al. (2004) | OA not related to specific sites | US healthcare system |

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| Documentation of parameters from physical examination ≥once in 2 years | Providers caring for patients with symptoms of OA should document the following for any one affected joint at least once in 2 years:<br>a. the presence or absence of effusion;<br>b. the presence or absence of bony enlargement;<br>c. the presence or absence of tenderness;<br>d. the presence or absence of limitations in range of motion. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Documentation the presence or absence of systemic or inflammatory disease, and joint trauma or surgery in patients with incident OA | Providers caring for patients with incident symptoms of OA should document at least one of the following:<br>• the presence or absence of a history of any systemic or inflammatory disease that may mimic OA;<br>• the presence or absence of any current symptoms of systemic or inflammatory disease that may mimic OA;<br>• the presence or absence of a history of joint trauma or surgery. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Recording of problem areas | Problem areas recorded (i.e. inflammation, pain, impairments of function, activity limitations, participation restrictions, and passive coping behaviour) (benchmark >90%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Recording of patient profile | Patient profile recording according to the Dutch physiotherapy guidelines (benchmark >90%) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| **Process: Follow up, treatment frequency, duration and aftercare** | | | | |
| Follow up review | You have been given a follow-up review of your joint problem. | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Follow up review | Patients receiving care for symptoms of OA should be seen in follow-up at least every 6 months. | Moore et al. (2000) | OA not related to specific sites | US healthcare system |
| Total number of sessions | Number of sessions lower than 12 | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Duration of treatment episode | Duration of treatment episode less than 6 weeks | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Treatment frequency | Treatment frequency | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |

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| Aftercare | Aftercare (e.g. home exercise programme, follow up consultation, advice to participate in community based or sport programmes) | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| **Outcome** | | | | |
| Healthcare providers' experience | Musculoskeletal specialty care provider experience with centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Healthcare providers' experience | Administrative staff and allied health professional experience with centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Healthcare providers' experience | Referring clinician's experience with centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Patient experience | Patient experience with centralized intake. | Barber et al. (2016) | OA not related to specific sites | Centralized intake care system in Canada |
| Patient satisfaction | You are satisfied with the overall quality of the consultation with his/her GP for OA. | Blackburn et al. (2016) | OA not related to specific sites | Primary care setting in the UK |
| Patient satisfaction | Patients satisfaction with treatment* | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Level of pain | VAS for severity of pain decrease of more than 25% | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Level of pain and function | Global perceived effect either for pain or for restrictions in daily activities (5 point Likert scale)* | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Functional capacity | Algofunctional index decrease of more than 25% | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |
| Achievement of treatment goals | The extent to which the treatment goals were achieved* | Jansen et al. (2010) | Knee and hip OA | Physiotherapy care in the Netherlands |

* No specific threshold reported in the article; QIs are developed based on the Dutch physiotherapy guideline and further information on thresholds is documented in the recommendations of this guideline.

# CHAPTER 6

## Evaluation of intermediate care for knee and hip osteoarthritis: a mixed-methods study

Ilgin G. Arslan, Vincent M.I. Voorbrood, Saskia A.G. Stitzinger, Maarten-Paul van de Kerkhove, Rianne M. Rozendaal, Marienke van Middelkoop, Patrick J.E. Bindels, Sita M.A. Bierma-Zeinstra, Dieuwke Schiphof

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## ABSTRACT

**Background:** To evaluate intermediate care for knee and hip osteoarthritis (KHOA) in the general practice that incorporate specialist services into general practice to prevent unnecessary referrals to hospitals.

**Methods:** We used a mixed methods approach including semi-structured interviews, patient experience questionnaires and data from medical records from three intermediate care projects. Semi-structured interviews were conducted with patients, general practitioners (GPs), orthopaedists and a healthcare manager in intermediate care. Satisfaction of patients who received intermediate care (*n*=100) was collected using questionnaires. Referral data and healthcare consumption from medical records were collected retrospectively from KHOA patients before (*n*=96) and after (*n*=208) the implementation of intermediate care.

**Results:** GPs and orthopaedists in intermediate care experienced more intensive collaboration compared to regular care. This led to a perceived increase in GPs' knowledge enabling better selection of referrals to orthopaedics and less healthcare consumption. Orthopaedists felt a higher workload and limited access to diagnostic facilities. Patients were satisfied and experienced better access to specialists' knowledge in a trusted environment compared to regular care. Referrals to physiotherapy increased significantly after the implementation of intermediate care (absolute difference=15%; 95% CI=7.19 to 22.8), but not significantly to orthopaedics (absolute difference=5.9%; 95% CI=-6.18 to 17.9).

**Conclusions:** Orthopaedists and GPs perceived the benefits of an intensified collaboration in intermediate care. Intermediate care may contribute to high quality of care through more physiotherapy referrals. Further research with longer follow-up is needed to confirm these findings and give more insight in referrals and healthcare consumption.

## BACKGROUND

Osteoarthritis is one of the most prevalent chronic diseases, affecting 250 million people worldwide; the knees and hips are the most affected joints.[1] The prevalence and disability burden of osteoarthritis are increasing.[2, 3] As a consequence, healthcare costs are increasing dramatically. Hospital care accounts for the biggest component of healthcare costs, with knee and hip replacements being a substantial element.[1, 3-5] Previous studies have shown that inappropriate joint replacements are common before core treatments for osteoarthritis (e.g. self-management education and exercise therapy[6]) have been optimally used. This leads to high unnecessary healthcare costs.[7, 8] Initiatives to address this rise in healthcare costs and hospital overuse are needed to support the affordability of the healthcare system.[9, 10]

To improve access to specialist services, reduce demand on hospitals, and enhance relationships between primary care providers and medical specialists, several 'shifted outpatients' models have been developed.[11, 12] These models focus on the substitution of hospital-based specialist care into a primary care setting, for example by replacing the primary care provider with a medical specialist as the doctor of first contact (i.e. 'replacement model'), or strengthening the relationship between medical specialists and primary care, but with most patient care mediated through the general practitioner (GP) (i.e. "consultation" model), or with the medical specialist as part of a team of visiting services (i.e. "liaison attachment" model).[11-13] In the Netherlands, GPs act as a gatekeeper to secondary care (i.e. hospital services) and patients can only access hospital services by a referral from their GP.[14, 15] Reinforcement of this gatekeeping role of GPs may help prevent unnecessary referrals to hospitals and thereby tackle rising healthcare costs.

A Dutch nation-wide initiative started in 2012 after the Dutch Ministry of Health, Welfare and Sport formulated recommendations to slow down rising costs through substitution of hospital care to primary care with care provided at 'the right place'. Based on this recommendation, an agreement was made between the Ministry of Health, Welfare and Sport and the National General Practitioners Association to investigate whether substitution of hospital care to primary care can be introduced in the Dutch healthcare system.[16] Therefore, a relatively new outpatient model was initiated in the Netherlands, termed 'intermediate care', often in the form of one-time consultations by medical specialists in the general practice.[17, 18] Previous research has shown the value of intermediate care for reducing waiting times in several medical specialties (e.g. dermatology, orthopaedics, cardiology and rheumatology).[17] However, studies that evaluated the effect on referrals to hospitals are scarce and to date have not included knee and hip osteoarthritis (KHOA).[17] Evidence regarding intermediate care for KHOA is urgently needed as KHOA accounts for a large proportion of hospital overuse and rising healthcare costs.

Recently, in cooperation with health insurance companies, several pragmatic pilot projects have started in the Netherlands to implement intermediate care for KHOA in general practices. Within these projects, orthopaedists (i.e. orthopaedic surgeons) provided face-to-face consultations in general practices. We evaluated three of these projects with regard to: 1) facilitators and barriers of intermediate care as perceived by patients and stakeholders; 2) patient satisfaction; and 3) the effect on the number of referrals to orthopaedics and physiotherapy, and healthcare consumption.

## METHODS

Intermediate care projects in three general practices initiated by the Dutch health insurance company CZ agreed to participate (Practices A-C). Practices A and C are located in an urban area with intermediate care constructed as a one-time consultation by an orthopaedist (i.e. orthopaedic surgeon) in the general practice to patients with musculoskeletal complaints. Practice B is located in a rural area and provided joint consultations by an orthopaedist and GP to patients with KHOA. At the start of this evaluation study, the projects in practices A and B had been running for one year, and the project in practice C for two years.

A mixed methods approach was performed using semi-structured interviews and data from medical records from the general practices. Practices A and B had already collected data on patient satisfaction, which we also included in the current study. Although practices A and C provided intermediate care to patients with all types of musculoskeletal complaints, this study focused on intermediate care provided to the subgroup of patients with KHOA. The characteristics and the parts of the evaluation programme that the projects participated in are shown in Table 1.

**Semi-structured interviews**

All healthcare providers (GPs (n=4), orthopaedists (n=3) and healthcare managers (n=1)) providing intermediate care in practices A and B were invited for semi-structured interviews. Non-responders received a reminder within 2 weeks of the invitation. These interviews focused on their perceived facilitators and barriers with intermediate care. In addition, GPs were asked to invite a convenience sample of patients with KHOA who had at least one intermediate care consultation to be interviewed. These interviews included pre-determined topics from the literature and based on the expert opinion of the research group. Based on these topics, interview guides with open-ended questions were composed and pilot tested (Supplementary File 1). One researcher (IGA, physiotherapist and researcher) conducted the interviews face-to-

face in the general practice or by telephone. The pre-determined topics needed to be covered during the conversations, although the interviewer was allowed to diverge from the interview guide to explore additional topics. Field notes were made by the interviewer during and after the interviews. The interviews were audiotaped, transcribed verbatim into written form and read by the interviewer to increase the validity. To guarantee transparency, all participants were offered to receive their transcript for comment and correction.

**TABLE 1.** Participating practices and their characteristics

| | **Practice A** | **Practice B** | **Practice C** |
|---|---|---|---|
| Target group | Patients with musculoskeletal complaints who would normally be referred to secondary care | 1) Patients with suspected knee or hip osteoarthritis.<br>2) Patients with knee or hip osteoarthritis aged 50 and older that do not qualify for surgery and patients who do not sufficiently respond to non-surgical treatment in primary care | Patients with musculoskeletal complaints who would normally be referred to secondary care |
| Area | Urban | Rural | Urban |
| Healthcare providers in intermediate care consultation | Orthopaedist, sometimes together with a GP | Joint consultation by a GP and orthopaedist | Orthopaedist |
| Scale of project | One general practice with one orthopaedist | Two general practices; one orthopaedist within each practice | One general practice with one orthopaedist |
| Participated in following programme evaluation parts | Semi-structured interviews, patient-level referral data and patient-reported experience measures | Semi-structured interviews, patient-level referral data and experience measures | Patient-level referral data |
| Data that had already been collected by the practice before the start of this evaluation study | Patient-reported experience measures (patient satisfaction) | Patient-reported experience measures (patient satisfaction) | - |

**Patient satisfaction**

We included satisfaction questionnaires that were already designed and collected by GPs and orthopaedists from practices A and B. Immediately after the intermediate care consultation, patients were asked by the GP assistants to complete the questionnaire anonymously. These questionnaires included questions about satisfaction with: 1) the consultation; 2) the provision of information by healthcare providers; and 3) the patient-healthcare provider relationship. Satisfaction scales in the questionnaires varied between the two practices (1-10 scale vs. 4-point Likert scale). Patients were allowed to add free-text comments.

**Healthcare consumption and referrals**

Data on patients' characteristics (e.g. age and sex), healthcare consumption in terms of number of consultations (i.e. face-to-face consultation, visit and telephone contact) and GP referrals to orthopaedics in hospital care were collected retrospectively from the medical records of practices A-C. In the Dutch healthcare system, GPs can refer patients to primary care physiotherapists, which is recommended by the Dutch GP guidelines for non-traumatic knee complaints[19] as part of OA core treatment.[15, 19] GP referrals to primary care physiotherapy were also collected retrospectively from the medical records of practices A-C. Records of patients with KHOA and with at least one consultation, visit or telephone contact by their GP either before or after the implementation of intermediate care (pre-implementation and post-implementation period) were selected. A diagnosis of KHOA was defined following the International Classification of Primary Care[20], coding L89 (hip osteoarthritis) and/or L90 (knee osteoarthritis). The duration of the pre- and post-implementation periods varied between the practices, since the practice projects were running for different periods at the time of this study. In practice A data was collected six months before and after implementation (i.e. one year in total) and in practices B and C one year before and after implementation (i.e. two years in total). Figure 1 shows the time periods for the practices in the pre-and post-implementation periods.

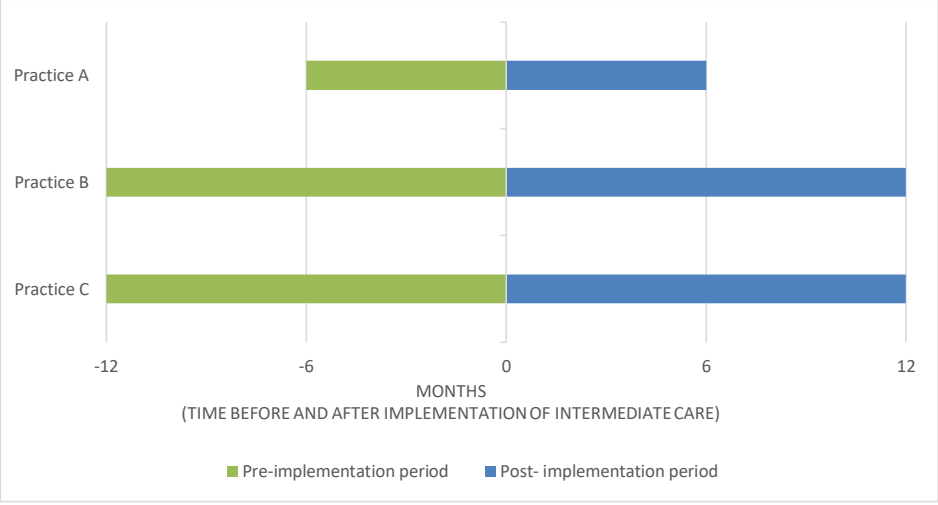


**FIGURE 1.** Time periods of the pre-implementation and post- implementation period of intermediate care for data collection on referrals

**Notes.** The starting point of the implementation of intermediate care is at the value '0' on the x-axis. Negative values on the x-axis represent the time before the implementation of intermediate care and positive values on the x-axis represent the time after the implementation of intermediate care.

**Data analysis**

Interviews were analysed following the steps of thematic analysis described by Braun and Clarke(24) and with assistance of the software MAXqda Version 2018.[21, 22] We used a semantic approach (i.e. analysis close to participants' language, capturing explicit meaning) to describe the opinions of different participants in intermediate care. Deductive coding was done based on pre-determined themes, and inductive coding based on additional topics that we extracted from the open-ended questions. Two interviews were coded independently by two researchers (IGA and DS) and then compared. Any disagreements were discussed until consensus was reached. The resulting codes were further applied for analysis, and iteratively modified if necessary after each interview coding. Codes were structured hierarchically and analysed using the thematic framework. Relevant quotes were selected from the transcripts.[22, 23]

Descriptive statistics of patient satisfaction, healthcare consumption (i.e. number of consultations) and referral data were analysed using R Studio Software V.3.6.3. Means and standard deviations (SDs) were calculated for numeric variables, and numbers (n) and percentages (%) for categorical variables. Differences in the percentage of referrals were assessed using the Chi-squared test with Yates's continuity correction. Absolute differences in the percentage of referred patients were reported, including 95% confidence interval (CI). The significance level throughout was set at two-tailed P<.05.

## RESULTS

**Semi-structured interviews**

Four GPs, two orthopaedists, and one healthcare manager were interviewed. Only one orthopaedists did not respond to the invitation letter and was therefore not interviewed. Furthermore, four patients invited by their GP were interviewed (see Supplementary File 2 for their characteristics). The duration of the interviews varied from 7.5 to 45 minutes. Information about the content of the projects that we extracted from the interviews is presented in Supplementary File 3.

***Facilitators for general practitioners, orthopaedists and healthcare manager***

GPs and orthopaedists experienced better multidisciplinary communication, with more transparency and mutual respect. They perceived this as an advantage for patients' trust in the healthcare system and for the relationship between healthcare providers (Quote 2, Table 2). In addition, GPs experienced an increase in their skills and more confidence about their clinical diagnosis. They also perceived more knowledge regarding indications of patients' referral to

secondary care due to intensive multidisciplinary collaboration. This was reported more frequently in projects with joint consultations by an orthopaedist and GP (Quotes 2 and 3, Table 2).

*Facilitators for patients*

Patients and healthcare providers said that the shorter waiting times, lower out-of-pocket costs and shorter travel distances resulted in better access to healthcare, especially for elderly patients (Quote 4, Table 2). Patients experienced added value in the fact that they received specialist care in a trusted environment on a small scale (i.e. the general practice) (Quotes 5 and 6, Table 2). Healthcare providers benefited from the longer consultations in intermediate care compared to regular care by having more time to inform patients properly about their health problem. They felt that this was highly valued by patients. (Quote 7, Table 2).

*Facilitators for society as a whole*

As a result of the longer consultations, healthcare providers experienced less follow-up consultations in which patients ask for more information compared to regular care (Quote 8, Table 2). Orthopaedists and the healthcare manager experienced less unnecessary diagnostic procedures (e.g. less MRI requests in general practice) due to increasing knowledge of healthcare providers through intensified multidisciplinary communication (Quote 9, Table 2). Furthermore, fewer patients were unnecessarily referred to the hospital (Quote 10, Table 2). Healthcare providers mentioned that this reduction in healthcare consumption led to lower healthcare costs, which benefits society as a whole.

*Barriers for healthcare providers*

Orthopaedists working in intermediate care had limited access to additional diagnostic equipment (e.g. MRI or X-ray equipment). As a consequence, they felt that requesting additional diagnostic tests led to logistics barriers and uncertainties about their diagnosis (Quote 11, Table 2). As a solution, GPs in one project started requesting X-rays routinely before referring patients to intermediate care.

Although orthopaedists agreed that better selection of patients to hospitals is a valuable consequence of intermediate care, some feared that the reduction of referrals to hospitals threatened the hospital's income. However, this did not appear to be the case, probably because of the increasing prevalence of patients with KHOA (Quote 12, Table 2). Orthopaedists believed that intermediate care reduced the number of referrals to hospitals, as a result, they felt that patients referred to hospitals were more complex and time-consuming patients than before. As a consequence, they felt an increase in their workload in the hospital (Quote 13, Table 2). As complex patients need more information and their healthcare takes more organizing,

healthcare providers recommended having longer consultations and employing more support personnel in hospitals (Quote 14, Table 2). Orthopaedists also experienced a higher workload, as the intermediate care project was an additional service on top of their usual work in the hospital (Quote 15, Table 2).

**TABLE 2.** Facilitators and barriers of intermediate care with example quotes

| **Facilitators** | | |
|---|---|---|
| **Main themes** | **Subthemes** | **Example quotes** |
| Facilitators for healthcare providers | Relationship between healthcare providers:<br>1) better multidisciplinary communication<br>2) more mutual respect | ***Quote 1:*** *"And the specialist is more aware of the problems the GP actually has. In other words, you end up respecting one another more. That's also an objective I actually find quite important: that you have respect for one another and the patient can see that. If the specialist says, 'Go back to your GP; what he says is right', or if I say, 'This specialist is really good with this particular problem'. And you say that about one another, which gives the patient more confidence too." (interview 10, GP)* |
| | Learning effect of healthcare providers:<br>1) more competent in specific skills<br>2) more confident about their clinical diagnosis<br>3) more knowledge about patients' referral | ***Quote 2:*** *"You educate one another a bit. I learn from the GP and [the GP] learns from us."(Interview 5, orthopaedist)* |
| | | ***Quote 3:*** *"But when you have someone sitting next to you who does an awful lot, you start doing it more often too. You see that happening with the knees. Giving an injection in the knee isn't so difficult, but if you aren't doing that and you don't have someone sitting next to you who does it at some point, then you don't start doing it yourself." (interview 6, GP)* |
| Facilitators for patients | Better access to healthcare | ***Quote 4:*** *"Right, I reckon that patients – certainly older patients – can get there on their own. They don't need to find someone who can take them to the hospital. Certainly for older patients: they don't need to find someone who can take them to the hospital." (Interview 2, orthopaedist)* |
| | Healthcare in familiar environment on a small scale | ***Quote 5:*** *"It's a more pleasant environment because it's familiar." (Interview 9, patient)* |
| | More specialized care | ***Quote 6:*** *"That sense of involvement with the orthopaedist. Of course you're more in his field of expertise. The GP is a bit more of a generalist, after all." (Interview 4, patient)* |
| | Longer consultations | ***Quote 7:*** *"That's precisely what I like about it: the fact that you have more time. And that's exactly what all the patients say. The fact that there's plenty of time for the explanation is something that everyone really likes. [...] Right, well, you have… I think your contact with the patient is rather more intensive. Of course, that's because you have more time." (Interview 2, orthopaedist)* |
| Facilitators for society as a whole | Lower healthcare costs due to less healthcare consumption | ***Quote 8****: "I also think [...] that the extra time [...] that I have for a patient in the GP practice means that I don't see the same people coming back so soon. Because I can really explain things properly to them in one go." (Interview 2, orthopaedist)* |
| | | ***Quote 9:*** *"We educate one another in that regard too, so if there are pointless examinations, we say 'Don't do that'. [...] It's also very much a learning process, and we're going to end up with fewer diagnostic tests." (Interview 5, orthopaedist)* |

| | | |
|---|---|---|
| | Lower healthcare costs due to better selection of patients for secondary care | ***Quote 10:*** *"Yes, we've been able to keep more than 80 per cent [of the patients] in primary care. Assuming you start with 100 per cent, then an expensive hospital treatment product would have been initialized for all of them and we've now managed to prevent that for four fifths." (Interview 11, healthcare manager)* |

**Barriers**

| Main themes | Subthemes | Example quotes |
|---|---|---|
| Less access to additional diagnostic facilities for orthopaedists | - | ***Quote 11:*** *"A minus point for orthopaedics in an intermediate care project is that you often don't have access to additional examinations. So you don't have any X-rays and if someone comes in and you're thinking it could be osteoarthritis, you'll still need... to see that, you'll still need to have an X-ray.*<br><br>*Interviewer: "And what impact does that have for you in your work – the fact that you can't easily get the additional diagnostics?"*<br><br>*"Well, it means you still, um, you still end up with people coming back one more time. And so you hesitate just that little bit, as it were, before making the definite diagnosis." (Interview 2, orthopaedist)* |
| Workload for orthopaedists | Workload in secondary care | ***Quote 12:*** "*That* [not being the case] *has to do with the big wave* [of osteoarthritis patients] *we are now facing. You can simply see it coming now. So we're getting just as many people now, but we're seeing more severe cases. The more minor cases are fortunately staying with the GPs for longer."(Interview 5, orthopaedist)* |
| | | ***Quote 13:*** *"They are seeing an increase in complex care needs. The contamination* [hospital overuse] *that you basically get rid of, because that's the intermediate care, you are taking that away. And the better care ends up in the right place, so it's really a reciprocal process." (Interview 10, healthcare manager)* |
| | | ***Quote 14:*** *"I think that as doctors and specialists, we need to look at whether we shouldn't perhaps be allocating more time for that patient visiting the outpatient clinic. Because if that's a more severe case, they'll need more explanation."(Interview 3, orthopaedist)* |
| | Additional workload in general due to intermediate care | ***Quote 15:*** *"It* [working in intermediate care in addition to working in a hospital] *is busy so that means you have to organize it well. I always do that on my free afternoon. [...] There is more pressure on you, quite apart from organizing the whole intermediate care consultations and it takes an awful lot of time. (Interview 5, orthopaedist)* |

**Patient satisfaction**

In total, 100 patients from practices A and B completed the satisfaction questionnaires (data shown in Supplementary File 1). Results from practice A (n=39) showed that most patients were 'very satisfied' with the consultation (63%), provision of information by healthcare providers (67%), and the patient-healthcare provider relationship (72%) (4-point Likert scale 'very unsatisfied' to 'very satisfied'). The remaining patients were 'satisfied'. Results from practice B (n=61) showed a mean satisfaction score of 9 (range 0 to 10) for the patient-healthcare provider relationship and provision of information, and 8.9 for the consultation in general.

Specific comments about the intermediate care consultation were positive, for example about the knowledge of the orthopaedist, short waiting times and consultation hours in the evening.

**Healthcare consumption and referrals**

A total of 96 patients with KHOA were seen during the pre-implementation period and 208 during the post-implementation period. Of the patients in the post-implementation period, 26.4% received intermediate care and the remaining 73.6% received regular GP care. Patients in the pre-implementation period had a mean age of 71.3 years (SD = 10.8), 66.7% of them were female, 67.7% had knee OA, and the remaining 32.3% hip OA. Patients in the post-implementation period had a mean age of 69.3 years (SD = 9.8), 66.3% of them were female, 65.9% had knee OA, and the remaining 43.1% hip OA. Patients in the pre-implementation period received on average 2.40 consultations (SD = 1.59) and patients in the post-implementation period on average 2.52 consultations (SD = 1.78). These characteristics did not significantly differ between patients in the pre- and post-implementation period (Table 3).

**TABLE 3.** Characteristics of patients in three general practices with intermediate care projects, comparing pre-implementation and post-implementation groups

| | **Pre-implementation period (n=96)** | **Post- implementation period (n=208)** | **Difference *P*-value** |
|---|---|---|---|
| Age, mean (SD) | 71.3 (10.8) | 69.3 (9.8) | *P* = .11 |
| Female, n (%) | 64 (66.7) | 138 (66.3) | *P* = 1.00 |
| Knee osteoarthritis coding, n (%) | 65 (67.7) | 137 (65.9) | *P* = .80 |
| Hip osteoarthritis coding, n (%) | 31 (32.3) | 71 (34.1) | *P* = .80 |
| Number of consultations, mean (SD) | 2.40 (1.59) | 2.52 (1.78) | *P* = .53 |

The percentage of referrals to physiotherapy increased significantly in the post-implementation period compared to pre-implementation (absolute difference=15%; 95% CI=7.19 to 22.8). In contrast, the percentage of referrals to orthopaedics increased slightly, but not statistically significant (absolute difference=5.9%; 95% CI=-6.18 to 17.9) (Table 4). Supplementary File 4 shows the referrals and number of consultations stratified by patients who received regular GP care and patients who received intermediate care during the post-implementation period.

**TABLE 4.** Referrals to physiotherapy and orthopaedics in the pre-implementation period compared to post-implementation

| | Pre-implementation period (n=96) | Post-implementation period (n=208) | Absolute difference (%) (95% CI) |
|---|---|---|---|
| Referrals to physiotherapy, n (%) | 5 (5.21) | 42 (20.2) | **+15.0% (7.19-22.8)** |
| Referrals to orthopaedics, n (%) | 29 (30.2) | 75 (36.1) | +5.9%; (-6.18-17.9) |

**Bold:** statistically significant at 5% level

# DISCUSSION

### Summary

This evaluation study showed that GPs and orthopaedists experienced more intensive collaboration due to the implementation of intermediate care in general practice. This led to a perceived increase in their knowledge, for the GP enabling a better selection of referrals to orthopaedics and physiotherapy. Patients were satisfied and experienced better access to healthcare, and the benefits of a trusted environment and specialists' knowledge. The percentage of referrals to physiotherapy increased significantly after the implementation of intermediate care. The observed increase in referrals to physiotherapy contributes to the quality of care, since offering patients with KHOA physiotherapy is an indicator for high quality of care.[24] Healthcare providers experienced better selection of referrals to orthopaedics and less healthcare consumption. However, the actual observed percentage of orthopaedic referrals and the mean number of consultations in the general practice did not decrease after the implementation.

### Strengths and limitations

A strength of the study is the mixed methodology that enabled a comprehensive evaluation of intermediate care with regard to the experiences of patients and other stakeholders, patient satisfaction, and referral trends. However, the findings of this study are subject to several limitations. First of all, the retrospective design of this study led to a lack of proper baseline measurements. This limited our information on for example the severity of KHOA and conclusions about the appropriateness of referrals to orthopaedics and physiotherapy are therefore not possible. It should be noted that the differences in referrals might partly be due to confounding by indication for a referral (e.g. more severe patients may be more likely to be referred to orthopaedics) and not only the effect of intermediate care. We were not able to draw conclusions about the effect of differences in patients' characteristics between the pre- and post-implementation period on referrals. A regression model which would be appropriate for this kind of analysis requires independent samples, which might not be the case in our study.

Nevertheless, explorative analysis showed no effect of age, sex or affected joint on referrals (data not shown). Furthermore, the current study only captured GP referrals to physiotherapy. Since 2006 patients in the Netherlands can also access physiotherapy care without a GP referral.[25] The number of physiotherapy uptake might therefore be underestimated in this study. Also, GPs invited a convenience sample of patients for the interviews and the experiences of those patients were generally positive. However, this may be the result of selection as GPs may have been more inclined to invite patients who are more positive about the provided care. Furthermore, all patients preferred a telephone interview instead of face-to-face interview. This, in addition to the low number of patients included, might have influenced the limited data saturation. As a consequence, findings from the interviews with patients might not be reflective of the full range of patient experience. Lastly, the findings of this study are restricted to intermediate care, a 'shifted-outpatient' model specifically in the Netherlands. Therefore, applicability to other countries may be limited.

**Comparison with existing literature**

Previous studies have shown that GPs have little confidence in their ability to diagnose and manage musculoskeletal conditions.[26, 27] The present study showed that GPs and orthopaedists providing intermediate care felt that they learned from each other and that their knowledge increased. Therefore, intermediate care might be a solution to increase the confidence of GPs.

Furthermore, this study showed that orthopaedists experienced a higher workload due to intermediate care. Previous research has shown that a substantial proportion of patients referred to secondary care could instead be seen by a GP with special interest in this area.[28] This may therefore be helpful in managing the high workload for orthopaedists and is worth exploring in future research. Orthopaedists also felt they had limited access to diagnostic facilities in the general practices, which is in line with a previous study[29] that evaluated barriers and facilitators in substituting hospital care with primary care. This barrier may lead to an increase in healthcare costs, as GPs in one project started requesting X-rays routinely before referring patients to intermediate care, while current clinical practice guidelines[19] do not recommend routine X-rays in primary care settings. Previous studies reported a decrease in referrals to orthopaedics.[11, 13, 29, 30] However, the current study shows that while healthcare providers experienced a better selection of referrals to orthopaedics, the actual observed percentage of referrals did not decrease. This might be due to the short follow-up time of the intermediate care projects. A longer follow-up time is probably needed to observe more reliable effects of intermediate care on referrals and healthcare consumption.

Healthcare providers who were interviewed in the present study felt that the longer consultation in intermediate care is a benefit for patients. However, a recent study[31] showed that

patients did not find the duration of the consultation very important, while healthcare providers did. Our study shows that healthcare providers experience longer consultations as a facilitator for providing better medical advice to patients, which might reduce the patient's need for further consultations. This finding is in line with results from a previous observational study[32]. Even though the observed mean number of consultations in the current study did not yet decrease, future research with a longer follow-up time may show a reduction.

**Implications for research**

We strongly recommend replication of this study with more rigorous data collection methods and a prospective study design (e.g. cluster or stepped wedged randomized controlled trial that decrease potential bias) to increase the reliability of the findings. In addition, a longer follow-up time in future research would be justified to show the long-term effects of intermediate care on referrals and healthcare consumption. Further research including different forms of intermediate care is also needed to provide more extensive recommendations on how to implement intermediate care most effectively, such as electronic consultations between GPs and specialists.[33] Lastly, our research indicated that intermediate care reduces healthcare costs based on the experiences of healthcare providers, as expressed in the interviews. Future research into the cost-effectiveness of intermediate care is recommended to strengthen the evidence for this result.

## CONCLUSIONS

This evaluation study of intermediate care for KHOA showed benefits in intensifying the collaboration between orthopaedists and GPs. This led to a perceived increase in their knowledge enabling better selection of referrals to orthopaedics and decrease in healthcare consumption. In contrast, orthopaedists providing intermediate care felt a higher workload and limited access to diagnostic facilities. Patients were satisfied and experienced better access to healthcare and the specialists' knowledge in a trusted environment. Intermediate care led to an increase in physiotherapy referrals, contributing to high quality of care, but did not reduce the number of referrals to orthopaedics and healthcare consumption in these projects yet.

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# SUPPLEMENTARY FILE 1.
## Interview guides

**Interview guide: patients**

| Topics | Interview questions |
|---|---|
| Experience with the patient-healthcare provider relationship | How did you experience the patient-healthcare provider relationship?<br>Are you satisfied with the information provided by the healthcare provider(s) regarding your health problem during the appointment? |
| Experienced accessibility of intermediate care; financially, in timing and geographically* | How do you experience the accessibility of intermediate care?<br>- Experience with waiting times<br>- Experience with travel times<br>- Experience with financial access |
| Experienced difference between usual and intermediate care | What is the difference between primary and intermediate care in your view? |
| Expectation of intermediate care | What were your expectations of intermediate care and does intermediate care comply with your expectations? |
| Other barriers | Have you experienced obstacles in receiving intermediate care? |
| Other facilitators | What are the advantages of intermediate care in your view? |
| Recommendations for improvement of intermediate care | Are there components of intermediate care that you would want to change to make the care better? |

* Accessibility of healthcare can be divided into three aspects:

1. Financially: refers to the extent in which patients are able to pay for healthcare.(8)

2. Timing: refers to the extent in which patients can receive healthcare within a reasonable time (e.g. waiting times). (8)

3. Geographically: refers to the extent in which healthcare facilities are available across the country so that everyone has access the healthcare facility within a reasonable period of time (e.g. travel time and travel distance). (8)

**Interview guide: healthcare providers and healthcare manager**

| Topics | Interview questions |
|---|---|
| Start of intermediate care project | How did the intermediate care project start?<br>Who initiated the intermediate care project?<br>What were the motivations to start the intermediate care project?<br>Where there any facilitators/barriers during the start of the intermediate care project? |
| Content of intermediate care | What is the target group of your intermediate care?<br>What is the protocol for referral of patients to intermediate care?<br>What is the method of communication between healthcare providers in intermediate care (communication between GPs and orthopaedists)?<br>What is the duration of an intermediate care consultation?<br>Are there any facilitators and/or barriers regarding the content of the project? |
| Experienced accessibility of intermediate care; financially and in timing | What is the usual waiting time for patients for a consultation in intermediate care?<br>Are there any out-of-pocket costs for patients with KHOA who receive a consultation in intermediate care? |
| Experienced difference between usual care and intermediate care | What is the difference in content between intermediate care and usual care (primary and/or secondary care) for patients with KHOA? |
| Financial structure of intermediate care project | How is intermediate care organized financially (for the general practice and patients)?<br>Are there any facilitators and/or barriers regarding the financial structure of the project? |
| Barriers for intermediate care | Have you experienced obstacles in intermediate care?<br>Are there components of intermediate care that you would want to change to make the care better? |
| Facilitators for intermediate care | What are the advantages of intermediate care in your view? |
| Recommendations | Do you have recommendations for other intermediate care projects to start up and manage the project successfully? |

## SUPPLEMENTARY FILE 2.

Characteristics of participants participating the semi-structured interviews

| Role | Female % (n) | Method of interview |
|---|---|---|
| Orthopaedist (n=2) | 50% (1) | All face-to-face |
| GP (n=4) | 25% (1) | Three face-to-face and one on telephone |
| Patients (n=4) | 25% (1) | All on telephone |
| Healthcare manager (n=1) | 100% (1) | Face-to-face |

**Notes.** Age of participants was not reported to preserve confidentiality, as the number of participants within one role is small and increases the likelihood that their confidentiality cannot be guaranteed.

## SUPPLEMENTARY FILE 3.

Content of the intermediate care projects for which semi-structured interviews were carried out

| | Project 1 | Project 2 |
|---|---|---|
| Target group | Patients with musculoskeletal complaints who would normally be referred to secondary care. | Patients of 50 and older with suspected or confirmed knee and/or hip osteoarthritis; patients with insufficient arguments for surgery; the patients does not sufficiently respond to non-surgical treatment in primary care. |
| Frequency | One afternoon per two weeks. | One evening per two weeks. |
| Length of consultation | 30 minutes | 5-20 minutes |
| Set-up | One-time consultation, normally provided by an orthopaedist alone, sometimes together with a GP. | One-time joint consultation by a GP with special interest and an orthopaedist. |
| Scale of project | One general practice with one orthopaedist. | Two general practices with one orthopaedist for each practice. |
| Method of referral to intermediate care | Referral by a GP. | Referral by a GP, always with an X-ray request. |
| Reasons to start intermediate care project | - Higher quality of care<br>- Lower healthcare costs<br>- More multi-disciplinary collaboration<br>- Intrinsic motivation/ personal interest | - Higher quality of care<br>- Lower healthcare costs<br>- Learning from other disciplines<br>- Providing healthcare in a familiar environment for the patient<br>- Prevent patients from seeking care abroad (Belgium)<br>- Better access to healthcare for the patient<br>- Reducing overuse of hospital care due to unnecessary referrals<br>- More multi-disciplinary collaboration |

# SUPPLEMENTARY FILE 4.
## Patients' satisfaction with intermediate care

**Practice A**

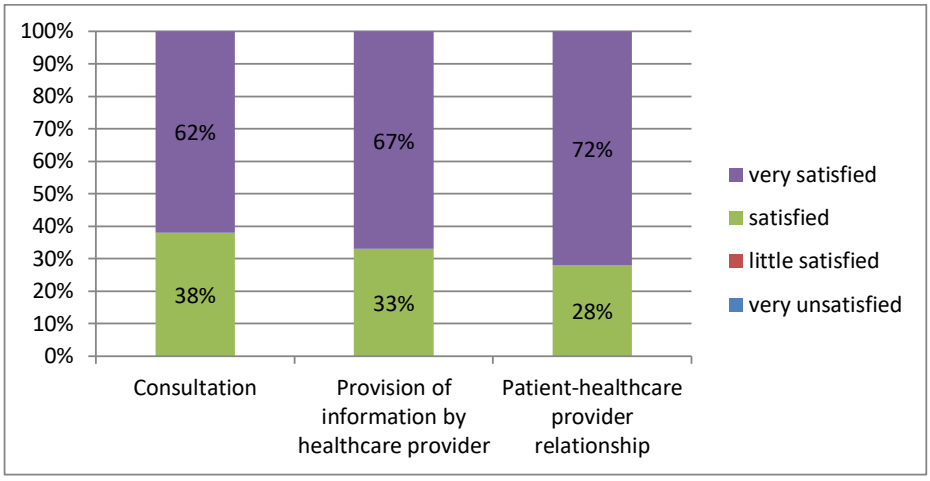


**FIGURE 1.** Results of n= 39 patient satisfaction questionnaires on a 4-point Likert scale

**Practice B**

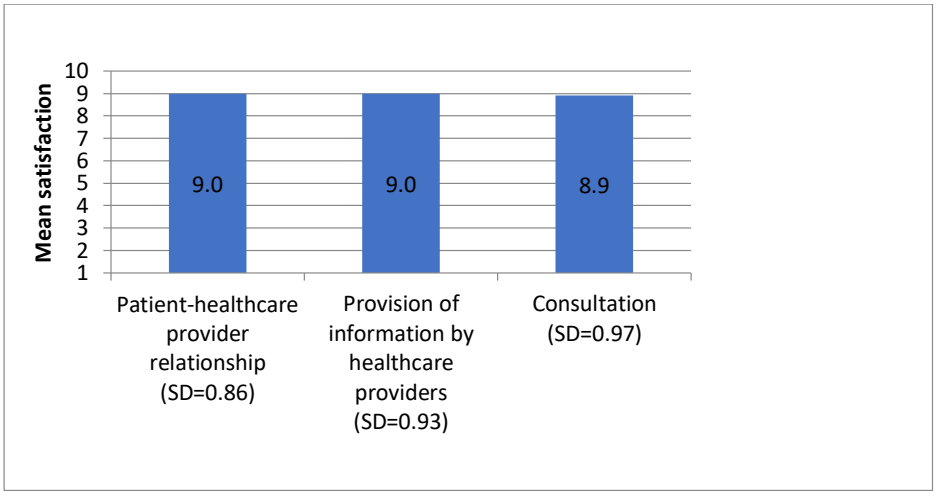


**FIGURE 2.** Results of n=61 patient satisfaction questionnaires on a scale from 1-10

**Abbreviation:** SD= standard deviation

## SUPPLEMENTARY FILE 5.

Referrals and healthcare consumption in the pre-and post-implementation period stratified by patients who received regular GP care or intermediate care

| | **Pre-implementation period** | **Post-implementation period** | |
|---|---|---|---|
| | **Regular GP care (n=96)** | **Regular GP care (n=153)** | **Intermediate care (n=55)** |
| Referrals to physiotherapy, n (%) | 5 (5.21) | 21 (50.0) | 21 (50.0) |
| Referrals to orthopaedics, n (%) | 29 (30.2) | 66 (88.0) | 9 (12.0) |
| Number of consultations, mean (SD) | 2.40 (1.59) | 2.55 (1.99) | 2.52 (1.71) |

# CHAPTER 7

## Patients', healthcare providers', and insurance company employees' preferences for knee and hip osteoarthritis care: a discrete choice experiment

Ilgin G. Arslan, Samare P.I. Huls, Esther W. de Bekker-Grob, Rianne Rozendaal, Marco C.T. Persoons, Mariëlleke E. Spruijt-van Hell, Patrick J.E. Bindels, Sita M.A. Bierma-Zeinstra, Dieuwke Schiphof

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## ABSTRACT

**Objective:** To determine patients', healthcare providers', and insurance company employees' preferences for knee and hip osteoarthritis (KHOA) care.

**Design:** In a discrete choice experiment, patients with KHOA or a joint replacement, healthcare providers, and insurance company employees were repetitively asked to choose between KHOA care alternatives that differed in six attributes: waiting times, out of pocket costs, travel distance, involved healthcare providers, duration of consultation, and access to specialist equipment. A (panel latent class) conditional logit model was used to determine preference heterogeneity and relative importance of the attributes.

**Results:** Patients (n=648) and healthcare providers (n=76) valued low out of pocket costs most, while insurance company employees (n=150) found a joint consultation by general practitioner (GP) and orthopaedist most important. Patients found the duration of consultation less important than healthcare providers and insurance company employees did. Patients without a joint replacement were likely to prefer healthcare with low out of pocket costs. Patients with a joint replacement and/or low disease-specific quality of life were likely to prefer healthcare from an orthopaedist. Patients who already received healthcare for knee/hip problems were likely to prefer a joint consultation by GP and orthopaedist, and direct access to specialist equipment.

**Conclusions:** Patients, healthcare providers, and insurance company employees highly prefer a joint consultation by GP and orthopaedist with low out of pocket costs. Within patients, there is substantial preference heterogeneity. These results can be used by policy makers and healthcare providers to choose the most optimal combination of KHOA care aligned to patients' preferences.

# INTRODUCTION

Osteoarthritis is one of the most prevalent chronic diseases, affecting 10% of the people over 60 years[1]. The knee and hip are the most commonly affected joints[2, 3]. Currently, treatment for knee and hip osteoarthritis (KHOA) focuses on controlling symptoms and improving function.

Guidelines advocate pro-active, non-surgical treatment for KHOA, which can be provided in primary care. Patients who do not respond sufficiently to non-surgical treatment are referred to secondary care for surgical treatment[4-6]. Despite the wide range of treatment options, not every patient receives healthcare as they should according to the guidelines[7-9]. Moreover, many patients who are referred to secondary care do not need surgical treatment (yet), leading to high healthcare costs and overuse of secondary care[10]. To prevent too early referral to secondary care, intermediate care setting has recently been developed, in which specialist services are implemented in primary care[11]. However, it is unknown whether this development matches the preferences of patients.

Healthcare tailored to patients' preferences could optimise care for KHOA and thereby improve its uptake, adherence, and effectiveness[12]. In addition, comparing preferences of healthcare providers, policy makers, and patients might reveal differences that change the view of policy makers and healthcare providers on how to arrange KHOA care.

A common quantitative technique used to determine preferences is a discrete choice experiment (DCE)[13, 14]. In DCEs, participants are repeatedly asked to make choices between different hypothetical alternatives, which eventually reveals their preferences[15]. Previous DCEs on osteoarthritis focused on patients' preferences for outcomes and content of treatments[16-21], such as efficacy and side-effects, benefits and risks associated with drug treatment, and joint replacement. No study to date has examined patients' preferences for structure aspects of healthcare settings for KHOA (i.e. attributes of material and human resources used for providing care), such as the type of healthcare providers present during consultation. Furthermore, the preferences of other stakeholders and heterogeneity in preferences within patients for KHOA care has not been identified in previous studies. This information is important for policy makers and healthcare providers to choose the most optimal combination of healthcare for KHOA aligned to patients' preferences.

We therefore aimed to determine the preferences of patients and the heterogeneity in their preferences for the characteristics of different healthcare settings of KHOA care. Secondly, we aimed to determine similarities and differences between the preferences of healthcare providers and insurance company employees with patients' preferences.

# METHODS

**Discrete choice experiment**

A DCE was performed to gain insight into the participants' preferences and how they evaluate and trade off characteristics of healthcare settings for KHOA. A DCE assumes that preferences of people are based on the underlying characteristics of healthcare services/goods/products, so-called attributes (e.g. waiting time)[13, 16, 22]. Those attributes are specified by their attribute levels that refer to possible values (e.g. for waiting time: one or two weeks)[14, 16]. We presented several alternatives of KHOA care with different combinations of attribute levels in a questionnaire to participants, so-called choice tasks. We repeatedly asked them to make a choice between hypothetical alternatives. This enabled us to identify how much they were willing to give up one attribute, to gain something on another attribute. As such, it provided information on the relative importance of each attribute and its levels.

**Attributes and levels**

We composed a list of potential attributes from previous qualitative studies on patients' preferences for KHOA care[23-27]. We interviewed experts in KHOA care (n=3 general practitioners (GPs); n=2 orthopaedists; n=1 healthcare manager; n=4 healthcare researchers) and KHOA patients (n=3) to complement this list and rank the attributes from most to least important with respect to their preferences. The list of potential attributes from the literature and interviews is presented in Supplementary File 1. In a DCE, the number of attributes to include is limited, because of the rising cognitive burden of the participant when the number increases. To reduce the number of attributes, we selected the six most relevant attributes from the ranking results (Table 1), since the attributes ranked seven or more were deemed substantially less important by the experts and patients. Attribute levels were specified by the same experts and from publications of national sources[28] based on realistic values from KHOA healthcare settings.

**TABLE 1.** Attributes and levels used in the discrete choice experiment

| Attribute | Definition | Levels |
|---|---|---|
| Waiting times | The length of time the patient has to wait to get access to the healthcare. | No waiting time<br>2 weeks<br>4 weeks |
| Out of pocket costs | Out of pocket costs are the costs the patient has to pay to get access to the healthcare. | € 0,-<br>€ 45,-<br>€ 90,- |
| Travel distance to the healthcare provider | This is the distance the patient has to travel to the location of the healthcare provider(s). | 1 kilometre<br>7 kilometres<br>20 kilometres |
| Health care providers during consultation | Healthcare providers at the consultation for the patient. | General practitioner<br>General practitioner and orthopaedist (joint consultation)<br>Orthopaedist |
| Duration of consultation | This is the length of time the patient has with the healthcare provider(s) for one consultation. | 10 minutes<br>15 minutes<br>30 minutes |
| Access to specialist equipment | Specialist equipment (e.g. MRI) is additional assessment which can only be done at another location and another day than where the patient has the consultation. It can also be done at the same location and same day as where the patient has the consultation. | Another location and another day than the consultation. (indirect)<br>Same location and same day as the consultation. (direct) |

**DCE design and questionnaire**

The combination of six attributes with two to four levels would result in many potential alternatives. It is not feasible to present all these alternatives to a single participant. Therefore, we generated a fractional design which takes a subset of the alternatives [14, 16] and optimized which choice tasks to present (i.e. to consider statistical properties and participant burden) using the D-efficient criterion and NGene software[29]. We created a design of 24 choice tasks and divided these into two blocks of 12 to limit cognitive burden following good research practice guidelines[14]. We randomly presented one of the two blocks to the participants[14]. Each choice task contained two alternatives of KHOA care. The Dutch healthcare system requires that all citizens are registered with a GP[30]. Therefore, patients can always access their GP. As a consequence, we did not allow participants to choose none of the alternatives (i.e. 'opt out'), because the option of 'no treatment' is not applicable to the Dutch healthcare system. Figure 1 shows an example of a presented choice task. We repeatedly asked patients with KHOA which of the alternatives they preferred most, and asked healthcare providers and insurance employees which of the alternatives they preferred most for their patients with KHOA.

**Imagine that you can choose which healthcare you receive for your complaints, which of the following would you choose, Scenario 1 or Scenario 2? Please select the Scenario that you prefer most by checking the box below.**

| | **Scenario 1** | **Scenario 2** |
|---|---|---|
| Waiting time to visit | 1 week | No waiting time |
| Healthcare providers during consultation | Orthopaedist | General practitioner |
| Out of pocket costs | €90,- | €0,- |
| Duration of consultation | 10 minutes | 10 minutes |
| Travel distance | 7 kilometres | 1 kilometre |
| Access to specialists equipment | Same location and same day as the consultation. (direct) | Another location and another day than the consultation. (indirect) |
| I would choose: | ☐ | ☐ |

**FIGURE 1.** Example of a choice task.

The questionnaire for patients also contained: demographic questions (e.g. gender, age, employment status), health-related questions (duration of knee/hip complaints, The Western Ontario and McMaster Osteoarthritis Index (WOMAC) pain questions[31], Knee Injury and Osteoarthritis Score (KOOS)[32] and the Hip Injury and Osteoarthritis Outcome Score (HOOS)[33] quality of life (QoL) questions, the EQ5D-3L[34]), and questions about experiences with healthcare. Questionnaires for healthcare providers and insurance company employees included demographic questions and work-related questions (e.g. profession and educational level). All questionnaires included an explanation of the attributes and levels, and a warm-up choice task before starting the choice tasks.

Questionnaires were pre-tested using a think-aloud strategy, where five patients and four healthcare providers were asked to read and think aloud while completing the questionnaire[35]. As a result, some textual alterations to the questionnaires were made. Also, we restricted the design to make sure that two unrealistic combinations of attribute levels as identified by patients (i.e. consultation by a GP with out of pocket costs of €90,-, and consultation by a GP with waiting time of 4 weeks) were not included. After roughly 20% of the data was collected (n=150 patients), prior estimates of the attribute-levels in were updated to increase the statistical efficiency of the DCE design [14, 36].

**Study sample**

Participants were recruited through a commercial survey sample provider, Dynata. Participants of 45 years and older who gave informed consent and fulfilled at least one of the following criteria were included: (i) meeting the criteria for KHOA according to the National Institute for

Health and Care Excellence (NICE) guidelines[5]: activity-related joint pain, and either no morning joint-related stiffness or morning stiffness that lasts no longer than 30 minutes; (ii) having a joint replacement; (iii) reported that they have been told by a physician and/or physiotherapist as having KHOA. All patients received a financial compensation (€8,-). Healthcare providers were recruited through sources of the Erasmus MC University Medical Center and approached via email. Insurance employees from all departments of the health insurance company CZ were also approached via email in collaboration with the Department of Innovation and Advice of the insurance company CZ. Healthcare providers and insurance employees did not receive a financial compensation. Non-responders received a reminder within two weeks of the invitation.

**Statistical analyses**

We analysed the choice observations from patients, healthcare providers, and insurance company employees separately using a logit model[37]. In addition, considering our interest in the heterogeneity of patients' preference, the model fit, and our sample size, we used a *panel* latent class model[38]. This model takes the panel structure of the data (i.e. each respondent completed 12 choice tasks) into account and determines whether different preference patterns can be found among participants; so-allocated latent classes. Furthermore, this model can incorporate participants' characteristics, which provides insight into how likely participants with certain covariates (e.g. joint replacement) are to belong to a certain latent class, so-called class assignment model. To determine the number of classes, we selected the model with the best model fit (AIC). Stepwise forward selection using log likelihood tests was used to determine which participant characteristics to include. We tested for linearity of the attributes and two-way interaction terms ('healthcare providers' and 'waiting times', and 'healthcare providers' and 'out of pocket costs'). As a result, we identified the utility function as presented in Supplementary File 2. Statistical analyses were performed using NLogit 6 software.

A significant coefficient () indicates that the attribute (level) is important for the participants' decision for KHOA care. The utilities were converted into odds ratios (ORs) and indicated the relative importance of each attribute level compared to its reference level. A statistically significant OR (p-value<0.05) indicates that the attribute level had an impact on the choice process of the participants. An OR higher than one indicates that the attribute level is desirable and an OR lower than one indicates that participants are less likely to select the attribute level, all compared to the reference attribute level. We additionally calculated the importance of each attribute relative to other attributes by computing the difference in the utility of the highest and lowest level of that attribute, divided by the sum of differences of all attributes. The larger the resulting percentage, the greater the importance relative to other attributes. For the panel latent class model, this was done stratified for each class.

Lastly, we calculated the willingness to wait (WTW) in weeks for the attributes, since literature suggests waiting time to be an important negative factor in the patients' experience[39], prolonged with the fact that it is an important health policy issue in many countries nowadays[40]. Further information is provided in Supplementary File 3.

## RESULTS

**Characteristics of participants**

A total of 730 participants met the inclusion criteria and gave informed consent. Of those, 648 participants (88.8%) completed DCE and were therefore included in the analyses. These participants had a mean age of 61.7 years (sd=8.9), 55.4% of them were female, and 42.4% had an intermediate education level (Table 2). A total of 49.4% was included for having KHOA according to NICE-guidelines only, 19.5% for a KHOA diagnosis by a clinician only, and 31.1% for both criteria. The remaining 23.1% had a joint replacement. In addition, 76 healthcare providers and 150 insurance company employees fully completed the questionnaire (see Supplementary File 4).

**Discrete choice experiment**

Table 3 presents the preferences of patients, healthcare providers, and insurance company employees (for utilities see Supplementary File 5). In general, all ORs were statistically significant ($p<0.05$), meaning that all attributes played a role in their decision for KHOA care. The signs (positive/negative) of the ORs of the attribute levels were on average similar for healthcare providers, insurance company employees, and patients, and had the a priori expected signs. That is, healthcare with low out of pockets costs, joint consultation by GP and orthopaedist with long duration, direct access to specialist equipment, short travel distances, and short waiting times. Participants preferred an orthopaedist alone during consultation instead of a GP alone (the reference category), and a joint consultation by GP and orthopaedist instead of a GP alone even more.

Figure 2 shows the relative importance of the attributes. Out of pocket costs were most important for patients and healthcare providers, relative to all other attributes. In contrast, insurance company employees found the healthcare providers during consultation most important. The duration of consultation was least important for patients and insurance company employees, while for healthcare providers this was waiting times.

**TABLE 2.** Characteristics of knee and hip osteoarthritis patients

| Variable | Knee and hip patients n=648 |
|---|---|
| | n (%) |
| Female | 359 (55.4) |
| Age, mean (sd) | 61.7 (8.9) |
| Joint | |
| Knee | 418 (64.5) |
| Hip | 230 (53.5) |
| Joint replacement | 150 (23.1) |
| Of whom still have joint complaints with joint replacement | 75 (50) |
| No joint replacement, but included for: | 498 (76.9) |
| Only clinical OA (NICE-guidelines) | 246 (49.4) |
| Only OA diagnosed by clinician | 97 (19.5) |
| Clinical OA (NICE-guidelines) and OA diagnosed by clinician both | 155 (31.1) |
| Education level*: | |
| Low | 207 (31.9) |
| Intermediate | 275 (42.4) |
| High | 164 (25.3) |
| Nationality Dutch | 639 (98.6) |
| Employment status: | |
| Paid work | 229 (35.3) |
| Unemployed | 41 (6.3) |
| Incapacitated | 111 (17.1) |
| Volunteer work | 58 (9.0) |
| Caregiver | 22 (3.4) |
| Retired | 232 (35.8) |
| Other | 18 (2.8) |
| Urbanization: | |
| Rural | 277 (57.3) |
| Urban | 371 (42.7) |
| Joint complaints (yes) | 577 |
| Duration of complaints in months, median (IQR)** | 48 (90) |
| WOMAC pain score (0-100), mean (sd) | 37.01 (22.52) |
| HOOS/KOOS QoL score (0-100), mean (sd) | 51.56 (18.50) |
| Currently receiving healthcare for knee/hip complaints by any healthcare provider | 142 (21.9) |
| Previously received healthcare for knee/hip complaints (yes) | 560 (82.4) |
| *From the following healthcare providers:* | |
| GP | 460 (71) |
| Physiotherapist | 350 (54) |
| Medical specialist in hospital setting | 349 (53.9) |
| Medical specialist at private clinic | 26 (4.0) |
| Dietician | 16 (2.5) |
| Podiatrist | 55 (8.5) |
| Occupational therapist | 18 (2.8) |
| Other | 17 (2.6) |
| Satisfaction with received healthcare (1-10), median (IQR) | 7 (2) |
| EQ5D-3L score, mean index value (sd) | 0.702 (0.237) |

**Notes.** A higher WOMAC pain score indicates more severe joint pain in daily life activities. A higher HOOS/KOOS QoL score indicates a better disease-specific QoL. A higher EuroQol score indicates a better generic QoL.

*Missings (n=2; 0.3%) **Missings (n=26; 4.5%)

**TABLE 3.** Results of the logit model of patients, healthcare providers and insurance company employees

| | Patients | | Healthcare providers | | Employees of healthcare insurance company | |
|---|---|---|---|---|---|---|
| **Attribute levels** | **OR** | **(95%CI)** | **OR** | **(95%CI)** | **OR** | **(95%CI)** |
| ASC | 1.05 | (0.99; 1.11) | 1.12 | (0.93; 1.35) | 0.92 | (0.80; 1.05) |
| Waiting time (per week) | 0.88*** | (0.86; 0.90) | 0.89*** | (0.82; 0.97) | 0.86*** | (0.81; 0.91) |
| Out of pocket costs (per euro €) | 0.98*** | (0.98; 0.98) | 0.98*** | (0.98; 0.98) | 0.98*** | (0.98; 0.99) |
| Duration of consultation (per minute) | 1.01*** | (1.01;1.02) | 1.02*** | (1.01; 1.03) | 1.02*** | (1.01; 1.02) |
| Travel distance to healthcare provider (per km) | 0.97*** | (0.97; 0.98) | 0.97*** | (0.96; 0.98) | 0.97*** | (0.97; 0.98) |
| *Healthcare providers during consultation* | | | | | | |
| General practitioner *(reference level)* | 1.00 | | 1.00 | | 1.00 | |
| Orthopaedist | 2.04*** | (1.84; 2.26) | 1.39** | (1.01; 1.92) | 2.17*** | (1.71; 2.75) |
| General practitioner and orthopaedist | 2.39*** | (2.17; 2.63) | 1.93*** | (1.45; 2.58) | 4.44*** | (3.55; 5.54) |
| *Access to specialist equipment* | | | | | | |
| Indirect *(reference level)* | 1.00 | | 1.00 | | 1.00 | |
| Direct | 1.54*** | (1.45; 1.64) | 1.88*** | (1.56; 2.26) | 2.25*** | (1.97; 2.57) |

***, **, *= Statistically significance at 1%, 5%, 10% level.

**Abbreviations:** OR= odds ratio; SE= standard error; CI= confidence interval; ASC= alternative specific constant

**Notes.** For a correct interpretation of the results, it is important to notice the different units of measurement, e.g. price is a continuous variable that is measured per euro, whereas healthcare providers and specialist equipment are categorical variables that are compared to their reference level. The alternative specific constant (ASC) was not statistically significant, indicating that the choice process of patients was free from left-right bias

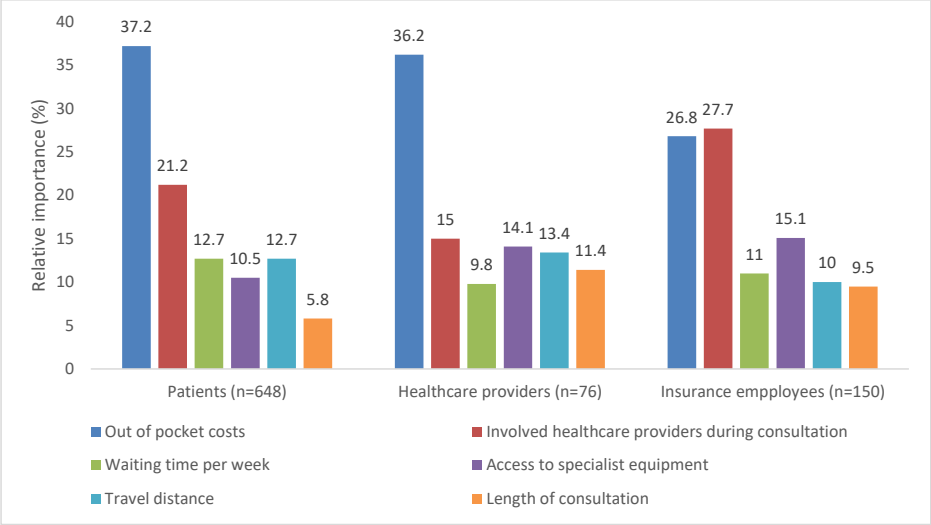


**FIGURE 2.** Relative importance of the attributes for patients, healthcare providers, and insurance company employees to choose for KHOA care.

**Note:** To determine the highest and lowest level for a single attribute, we used the values of the attributes in current healthcare in the Netherlands in primary, intermediate, and secondary care.

### Latent class analysis of patients

Four latent classes of patients' preference patterns were identified. The average probability that a patient belong to these classes was respectively 33.3%, 30.3%, 19.7%, and 16.7% (Table 4). The probability of patients to belong to a specific class depended on three patient characteristics: their disease-specific QoL, having a joint replacement or not, and their experiences with healthcare. Patients who belong to class 1 were used as the reference category and all attributes significantly influenced their preferences with the a priori expected signs, except for the duration of consultation. Patients without a joint replacement had a higher probability to belong to class 2 and a strong preference for low out of pocket costs. Patients with low disease-specific QoL and/or a joint replacement had a higher probability to belong to class 3 and a strong preference for an orthopaedist during consultation. The travel distance did not significantly influence their preferences. Patients who received healthcare for their knee or hip complaints previously had a higher probability to belong to class 4 and had a strong preference for direct access to specialist equipment and joint consultation by a GP and orthopaedist, while waiting time did not significantly influence their preferences. Only in this class, the duration of consultation significantly influenced their preferences. Figure 3 shows the relative importance of the attributes relatively to all other attributes for patients to choose for KHOA care, stratified by latent class.

**TABLE 4.** Results of the latent class logit model of patients

| | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
|---|---|---|---|---|---|---|---|---|
| **Class probability** | | | | | | | | |
| Average | 0.333 | | 0.303 | | 0.197 | | 0.167 | |
| **Attribute levels** | **OR** | **(95%CI)** | **OR** | **(95%CI)** | **OR** | **(95%CI)** | **OR** | **(95%CI)** |
| ASC | 1.22*** | (1.07; 1.38) | 0.90 | (0.73; 1.08) | 0.75*** | (0.63; 0.90) | 0.85 | (0.67; 1.09) |
| Waiting time (per week) | 0.75*** | (0.70; 0.80) | 0.73*** | (0.64; 0.82) | 0.86*** | (0.77; 0.95) | 0.95 | (0.85; 1.05) |
| Out of pocket costs per euro (per euro €) | 0.99*** | (0.98; 0.99) | 0.92*** | (0.91; 0.94) | 0.99*** | (0.99; 1.00) | 0.99*** | (0.98; 0.99) |
| Duration of consultation (per minute) | 1.00 | (0.99; 1.01) | 1.00 | (0.99; 1.01) | 1.00 | (0.99; 1.01) | 1.03*** | (1.01; 1.04) |
| Travel distance to healthcare provider (per km) | 0.94*** | (0.93; 0.95) | 0.96*** | (0.94; 0.98) | 1.00 | (0.99; 1.02) | 0.97*** | (0.94; 0.99) |
| **Healthcare providers during consultation** | | | | | | | | |
| General practitioner *(reference level)* | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Orthopaedist | 1.43*** | (1.17; 1.75) | 1.67*** | (1.19; 2.34) | 23.57*** | (11.94; 46.06) | 2.44*** | (1.45; 4.14) |
| General practitioner and orthopaedist | 1.65*** | (1.35; 2.01) | 3.53*** | (2.34; 5.31) | 21.54*** | (12.18; 38.09) | 4.71*** | (2.72; 8.25) |
| **Access to specialist equipment** | | | | | | | | |
| Indirect *(reference level)* | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Direct | 1.32*** | (1.14; 1.54) | 1.55*** | (1.26; 1.90) | 1.46*** | (1.19; 1.80) | 5.10*** | (3.60; 7.32) |
| Class assignment model | | | | | | | | |
| Constant | 1.00 | - | 0.91 | (0.54; 1.54) | 0.51** | (0.29; 0.90) | 0.25*** | (0.11; 0.58) |
| Higher disease-specific QoL (HOOS/KOOS>50) | 1.00 | - | 1.23 | (0.75; 2.03) | 0.54** | (0.31; 0.94) | 1.68 | (0.86; 3.29) |
| Having a joint replacement | 1.00 | - | 0.55* | (0.29; 1.05) | 2.32*** | (1.28; 4.18) | 0.80 | (0.37; 1.73) |
| Experience with healthcare for knee/hip complaints | 1.00 | - | 0.93 | (0.58; 1.51) | 1.39 | (0.80; 2.44) | 2.03** | (1.05; 3.90) |

| Model fit | |
|---|---|
| Log-likelihood | -4185.39 |
| AIC | 1.088 |
| BIC | 1.113 |

***, **, *= Statistically significant at 1%, 5%, 10% level.

**Abbreviations:** OR= odds ratio compared to the reference level of the attribute; SE= standard error; CI= confidence interval; ref. level= reference level; ASC= alternative specific constant.

**Notes.** The ASC was statistically significant in class 3 and 4, indicating that there could be a systematic tendency for patients in these classes to choose the alternative presented left. However, the ORs are relatively low compared to other variables in the model. Class 1 does not have coefficients in the class assignment model as this class is the reference category; class 2 to 4 are relative to class 1

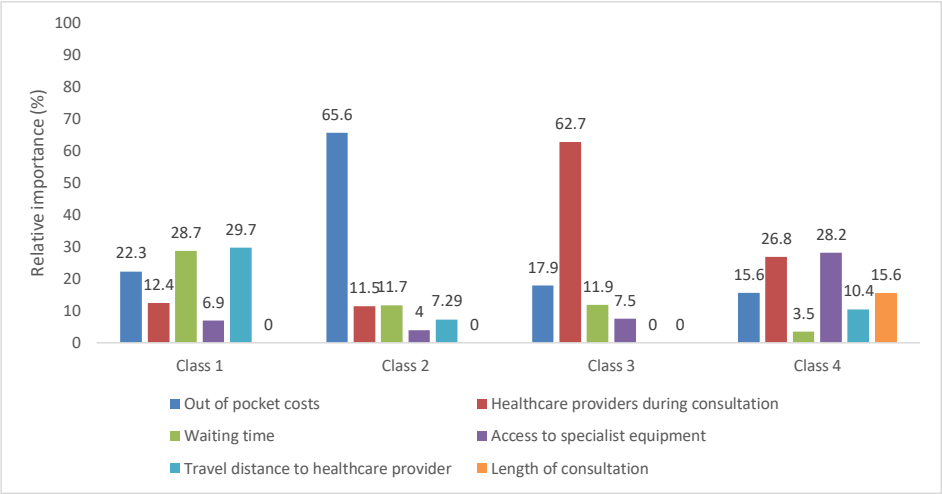


**FIGURE 3.** Relative importance of the attributes for patients to choose for KHOA care, stratified by latent class.

**Notes.** To determine the highest and lowest level for a single attribute, we used the values of the attributes in current healthcare in the Netherlands in primary, intermediate, and secondary care.

**Willingness to wait**

On average, patients were willing to wait the longest for their preferred healthcare provider(s) and direct access to specialist equipment. However, there were some differences between the four classes (Supplementary File 6). Relatively to the other classes, patients who received healthcare for their knee or hip complaints previously (class 4) were willing to wait the longest for a joint consultation by a GP and orthopaedist, instead of a GP alone (31 weeks). They were also willing to wait the longest for direct access to specialist equipment (32.6 weeks). Patients with low disease-specific QoL and/or a joint replacement (class 3) were willing to wait almost as long for a joint consultation instead of a GP alone (20.5 weeks) than for an orthopaedist instead of a GP alone (21.07 weeks).

## DISCUSSION

Patients and healthcare providers valued low out of pocket costs the most, while insurance company employees valued the involved healthcare providers during consultation as most important. Moreover, insurance company employees and healthcare providers attached greater

importance to the duration of consultation than most patients did. Patients without a joint replacement had a higher probability to prefer care with the lowest out of pocket costs. In contrast, patients with a joint replacement and patients with low disease -specific QoL had a higher probability to prefer care from an orthopaedist; they were willing to wait 21 weeks additional instead of a GP alone. Patients who already received healthcare for their complaints also had a high probability to prefer an orthopaedist during consultation, but were willing to wait the longest for a joint consultation (21 vs. 31 weeks respectively). Furthermore, they had the highest probability to prefer direct access to specialist equipment (willingness to wait of 33 weeks).

This is the first study that specifically investigated preferences for KHOA care focusing on aspects from various healthcare settings. Results from previous DCEs on OA care that included out of pocket costs as an attribute [16, 19, 21] correspond to our result that patients generally attach the greatest importance to low out of pocket costs. Furthermore, results from a previous observational study[41] showed that longer consultations are associated with better medical advice of the GP and more shared decision-making. This might explain why healthcare providers value the duration of consultation in the current study.

Previous studies have shown that a sample size of at least 40-100 respondents provides reliable parameter estimates in DCEs[42]. We reached at least these numbers and therefore provided reliable statistical analyses of our choice data. In our study, we identified patients' preferences, but also those of healthcare providers and insurance company employees. This information gives insight into the differences in preferences to tailor KHOA care better to patients' preferences, for example awareness of healthcare providers about the finding that patients value the duration of consultation less than they do. For optimal policy-making, insurance companies should be aware that out of pocket costs and healthcare providers are important factors for patients. Furthermore, the identified preference heterogeneity informs policy makers about the optimal and most preferred combination of characteristics of healthcare for more individualised KHOA care[15]. For example, for patients without a joint replacement who preferred a quickly accessible care joint consultation by GP and orthopaedist, the most suitable healthcare setting might be intermediate care with joint consultations. This healthcare setting may also prevent the existing hospital overuse and contribute to lower healthcare costs, since secondary care is generally more expensive[11].

One limitation of this study may be that we included people with self-reported KHOA and might deviate from the physician-diagnosed KHOA patient population. However, respondents were screened using the same clinical criteria for KHOA as recommended by current guidelines[4,5]. Hence, we believe it has not influenced the validity of our results. Furthermore, preferences might be country-specific, as health systems and other structural factors such as geographical

distribution of health services (e.g. travel distances) may differ across countries. Lastly, due to the low sample size of some subgroups, we were not able to perform subgroup analyses that could reveal additional information on preferences, such as preferences of patients with a joint replacement with complaints versus without complaints.

This study showed that patients who received healthcare for their knee or hip complaints previously and/or low disease-specific QoL and/or a joint replacement strongly preferred an orthopaedist during consultation. Since orthopaedist consultations are generally more expensive than GP consultations, future research in GPs with special interest may be valuable. Moreover, previous research showed that a substantial part of patients referred to secondary care could instead be seen by a GP with special interest[43]. Furthermore, further research is needed to gain better understanding of the rationale behind the revealed preferences. For example, the rationale behind our finding that most patients prefer care provided by an orthopaedist instead of a GP alone. Also, the results of this study cannot be interpreted as the best practice for KHOA care. Patients' preferences is just one aspect of care, and should be evaluated in relation to healthcare costs and health outcomes in further research[44].

## CONCLUSIONS

In conclusion, KHOA care including joint consultations by GP and orthopaedist, and low out of pocket costs is most preferred. KHOA care can be optimised through more focus on: 1) care with low out of pocket costs for patients without joint replacement, 2) joint consultations and direct access to specialist equipment for patients who already received healthcare, and 3) consultation by an orthopaedist for patients with a joint replacement and/or with low disease-specific quality of life. Results of this study can be used by policy makers and healthcare providers to choose the most optimal combination of more individualised healthcare for KHOA aligned to patients' preferences.

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# SUPPLEMENTARY FILE 1.
## Utility functions

The following utility functions that are written to be class-specific, but can also be generalized to the logit model:

$$V(alt1)_{nsj|c} = \beta_{0|c} + \beta_{1|c}\,\text{waiting time}_{nsj|c} + \beta_{2|c}\,out\ of\ pocket\ costs_{nsj|c} + \beta_{3|c}\,\text{duration of consultation}_{nsj|c} + \beta_{4|c}\,\text{travel distance}_{nsj|c} + \beta_{5|c}\,\text{orthopedist involved}_{nsj|c} + \beta_{6|c}\,\text{general practitioner and orthopedist involved}_{nsj|c} + \beta_{7|c}\,\text{direct access to specialist equipment}_{nsj|c}$$

$$V(alt2)_{nsj|c} = \beta_{1|c}\,\text{waiting time}_{nsj|c} + \beta_{2|c}\,out\ of\ pocket\ costs_{nsj|c} + \beta_{3|c}\,\text{duration of consultation}_{nsj|c} + \beta_{4|c}\,\text{travel distance}_{nsj|c} + \beta_{5|c}\,\text{orthopedist involved}_{nsj|c} + \beta_{6|c}\,\text{general practitioner and orthopedist involved}_{nsj|c} + \beta_{7|c}\,\text{direct access to specialist equipment}_{nsj|c}$$

where $V_{nsj|c}$ is the observed utility of participant *n* in class *c* for choice set *s* for alternative *j*;

alt is either of the two alternatives;

$\beta_{0|c}$ is the alternative specific constant;

$\beta_{1-4|c}$ are the class-specific coefficients of the linearly estimated attributes;

$\beta_{5-6|c}$ are the class-specific coefficients of the involved health professionals, as compared to the reference level general practitioner;

$\beta_{7|c}$ is the class-specific coefficients of having direct access to specialist equipment, as compared to the reference level of having indirect access to specialist equipment.

# SUPPLEMENTARY FILE 2.
## Willingness to wait calculation

Willingness to wait in weeks was calculated for the involved healthcare providers using the following equation:

$$Willingness\ to\ wait = \frac{-\beta k}{\beta 1}$$

These coefficients represent how much a participant is willing to wait for one unit change (or to change from one level to another) in an attribute, and are calculated by the ratio of the coefficient for attribute *k* to the coefficient of attribute 'waiting time' (β*1*).

# SUPPLEMENTARY FILE 3.
## Characteristics of healthcare providers and insurance company employees

**TABLE 1.** Participants' characteristics: healthcare providers

| **Variable** | **Healthcare providers (n=76)** n (%) |
|---|---|
| Female | 22 (28.9) |
| Age, mean (sd) | 48.1 (9.6) |
| Profession: | |
| GP | 47 (61.8) |
| GP specialized in musculoskeletal disorders | 9 (19.1) |
| Orthopaedist | 29 (38.2) |
| Working in peripheral hospital | 29 (100) |
| Working as healthcare provider in urban area | 63 (82.9) |
| Currently working or worked in the past as healthcare provider in intermediate care facilities | 17 (22.4) |
| Of those intermediate care facilities for KHOA | 10 (58.8) |
| Working as healthcare provider for: | |
| <5 years | 15 (19.7) |
| 5-10 years | 15 (19.7) |
| >10 years | 46 (60.5) |

**TABLE 2.** Participants' characteristics: employees of the health insurance company

| Variable | Insurance company employees N= 150 |
|---|---|
| | n (%) |
| Female | 94 (62.7) |
| Age, mean (sd) | 43.5 (12.1) |
| Position at healthcare insurance company: | |
| Medical advisor | 16 (10.7) |
| Healthcare purchaser | 59 (39.3) |
| Policy-supporting function | 14 (9.3) |
| Secretariat | 19 (12.7) |
| Data analyst | 11 (7.3) |
| Manager | 8 (5.3) |
| Economic employee | 2 (1.3) |
| Team/project leader | 4 (3.3) |
| Healthcare purchase support | 5 (3.3) |
| Other | 11 (7.3) |
| Working as employee at healthcare insurance company for: | |
| <5 years | 42 (28.0) |
| 5-10 years | 38 (25.3) |
| >10 years | 70 (46.7) |
| Education level: | |
| Low | 3 (2.0) |
| Intermediate | 19 (12.7) |
| High | 128 (85.3) |
| Vocational training area: | |
| Healthcare | 57 (38) |
| Economics | 55 (36.7) |
| Business administration | 28 (18.7) |
| No vocational training | 13 (8.7) |
| Other | 26 (17.3) |
| Involved with intermediate care projects at healthcare insurance company | 39 (26.0) |
| Previously worked as healthcare provider | 29 (19.3) |

# SUPPLEMENTARY FILE 4.

## Results of (latent class) logit models on utility scale

A significant coefficient indicates that the attribute (level) is important for the participant's decision for knee and hip osteoarthritis healthcare. The sign of the coefficient indicates a positive or negative preference for that particular level of the attribute.

**TABLE 1.** Results of the logit model of patients, healthcare providers and employees of healthcare insurance company

| | **Patients** | | **Healthcare providers** | | **Employees of healthcare insurance company** | |
|---|---|---|---|---|---|---|
| **Attribute levels** | **Coef.** | **(95%CI)** | **Coef.** | **(95%CI)** | **Coef.** | **(95%CI)** |
| ASC | 0.045 | (-0.013; 0.103) | 0.115 | (-0.068; 0.298) | -0.088 | (-0.223; 0.048) |
| Waiting time (per week) | -0.130*** | (-0.156;-0.103) | -0.111*** | (-0.196; -0.027) | -0.148*** | (-0.206; -0.090) |
| Out of pocket costs (per euro €) | -0.017*** | (-0.019;-0.016) | -0.018*** | (-0.021; -0.014) | -0.016*** | (-0.019; -0.014) |
| Duration of consultation (per minute) | 0.008*** | (0.005;0.012) | 0.017*** | (0.007; 0.028) | 0.017*** | (0.009; 0.024) |
| Travel distance to healthcare provider (per km) | -0.026*** | (-0.030;-0.022) | -0.030*** | (-0.042; -0.018) | -0.027*** | (-0.035; -0.018) |
| **Healthcare providers during consultation** | | | | | | |
| General practitioner *(reference level)* | 0 | | 0 | | 0 | |
| Orthopaedist | 0.714*** | (0.611;0.817) | 0.330** | (0.007; 0.652) | 0.773*** | (0.535; 1.011) |
| General practitioner and orthopaedist | 0.870*** | (0.775;0.966) | 0.659*** | (0.369; 0.949) | 1.490*** | (1.268; 1.712) |
| **Access to specialist equipment** | | | | | | |
| Indirect *(reference level)* | 0 | | 0 | | 0 | |
| Direct | 0.433*** | (0.373;0.492) | 0.629*** | (0.442; 0.817) | 0.810*** | (0.678; 0.942) |

***, **, *= Statistically significant at 1%, 5%, 10% level.

Abbreviations: Coef.= coefficient; SE= standard error; CI= confidence interval; ASC= alternative specific constant

**TABLE 2.** Results of the latent class logit model of patients

| | **Class 1** | | **Class 2** | | **Class 3** | | **Class 4** | |
|---|---|---|---|---|---|---|---|---|
| **Class probability** | | | | | | | | |
| Average | 0.333 | | 0.303 | | 0.197 | | 0.167 | |
| **Attribute levels** | **Coef.** | **(95%CI)** | **Coef.** | **(95%CI)** | **Coef.** | **(95%CI)** | **Coef.** | **(95%CI)** |
| ASC | 0.20*** | (0.07; 0.32) | -0.11 | (-0.31; 0.08) | -0.29*** | (-0.46; -0.11) | -0.16 | (-0.40; 0.09) |
| Waiting time (per week) | -0.29*** | (-0.36; -0.22) | -0.32*** | (-0.45; -0.20) | -0.15*** | (-0.26; -0.05) | -0.05 | (-0.16; 0.05) |
| Out of pocket costs per euro (per euro €) | -0.01*** | (-0.02; -0.01) | -0.08*** | (-0.09; -0.06) | -0.01*** | (-0.01; -0.00) | -0.01*** | (-0.02; -0.01) |
| Duration of consultation (per minute) | 0.00 | (-0.01; 0.01) | 0.00 | (-0.01; 0.01) | 0.00 | (-0.01; 0.01) | 0.03*** | (0.01; 0.04) |
| Travel distance to healthcare provider (per km) | -0.06*** | (-0.07; -0.05) | -0.04*** | (-0.06;-0.02) | 0.00 | (-0.01; 0.02) | -0.03*** | (-0.06; -0.01) |
| *Healthcare providers during consultation* | | | | | | | | |
| General practitioner *(reference level)* | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| Orthopaedist | 0.36*** | (0.16; 0.56) | 0.51*** | (0.17; 0.85) | 3.16*** | (2.48; 3.83) | 0.89*** | (0.37; 1.42) |
| General practitioner and orthopaedist | 0.50*** | (0.30; 0.70) | 1.26*** | (0.85; 1.67) | 3.07*** | (2.50; 3.64) | 1.55*** | (1.00; 2.11) |
| *Access to specialist equipment* | | | | | | | | |
| Indirect *(reference level)* | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| Direct | 0.28*** | (0.13; 0.43) | 0.44*** | (0.23; 0.64) | 0.38*** | (0.17; 0.59) | 1.63*** | (1.28; 1.99) |
| **Class assignment model** | | | | | | | | |
| Constant | - | - | -0.09 | (-0.61; 0.43) | -0.67** | (-1.23; -0.11) | -1.40*** | (-2.25; -0.55) |
| Higher disease-specific QoL (HOOS/KOOS>50) | - | - | 0.21 | (-0.29; 0.71) | -0.61** | (-1.16; -0.06) | 0.52 | (-0.15; 1.19) |
| Having a joint replacement | - | - | -0.60* | (-1.24; 0.05) | 0.84*** | (0.25; 1.43) | -0.22 | (-0.99; 0.55) |
| Experience with healthcare for knee/hip complaints | - | - | -0.07 | (-0.55; 0.41) | 0.33 | (-0.22; 0.89) | 0.71** | (0.05; 1.36) |
| **Model fit** | | | | | | | | |
| AIC | 8458.80 | | | | | | | |

***, **, *= Statistically significant at 1%, 5%, 10% level.

**Abbreviations:** Coef.= coefficient; SE= standard error; CI= confidence interval; ref. level= reference level; ASC= alternative specific constant.

**Notes.** Class 1 does not have parameters as this class is the reference category; class 2 to 4 are relative to class 1 in the class probability model. The utilities for realistic healthcare settings are all compared to a base-case scenario of healthcare settings, which is: a healthcare setting with no out of pocket costs, no waiting times, no consultation time, no travel distances, a GP during consultation, and no direct access to specialist equipment.

# SUPPLEMENTARY FILE 5.

## Willingness to wait

**TABLE 1.** Willingness to wait for patients to receive improvement in one of the knee and hip osteoarthritis care attributes

| | | WTW in weeks | | | | |
|---|---|---|---|---|---|---|
| **Attribute** | **To receive care for knee and hip osteoarthritis** | **Average** | **Class 1** | **Class 2** | **Class 3** | **Class 4** |
| Out of pocket costs | That costs one euro more out of pocket costs | -0.13 | -0.03 | -0.25 | -0.07 | -0.20 |
| Healthcare providers during consultation | | | | | | |
| | With an orthopaedist instead of a GP | 5.50 | 1.24 | 1.59 | 21.07 | 17.80 |
| | With a GP and orthopaedist instead of a GP | 6.70 | 1.72 | 3.94 | 20.47 | 31.00 |
| Access to specialist equipment | With direct access to specialist equipment instead of indirect | 3.33 | 0.97 | 1.38 | 2.53 | 32.60 |
| Duration of consultation | With one minute more waiting time | 0.04 | NS | NS | NS | 0.60 |
| Travel distance to healthcare provider | With one kilometre more travel distance | 0.20 | -0.21 | -0.13 | NS | -0.60 |

**Abbreviations:** WTW= willingness to wait; NS= not statistically significant

**Notes.** The average of patients is based on the multinomial logit model. Calculation of WTW for not statistically significant attributes is not possible and therefore stated as 'NS' in the table.

# CHAPTER 8

## General discussion

Osteoarthritis (OA) in the knee or hip is a highly prevalent chronic musculoskeletal disease in the general population. The prevalence and related healthcare demand are expected to increase dramatically in the future, putting pressure on the healthcare system. General practitioners (GPs) are often the first point of contact for patients in the Dutch healthcare system and therefore play an important role in the initial recognition and treatment of knee and hip OA. Current evidence on the extent of knee and hip OA in general practice is insufficient and treatment in general practice is suboptimal. There are gaps that lead to inadequate planning and prioritization of healthcare resources, low quality of care, redundant healthcare consumption, high healthcare costs, poor healthcare outcomes and low patient and healthcare provider satisfaction. This will put even more pressure on the sustainability of the healthcare system. To fill these gaps, this thesis aimed to provide more valid knowledge on the incidence and prevalence of knee and hip OA and on the related healthcare provision in general practice. It also aimed to identify possibilities for better care. In this final chapter, I will reflect on the results presented in the previous chapters and will provide recommendations for future research, clinical practice and policy.

## KEY FINDINGS OF THIS THESIS

In **Chapters 2 and 3**, we estimated the prevalence and incidence of knee and hip OA based on Dutch routine healthcare data from general practices. We developed algorithms to identify knee and hip OA diagnoses in the narrative data (i.e. free-text fields) of electronic health records (EHRs), to provide more accurate prevalence and incidence estimates than the standard approach of using codified data alone. Using these algorithms, estimates were on average twice as high as estimates from codified data alone. This finding suggests that our current figures for the incidence and prevalence of knee and hip OA from Dutch routine healthcare data, which are all based on codified data alone, are an underestimation. In addition, findings from the studies in this thesis showed that GPs are more prone to give an official code for knee and hip OA to patients who fit the risk factor profile, such as older age and specific comorbidities. Another important finding was that around 40% of codified knee and hip OA patients are actually diagnosed approximately two to three years earlier, but the diagnosis is documented by the GP in free-text fields (i.e. narrative data) rather than an official ICPC code for OA. This increases the validity of the timing of incidence estimates using narrative data. Developing a valid narrative data algorithm for hip OA (**Chapter 3**) was more challenging than for knee OA (**Chapter 2**), possibly due to the greater diagnostic complexity of hip pain in general practice. This suggests that the feasibility of narrative data algorithms for OA is joint-dependent.

In **Chapter 4**, we determined patterns in the management of knee OA by GPs using Dutch routine healthcare data from general practices. We used the algorithm developed in **Chapter 2** to select knee OA patients with the narrative data (i.e. free-text fields) of EHRs in addition to codified data. Recorded information was extracted on GPs' management from six months before to three years after knee OA diagnosis. An X-ray referral was the most widely recorded management modality, most often at the initial consultation in general practice. In addition, this study showed indications for the underutilization of a stepped-care approach for knee OA (i.e. treatment starting with general modalities such as education or lifestyle advice, followed by more intensive or invasive treatments such as intra-articular injections or joint replacements at a later stage of the disease). This often started at the first GP consultation, as, for example, many patient EHRs contained a record of a secondary care referral at first consultation. These findings emphasized the importance of a better implementation of non-surgical management modalities of knee OA in general practice, especially during the first GP consultation, and on initiatives for reducing the overuse of X-rays for diagnosing knee OA in general practice.

In **Chapter 5**, we provided an overview of the literature on quality indicators for knee and hip OA care, which showed substantial differences in the content of quality indicators depending on the healthcare setting. This emphasized the need to carefully select quality indicators for the appropriate healthcare setting. Moreover, most of the quality indicators were developed from the perspective of healthcare professionals and researchers; there was only limited input from the patient perspective. Quality indicators concerning the indication for radiographic assessment of the joint were not consistent in their content. In addition, quality indicators regarding pharmacological treatment were not fully up to date.

In **Chapter 6**, we evaluated intermediate care projects for knee and hip OA, where general practice care with one-time consultations by orthopaedists is substituted for specialist care. The main goal of intermediate care is to prevent unnecessary referrals to secondary care. Patients were satisfied and experienced better access to specialists' knowledge in a trusted environment compared to regular care. GPs and orthopaedists experienced more intensive collaboration, leading to a perceived increase in their knowledge regarding referrals to secondary care and a perceived reduction in healthcare consumption — although we have not (yet) found evidence from patients' EHRs to support this. Important barriers to intermediate care were that orthopaedists felt a higher workload and felt they had limited access to diagnostic facilities. The pragmatic design and short follow-up duration may have influenced the reliability of the findings. Nevertheless, we concluded that intermediate care may be a solution to increase the confidence of GPs for diagnosing and managing knee and hip OA patients, and may contribute to better quality of care due to the increased percentage of patients referred to physiotherapy.

In **Chapter 7**, we measured patients' preferences for the characteristics of different healthcare settings of knee and hip OA care and compared this with the preferences of healthcare providers and insurance company employees. We found differences between the preferences of patients, healthcare providers and insurance company employees. In addition, there was substantial heterogeneity in patients' preferences. Based on this, we formulated the following recommendations for policymakers for knee and hip OA care tailored to patients' preferences: 1) low out-of-pocket costs for patients without joint replacement; 2) combined consultations of a GP and orthopaedist with direct access to specialist equipment for patients who have already received healthcare; and 3) consultation by an orthopaedist for patients with a joint replacement and/or with low disease-specific quality of life.

## REUSE OF ROUTINE HEALTHCARE DATA FOR RESEARCH

Routine healthcare data are data that are routinely recorded as part of the healthcare process and are primarily aimed at managing the individual patient care. Routine healthcare data are widely used in the healthcare process to share medical information about an individual patient between multiple healthcare providers. Although routine healthcare data are intended to facilitate the healthcare process, this type of data is increasingly also stored in databases for research purposes. These data are mainly derived from primary care settings, as in many countries (e.g. Scandinavian countries, the United Kingdom and the Netherlands) patients first consult a primary care provider for most health problems. Examples of such databases are the Clinical Practice Research Datalink in the United Kingdom, Intego Network in Belgium, l'Observatoire de la médecine générale in France, the IPCI database, the Netherlands Institute for Health Services Research (Nivel) Primary Care database, the Academisch Huisartsen Ontwikkel Netwerk (AHON) database and the Academisch Netwerk Huisartsgeneeskunde (ANH) database in the Netherlands. Reuse of routine healthcare data for research has several advantages compared to data primarily collected for research (e.g. observational studies and randomized controlled trials). There are fewer systematic errors, such as response bias, selective non-response and recall bias.[1] Also, routine healthcare data are data continuously recorded in clinical practice, providing real-world data at relatively low cost. Another advantage is that routine healthcare data allow researchers to study research questions in large populations over long periods of time.[2] Especially for epidemiological research and health service research, where real-world data is crucial to answer research questions of interest, routine healthcare data provide useful information. Despite its advantages, reusing routine health data validly for research also poses multiple challenges. These challenges are often related to the problem that data collected for

one purpose, in this case as part of the healthcare process, may not be suitable for another purpose, in this case for research purposes.[1, 3-5] In the next section, we will address some of the challenges of reusing routine healthcare data.

**Misclassifications and under-recording**

Misclassifications and under-recordings in routine healthcare data can have major consequences for the validity of research results. In **Chapters 2 and 3**, we have seen an example of this problem in the context of data on knee and hip OA from Dutch general practices. Almost half of the OA patients did not have a code for knee or hip OA in their EHR. This shows that using codified data alone leads to an underestimation of the incidence and prevalence of knee and hip OA. Also, focusing on codified data alone may cause a delay in the timing of incidence estimates, as illustrated in **Chapters 2 and 3**: 40% of the patients with knee and hip OA with a code in their EHR had already been diagnosed with knee or hip OA approximately two to three years earlier based on narrative data. In addition, previous research suggested that the proportion of severe OA patients may be overrepresented in the prevalence of knee and hip OA based on routine healthcare data, since patients with less severe OA appeared to be less likely to have a code for OA in their EHR.[6] In **Chapters 2 and 3**, we found that patients with a code for knee or hip OA were relatively older than the patients without a code, who were only documented with knee or hip OA in narrative data — this may also be an indication that more severe OA patients are more likely to have a code for OA. Also, diagnoses recorded in EHRs may include misclassified codes (i.e. errors in the recordings) due to various reasons, such as healthcare providers' lack of time.[1, 7] The reasons behind these misclassifications and under-recordings have not yet been studied properly, but there are opinions that OA may be under-recorded when GPs give a lower priority to recording OA with a code and a higher priority to recording another symptom or diagnosis when presented during the same consultation[8-10]. In addition, in **Chapter 4**, records of an X-ray referral were often found in patients with narratively diagnosed knee OA before the GP recorded a code for knee OA in their EHR. This may indicate that GPs are more confident about record knee OA with a code when they have the support of the results of an X-ray. Nevertheless, previous studies[11-15] reusing large-scale routine healthcare data from primary care settings for OA research relied heavily on codified data and are therefore likely to be influenced by misclassifications and under-recording. Similarly, predictions of the future prevalence of OA aimed at preparing for future healthcare demands are often based on codified data from routine healthcare data alone, hampering a reliable picture of the current prevalence of knee and hip OA. In the Netherlands, this prediction of the future prevalence is also based on codified data alone from the Dutch primary care registry data of Nivel. It gives a predicted increase in the prevalence of OA of 36% between 2018 and 2040; this may also be

an underestimation of the true burden of disease.[15] Researchers and policymakers need to be aware of the shortcomings of codified data in routine healthcare and the importance of using narrative data in addition to codified data. The method presented in **Chapters 2 and 3**, in which we developed narrative data algorithms with keywords referring to knee and hip OA diagnoses, is one way to deal with this problem, but there are several alternative ways to use narrative data that have been developed recently. An example is natural language processing (NLP), which feeds an algorithm with large amounts of text from EHRs whereby the algorithm "learns" a set of rules to identify the phenomena of interest. Several studies used NLP to identify patients with a specific disease, such as rheumatoid arthritis[16]. Although NLP is a cost-effective and quick method for utilizing narrative data in EHRs, developing highly accurate NLP algorithms is still challenging.[17] It is also important to note that the feasibility of using narrative data may be disease-dependent or even joint-dependent within a disease. This is shown in **Chapters 2 and 3**, where developing a narrative data algorithm to identify hip OA patients was more challenging than for knee OA patients — probably due to the diagnostic complexity of hip pain in general practice.

**Context of healthcare**

Another aspect to be considered when reusing routine healthcare data for research is the context in which data are being recorded. For example, primary care registrations are focused on the care provided in primary care settings and do not include all information on the care that is being delivered in the secondary care setting (e.g. surgical treatment). Current healthcare policy in the Netherlands is focused on incidence and prevalence estimates from the Dutch National Institute for Public Health and the Environment (RIVM) and is based on GP registries only (Nivel primary care registry).[15] Multiple studies have shown that linking primary and secondary care databases is crucial for more complete and valid medical information.[18-22] In 2020, Nivel published a report on the effect of linking the Nivel primary care registry to other registries on the estimated incidence and prevalence of various diseases, including OA.[23] Of all patients with OA based on database sources from both primary and secondary care, 17% were not found in the Nivel primary care registry. Most of these patients who were 'missing' in primary care data were identified from a secondary care database – the Diagnosis Treatment Combinations of Specialist Medical Care Database. This under-recording in general practice was also found for patients with other chronic diseases, such as diabetes mellitus and chronic obstructive pulmonary disease (under-recorded patients: 3% and 11% respectively). Thus, this study showed that linking primary and secondary care databases is crucial for a more valid picture of the incidence and prevalence of OA and this should be the standard for accurate national healthcare policy. However, the use of narrative data in addition to codified data

gave an even higher percentage for under-recording in general practice (approximately 50%; **Chapters 2 and 3**). Therefore, utilizing narrative data in addition to codified data seems to be crucial for an accurate picture of the burden of OA. The same may apply for different disciplines within primary care, such as patients diagnosed with OA by a physiotherapist and who have not (yet) visited their GP for this complaint. Another benefit of linking multiple databases is the ability to better understand research findings by having a more complete picture with additional covariates, such as demographic information. An excellent example of linked databases is the Skåne Healthcare Register in southern Sweden.[24] This healthcare database includes medical information about every healthcare contact in the region in primary and secondary care. In addition, this database is linked to data from Statistics Sweden, providing individual-level data on income and vital events such as births, deaths and changes in residential address. Creating such clinical research databases is recommended for researchers and policymakers to establish more valid courses and treatments of diseases. Given the legal and technical aspects of linking routine healthcare databases, this is a multidisciplinary task, requiring researchers to join forces with legal experts and medical informatics experts.

**Information systems**

Several studies [25-28] have shown that variation in the functionalities of EHR information systems can influence the completeness of EHR data. GPs in the Netherlands are free to choose among competing EHR information systems that differ significantly in the implementation of these requirements.[29] For example, not all EHR information systems require GPs to link each consultation to a code, which can increase the under-recording of symptoms and diseases. In the studies in **Chapter 2 and 3**, we performed an additional regression analysis to explore the association between EHR information systems and codified knee/hip OA among all prevalent knee/hip OA patients (data not shown in the articles). We found that patients with knee or hip OA were more likely to be under-recorded if their GP used an EHR information system that did not require GPs to link consultations to a code. In addition, some EHR information systems in the Netherlands include *automatic* processing of medical information from external sources, such as electronic letters from other healthcare providers. This may result in more complete documentation of medical information in EHRs. Researchers should be aware of these differences in EHR information systems and the effects on the completeness of EHR data.

**Financial incentives and reimbursement schemes**

Financial incentives and reimbursement schemes can also influence the completeness of the data. For example, in 2013, a national pay-for-performance model was launched in Dutch general practice to encourage proper recording of information in EHRs according to the

'Adequate Record Formation with EHRs' guideline (ADEPD). Another example is the financial incentive in the Netherlands to annually record blood pressure in people with diabetes and cardiovascular diseases. This financial incentive resulted in more intensive monitoring, leading to more complete recordings for patients known to have diabetes and cardiovascular diseases.[1] Lack of financial incentives for OA may be one of the reasons why half of the patients with knee and hip OA appeared not to be recorded properly, as shown in **Chapters 2 and 3**. Study findings from routine healthcare data should always be interpreted in the context of changes in the healthcare system, such as financial incentives or guideline changes (e.g. a change in diagnostic criteria leading to an earlier diagnosis). In addition, policymakers and healthcare insurers should always consider the effect of such changes in the healthcare system on the quality of routine healthcare data, as this may have implications for the interpretation of routine healthcare data for healthcare policy and prioritizing healthcare resources.

## OPTIMIZING KNEE AND HIP OSTEOARTHRITIS CARE IN GENERAL PRACTICE

Current guidelines[30-34] are consistent in their recommendations for the non-surgical care of knee and hip OA. Yet inappropriate diagnostic procedures and referrals and insufficient use of treatment modalities are widely seen in clinical practice, leading to suboptimal quality of care, high healthcare costs, poor healthcare outcomes, and low patient and healthcare provider satisfaction.[35, 36] With the expected dramatic increase in the burden and the number of total joint replacements, targeted effort should be spent on further improving care for knee and hip OA. We discuss the following important aspects in optimizing knee and hip OA care: 1) optimal use of core treatments in primary care; 2) inappropriate use of X-rays in general practice; and 3) patient preferences.

**Optimal use of core treatments in primary care**

Non-surgical core treatments for OA recommended by current national and international guidelines[30-34] include education and self-management, exercise therapy, weight loss and walking aids. For pain reduction, oral or topical analgesics and intra-articular corticosteroids are recommended. These non-surgical core treatments are cost-effective and can slow down the rate of increase of healthcare costs caused by knee and hip OA by delaying or even avoiding surgical treatment.[37] We found in **Chapter 4** that patients with knee and hip OA in Dutch general practice are frequently referred to secondary care before optimal use has been made of non-surgical care in primary care. This under-utilization of non-surgical care was also found in a

recently published study[38] conducted in the Netherlands, as well as in studies[39-48] from other countries.

*Multidisciplinary collaboration*

To stimulate the optimal use of non-surgical care and prevent unnecessary referrals to secondary care, several pilot projects have started in the Netherlands for intermediate care, in which orthopaedists provide face-to-face consultations in general practices. Although the evaluation of three intermediate care projects for knee and hip OA in **Chapter 6** did not show a decrease in the number of referrals to secondary care, the number of referrals to physical therapy for exercise therapy — one of the core treatments for OA[30-34] — did increase substantially. The exchange of knowledge between GPs and orthopaedists during intermediate care consultations may have played an important role in this effect, as interviews showed that GPs thought their knowledge about OA care had increased (**Chapter 6**). Strengthening the multidisciplinary collaboration between GPs and orthopaedists may be an effective strategy to encourage the use of non-surgical treatment. In addition, GPs with a special interest, which are GPs with additional training and experience in a specific clinical area (for instance in musculoskeletal disorders), could play a role in enhancing specialist knowledge in general practice. In the Netherlands, there are over 650 GPs with a special interest.[49] The goal of the role of GPs with special interest is to improve the quality of care, including through the prevention of unnecessary referrals to secondary care.[50] Having GPs with a special interest for musculoskeletal disorders (e.g. shoulder and knee complaints) in the Dutch general practice setting has been shown to be effective in reducing the number of referrals to secondary care.[51] Future research should investigate whether strengthening the role of GPs with special interests for OA care in Dutch general practice setting can also increase the optimal use of core treatments. If so, this strategy may be a cheaper alternative to orthopaedic consultations in general practices. Furthermore, most of the core treatments for OA recommended by guidelines form a fundamental part of physiotherapy care, such as the provision of education, advice and exercise therapy.[52] As GPs are often the first point of contact in the Dutch healthcare system, GPs' attitudes towards physiotherapy can determine whether the patient receives physiotherapy care. A previous qualitative study[53] found that GPs lacked knowledge and confidence about the role of physiotherapists in the management of OA, creating a barrier to referring patients to a physiotherapist. Another qualitative study[54] showed that short lines of communication between GPs and physiotherapists facilitate referrals to other disciplines. Increased awareness among GPs about the professional role and responsibilities of physiotherapists and short lines of communication between GPs and physiotherapists will stimulate referrals to physiotherapy for the optimal use of core treatments.

***Stepped care and other osteoarthritis care models***

Stepped care can be an approach for encouraging the optimal use of core treatments. Stepped care means that treatment should start with general modalities (e.g. education or lifestyle advice) and that more intensive or invasive treatments (e.g. intra-articular injections or joint replacements) only start at a later stage of the disease. Van den Boogaart et al.[55] evaluated a stepped-care initiative in Dutch general practice for knee and hip OA that involved educational meetings for GPs and physiotherapists, distributing guidelines and incorporating reminders in the GPs' referral application. The number of referrals to secondary care did not decline after this stepped-care intervention was implemented. In addition, Smink et al. evaluated a stepped-care strategy intervention, but with a *multidisciplinary* focus: the Beating osteoARThritis [BART] intervention.[56] This stepped-care strategy was implemented using seminars, educational material and reminder material distributed among patients, GPs, medical specialists, physiotherapists and dieticians. In addition, educational outreach visits were conducted at general practices and in secondary care for medical specialists. After the implementation of this programme, most of the recommended evidence-based non-surgical treatment options seem to be well used. However, the majority of patients referred to secondary care did not receive all the recommended non-surgical treatment modalities; dietary therapy was found to be relatively underutilized, as only one out of six overweight patients reported being treated by a dietician. Thus, a stepped-care approach for knee and hip OA care with a *multidisciplinary focus* showed some promising results, but further innovative efforts are needed to further optimize the use of non-surgical treatment before referral to secondary care. To achieve this, lessons can be learned from effective primary care models with a multidisciplinary focus in countries with similar healthcare systems to the Netherlands. The SAMBA model in Norway[57] included a structured pathway for patients with knee or hip OA through the healthcare system, starting with a GP consultation, an education and exercise programme provided by a physiotherapist, an optional healthy eating programme and a GP review consultation. Also, multidisciplinary workshops and discussions to increase awareness of current treatment recommendations were conducted within the general practices. As a result, more patients were referred to physiotherapy (OR 2.5; 95% CI 1.08, 5.73; p = 0.03) and fewer to secondary care (OR 0.3; 95% CI 0.08, 0.80; p = 0.02) compared with the control group. The authors concluded that a *multidisciplinary approach* may have beneficial effects, including improved multidisciplinary collaboration, integrated care and consistent patient information. Furthermore, a GP and practice nurse integrated OA consultation model in general practice was implemented in the United Kingdom: the Managing OSteoArthritis In ConsultationS (MOSAICS) study.[58] These consultations were supported by the use of a guidebook based on OA core recommendations. An important aspect that distinguishes the MOSAICS study from other models is the use of an OA consultation e-template to monitor

and give feedback on the quality of care for healthcare providers. This e-template appeared to be a feasible tool to improve the quality of care.[59] The prescription of recommended first-line analgesics increased significantly after the implementation of the e-template for paracetamol (OR 1.49; 95% CI 1.22, 1.82) and for topical NSAIDs (OR 1.95; 95% CI 1.61, 2.35). Implementing such a template in practice would be a useful basis for promoting optimal care. However, as shown in **Chapter 5**, an important caveat to the use of quality indicators is that not all quality indicators taken from the literature are fully up to date. Also, some important aspects of the care process are not covered, such as the indication for radiographic assessment of the joint. Therefore, quality indicators for knee and hip OA should always be reviewed against the current evidence before using them in clinical practice and checked to see whether they are applicable for the general practice setting, since the content of quality indicators differs substantially between healthcare settings. Also, the cost-effectiveness of these OA models has not yet been evaluated and this is an important aspect to be considered for future research.

**X-ray imaging in general practice**

Current guidelines[30-34] do not recommend the use of X-rays for the diagnosis of knee and hip OA, since OA is primarily a clinical diagnosis. There is a poor correlation between the severity of the structural damage of the joint and the severity of symptoms.[34, 60] Instead, history and physical examination provide a reliable indication for the diagnosis of knee and hip OA. [32, 33, 61, 62] Despite these recommendations, our study in **Chapter 4** showed that GPs in the Netherlands often request an X-ray for the diagnosis of knee OA (i.e. 63.2% of the patients); this finding confirms the results from a previous study[63]. This inappropriate use of X-rays for OA can lead to unnecessary healthcare costs. In addition, the idea that there is damage visible in X-rays can give the patient the wrong idea that OA is caused by 'wear and tear'.[64]. It can lead GPs to make inappropriate decisions about the treatment or referral of patients with OA. This may raise concerns that weight-bearing exercise will exacerbate joint damage [65] and these concerns may lead patients to reduce their level of activity or avoid certain activities[66], even though exercise is an extremely important core treatment for OA.

One of the reasons that GPs often request diagnostic imaging for OA is to feel more confident about their diagnosis.[67] This may be even more the case in hip OA than knee OA, since hip pain is sometimes difficult to define and to distinguish from spinal or non-joint-related pain.[68, 69] Helping GPs to perform more extensive history taking and physical examination in patients with knee or hip complaints may give GPs more confidence in their ability to reach a diagnosis without the need for an X-ray. An example is an ongoing project by the Erasmus University Medical Center, called '*Doen of Laten*' (in Dutch), in which GPs receive training to improve their knowledge and skills about the diagnosis of knee and hip OA. After this training,

the number of X-ray requests for diagnosing knee and hip OA is tracked based on EHRs, and feedback is given to GPs to increase their awareness. The results of this project will show whether such a strategy to improve GPs' skills and knowledge in diagnosing knee and hip OA should be the focus in future interventions to tackle the overuse of X-rays. In addition, **Chapter 6** showed that GPs who provided knee and hip OA care consultations jointly with an orthopaedist in intermediate care felt more confident about their diagnosis. This suggests that more multidisciplinary collaboration between GPs and specialists may improve GPs' skills and knowledge in diagnosing knee and hip OA. Furthermore, several studies[70, 71] have shown that the patients' preferences and beliefs sometimes influence the indication for diagnostic imaging. GPs seem to be uncomfortable with rejecting patients' requests for X-rays and believe that this negatively affects the relationship between the GP and the patient.[70] Therefore, patient education about the role of diagnostic imaging in care for OA may also help reduce X-rays in the general practice setting. In addition, improving GPs' communication skills may also be beneficial, since patient-centred communication skills are associated with fewer diagnostic imaging requests.[72]

**Patient preferences**

Current evidence-based recommendations for the management of OA hardly include patients' preferences at all. A recent study showed that not all recommended core interventions are preferred by cross-sectoral stakeholders, which may present a barrier to the uptake of and adherence to OA core treatments.[36] At the same time, strategies to optimize knee and hip OA are increasingly being implemented, such as the introduction of the intermediate care setting. One of the questions addressed in this thesis was to determine the preferences of patients for different healthcare settings in the Netherlands and to identify the extent to which other stakeholders have insight into the preferences of patients (**Chapter 8**). The major conclusion drawn from our discrete choice experiment study was that there is great heterogeneity in preferences between patients, depending on their characteristics, such as whether or not they had had a total joint replacement. This emphasizes the need for a more patient-stratified approach for OA treatment rather than a 'one size fits all' approach. Stratified care has already been shown to be cost-effective in healthcare for low back pain[73]. Specifically for OA, there are some studies ongoing, such as the OCTOPuS study, a pragmatic cluster randomized controlled trial which will compare stratified exercise therapy with usual care by physiotherapists in primary care for patients with knee OA.[74] Yet little is known about stratified care for patients with knee and hip OA, and ongoing studies and future research in this area are important to optimize care for this group of patients. In addition, broader patient engagement can lead to more effective implementation strategies[75] and improvement of the uptake, adherence and

effectiveness of treatments.[76, 77] Preferably, this patient engagement should take place prior to implementing new strategies to optimize care for knee and hip OA, such as the introduction of intermediate care settings.

## IMPLICATIONS FOR FUTURE RESEARCH, CLINICAL PRACTICE AND POLICY

This thesis showed that using narrative data in addition to codified data taken from routine healthcare data in general practice provided prevalence and incidence estimates of knee and hip OA that are twice as high on average. Therefore, this thesis implies that our knowledge of the current and future demand for healthcare related to knee and hip OA as used for national policies — which is based on codified data alone — is just the tip of the iceberg. If we want to prepare better for future healthcare demand, researchers and policymakers urgently need to focus not only on codified data, but also on narrative data. In addition, an important recommendation for researchers, policymakers and healthcare insurers is to always take into account the effect of changes in the healthcare system (e.g. financial incentives) on the quality of data when reusing routine healthcare data.

Future research should focus on the potential of decision support tools integrated in GP information systems for improving the quality of routine healthcare data. Tools supporting GPs in their choice of diagnostic or symptomatic codes (e.g. ICPC codes) during consultations, for example through free-text mining of notes that GPs make during consultations, may reduce the under-recording and misclassification of OA patients. This is important not only for the reuse of routine healthcare data for research and policy, but also for the complete and reliable exchange of healthcare information between healthcare providers in the primary care process. In addition, electronic decision tools that help GPs to decide *which* care to provide and *when* can help address the underutilization of non-surgical care in general practice, as found in this thesis.

This thesis also shows that GPs in the Netherlands often request an X-ray for the diagnosis of knee and hip OA, which can lead to unnecessary healthcare costs, misconceptions about OA in patients and incorrect treatment and referral decisions by GPs. Providing feedback to GPs to make them more aware of their behaviour regarding X-ray requests may be a solution for tackling the overuse of X-rays in general practice. This could be done through real-time feedback tools in GP information systems, and the effect of such electronic tools should also be evaluated in future research.

One of the main lessons from this thesis, based on the results of our study evaluating intermediate care for knee and hip OA, is that collaboration between healthcare providers is

important in further improving knee and hip OA care. Currently, knee and hip OA care is too fragmented, with insufficient communication between disciplines (e.g. GP, physiotherapist and orthopaedist). More structural collaboration between healthcare providers across the total clinical pathway is needed to improve the use of non-surgical treatment. This all starts with awareness among healthcare providers of each other's professional roles and responsibilities. Ideally, this should already be addressed during the education of healthcare providers and should be continued after they finished their education, for example through training programmes that focus on multiple disciplines instead of on one discipline or on combined consultation with orthopaedists, as shown in this thesis in our intermediate care evaluation study.

Finally, the current thesis has shown the heterogeneity in patient preferences for knee and hip OA care. This suggests that we should focus on the management of knee and hip OA with a patient-stratified approach rather than a 'one size fits all' approach in general practice. Future research should explore whether this approach is actually more effective. Furthermore, I advise researchers and policymakers to first explore the preferences of stakeholders in knee and hip OA care prior to implementing new strategies to optimize care for knee and hip OA (e.g. with intermediate care settings). Engagement of stakeholders can be achieved through OA platform initiatives, such as the Dutch research platform 'Artrose Gezond'[78], and such initiatives should be implemented more often and used in future research and policies for improved knee and hip OA care.

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# CHAPTER 9


Summary

Samenvatting

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# SUMMARY

Osteoarthritis (OA) in the knee or hip is a highly prevalent chronic musculoskeletal disease in the general population. The prevalence and associated healthcare demand are expected to increase dramatically in the future, putting pressure on the healthcare system. General practitioners (GPs) are often the first point of contact for patients in the Dutch healthcare system and therefore play an important role in the initial recognition and treatment of knee and hip OA. Current evidence on the extent of knee and hip OA in general practice is insufficient, since incidence and prevalence estimates and predictions are based exclusively on codified data from primary-care electronic health records (EHRs), while earlier research showed significant under-recording of OA in codified data from primary-care EHRs. Also, treatment in general practice is suboptimal: overuse of non-recommended care (e.g. inappropriately early referrals from primary to secondary care and X-ray imaging for the diagnosis of OA) and underuse of non-surgical core treatments (e.g. exercise therapy) for knee and hip OA are common. The insufficient knowledge about the extent of knee and hip OA and suboptimal treatment in general practice for knee and hip OA lead to inadequate planning and prioritization of healthcare resources, low quality of care, redundant healthcare consumption, high healthcare costs, poor healthcare outcomes and low patient and healthcare provider satisfaction. This will all put even more pressure on the sustainability of the healthcare system. To fill these gaps, this thesis aimed to provide more valid knowledge about the incidence and prevalence and about the provision of healthcare related to knee and hip OA in general practice. It also aimed to identify possibilities for improvements to the care, with a focus on Dutch general practice.

Healthcare data routinely recorded in EHRs as part of the healthcare process are often reused to estimate the prevalence and incidence of knee and hip OA. However, so far these studies have all focused on codified data (i.e. specific codes for specific diseases and tests) from EHRs and have neglected narrative data (i.e. narrative free-text notes by healthcare providers that are documented during consultations and in clinical letters). Utilizing both codified and narrative data from EHRs may increase the validity of findings from knee and hip OA research. In **Chapter 2**, we developed an algorithm to select patients with knee OA based on codified and narrative data from EHRs and to provide a more accurate picture of the incidence and prevalence than the standard approach of using codified data alone. In **Chapter 3**, we use similar research methods to the methods in Chapter 2, but with a focus on selecting patients with hip OA using codified and narrative data from EHRs. Developing a valid algorithm was more difficult for hip OA than for knee OA (positive predicted value = 72% and 94% respectively), possibly due to the diagnostic complexity of hip pain in general practice. We found that using

narrative data in addition to codified data produced prevalence and incidence estimates of knee and hip OA that were on average twice as high as the estimates based on codified data only. This indicates that current estimates from routine healthcare data based on codified data alone are an underestimation. Comorbidities, such as hypertension, hyperlipidaemia and OA in other joints, increased the likelihood of knee and hip OA being recorded with codes in EHRs (i.e. diagnosis identified with codified data), suggesting that GPs are more likely to record a code for knee or hip OA when patients fit the risk factor profile for knee or hip OA. In addition, 40% of the patients with a code for knee or hip OA in their EHR (i.e. diagnosis identified with codified data) had already been diagnosed with knee or hip OA approximately two to three years earlier according to narrative data. Thus, using narrative data in addition to codified data increases the accuracy of the timelines of knee and hip OA incidence estimates. Capturing knee and hip OA patients earlier may help policymakers to plan and prioritize resources more adequately and thereby keep healthcare affordable. Using our algorithms, narrative data can be added to codified data for more realistic epidemiological estimates of knee and hip OA based on routine healthcare data.

In **Chapter 4**, we conducted a retrospective cohort study to determine patterns in the management of knee OA by GPs using Dutch routine healthcare data from general practices. We used the algorithm developed in *Chapter 2* to select knee OA patients with the narrative data (i.e. free-text fields) of EHRs in addition to codified data. Recorded information was extracted on GPs' management from six months before to three years after knee OA diagnosis from 503 eligible patients. An X-ray referral was the most widely recorded management modality (i.e. in 63.2% of the patients), most often at the initial consultation in general practice. The next most widely recorded types of management were a referral to an orthopaedist in secondary care and medication prescription or advice. Recommendation of/referrals to other primary care practitioners (e.g. physiotherapists) were recorded in only one third of the patients and records of advice to lose weight were found the least (1.2% of the patients). In addition, this study showed indications for the underutilization of a stepped-care approach for knee OA. This often started at the first GP consultation, as, for example, many patient EHRs contained a record of a secondary care referral at first consultation. These findings emphasized the importance of a better implementation of non-surgical management modalities of knee OA in general practice, especially during the first GP consultation, and on initiatives for reducing the overuse of X-rays for diagnosing knee OA in general practice.

One way to optimize care is by using quality indicators for routinely monitoring and providing feedback on the quality of care for quality improvement. **Chapter 5** provides an overview of

quality indicators for knee and hip OA care in various healthcare settings. This information can help healthcare providers and policymakers monitor the quality of care in a valid way. In this systematic review, we included 20 studies developing or adapting existing quality indicators for knee and hip OA, with a total of 196 quality indicators, mostly related to the process of care in different healthcare settings. We found that the content of these quality indicators depends very much on the healthcare setting. Moreover, most of the quality indicators were developed from the perspective of healthcare professionals and researchers; there was only limited input from the patient perspective. Quality indicators relating to the indication for radiographic assessment of the joint were not consistent in their content. In addition, quality indicators regarding pharmacological treatment were not fully up to date. From these results, it can be concluded that quality indicators for knee and hip OA should always be reviewed against the current evidence and the appropriate healthcare setting before using them in clinical practice.

As another effort towards improved knee and hip OA care, in **Chapter 6** we evaluated intermediate care projects for knee and hip OA, where one-time consultations by orthopaedists in general practice are substituted for specialist care. The main goal of this intervention is to prevent unnecessary referrals to secondary care. In this study, we used a mixed methods approach including semi-structured interviews, patient experience questionnaires and data from medical records from three intermediate care projects. GPs and orthopaedists in intermediate care experienced more intensive collaboration compared to regular care. This led to a perceived increase in GPs' knowledge, enabling better selection of referrals to orthopaedics and less healthcare consumption. Important barriers to the use of intermediate care were that orthopaedists experienced a higher workload and limited access to diagnostic facilities. Patients were satisfied and experienced better access to specialists' knowledge in a trusted environment when compared to regular care. Referrals to physiotherapy increased significantly after the implementation of intermediate care (absolute difference = 15%; 95% CI = 7.19 to 22.8), but there was no significant difference in referrals to orthopaedics (absolute difference = 5.9%; 95% CI = 6.18 to 17.9). The pragmatic design and short follow-up duration may have influenced the reliability of the findings. Nevertheless, we concluded that intermediate care may be a solution to increase GPs' confidence in diagnosing and managing knee and hip OA patients, and may contribute to better quality of care due to the increased percentage of patients referred to physiotherapy.

Another way to improve knee and hip OA care is to tailor healthcare to patients' preferences in order to provide patient-centred care. In **Chapter 7**, we measured patients' preferences for the characteristics of different healthcare settings of knee and hip OA care and compared this with

the preferences of healthcare providers and insurance company employees using a discrete choice experiment. We repeatedly asked patients with knee or hip OA or a joint replacement (n=648), healthcare providers (n=76) and insurance company employees (n=150) to choose between knee and hip OA care alternatives that differed in six attributes: waiting times, out-of-pocket costs, travel distance, the healthcare providers involved, duration of consultation and access to specialist equipment. Patients and healthcare providers attached most importance to low out-of-pocket costs, while insurance company employees found a joint consultation with the GP and orthopaedist most important. Patients found the duration of the consultation less important than healthcare providers and insurance company employees did. In addition, there was substantial heterogeneity in patients' preferences. Based on these findings, the following recommendations are made for policymakers for knee and hip OA care tailored to patients' preferences: 1) low out-of-pocket costs for patients without joint replacement; 2) combined consultations with a GP and orthopaedist with direct access to specialist equipment for patients who have already received healthcare; and 3) consultation with an orthopaedist for patients with a joint replacement and/or with low disease-specific quality of life.

Finally, **Chapter 8** provides an overview of the key findings of this thesis. In addition, it discusses the reuse of routine healthcare data for OA research, the optimal use of core treatments in primary care, inappropriate use of X-rays in general practice, and patient preferences for optimizing knee and hip OA care. Based on the studies in this thesis and existing knowledge, suggestions are made for future research, clinical practice and policy to enable better planning and prioritization of healthcare resources and further improvements to knee and hip OA care.

# SAMENVATTING

Artrose in de knie of heup is een veel voorkomende chronische musculoskeletale aandoening in de bevolking. De prevalentie en de daarmee samenhangende zorgvraag zullen naar verwachting in de toekomst drastisch toenemen, waardoor het zorgstelsel onder druk komt te staan. In het Nederlandse zorgsysteem zijn huisartsen vaak het eerste aanspreekpunt voor patiënten en zij spelen daarom een belangrijke rol bij de herkenning en behandeling van knie- en heupartrose. De huidige kennis over de omvang van knie- en heupartrose in de huisartsenpraktijk is onvoldoende, omdat de schattingen en voorspellingen van de incidentie en prevalentie uitsluitend zijn gebaseerd op gecodeerde gegevens uit elektronische gezondheidsdossiers (EPD's). Eerder onderzoek heeft aangetoond dat een significant aantal patiënten die bekend zijn met artrose in de huisartspraktijk niet in EPD's zijn gerapporteerd met een code voor artrose. Ook is de behandeling in de huisartsenpraktijk voor knie- en heupartrose suboptimaal: er wordt overmatig gebruik gemaakt van niet aanbevolen zorg zoals onterechte en te vroege verwijzingen van patiënten van de huisartspraktijk naar de tweedelijnszorg en het gebruik van röntgenonderzoek voor de diagnose van artrose. Tevens is er onvoldoende inzet van niet-operatieve behandelingen, zoals oefentherapie. Gebrek aan goede kennis over de omvang van knie- en heupartrose en optimale behandeling in de huisartsenpraktijk voor knie- en heupartrose leidt tot onvermogen om zorgmiddelen goed te kunnen plannen en prioriteren, lage kwaliteit van zorg, overmatig zorggebruik, hoge zorgkosten, slechte zorguitkomsten en ontevredenheid van de patiënt en de zorgverlener. Dit alles zal de duurzaamheid van het zorgstelsel nog meer onder druk zetten. Om deze lacunes op te vullen, richt dit proefschrift zich op het verkrijgen van betere kennis over de incidentie en prevalentie van de zorg voor knie- en heupartrose in de huisartspraktijk. Daarnaast richt dit proefschrift zich op de mogelijkheden voor optimalere zorg voor knie- en heupartrose in kaart te brengen, met een focus op de Nederlandse huisartsenpraktijk.

In wetenschappelijk onderzoek worden zorggegevens die routinematig zijn vastgelegd in EPD's tijdens het zorgproces vaak hergebruikt om de prevalentie en incidentie van knie- en heupartrose te schatten. Tot dusver hebben deze onderzoeken zich allemaal gericht op gegevens die op gecodeerde wijze zijn vastgelegd in EPD's (d.w.z. specifieke codes voor symptomen en ziektes). Gegevens die op narratieve wijze zijn vastgelegd in EPD's (d.w.z. notities gedocumenteerd door zorgverleners tijdens consulten en in brieven van en naar andere zorgverleners in vrije tekst velden) zijn niet meegenomen. Het gebruik van zowel gecodeerde als narratieve gegevens uit EPD's kan de validiteit van bevindingen uit onderzoek naar knie- en heupartrose vergroten. In **Hoofdstuk 2** hebben we een algoritme ontwikkeld om patiënten met knieartrose te selecteren op basis van gecodeerde en narratieve gegevens van EPD's, zodat een nauwkeuriger beeld kan

worden verkregen van de incidentie en prevalentie ten opzichte van de standaardbenadering waarbij alleen gecodeerde gegevens worden gebruikt. In **Hoofdstuk 3** gebruiken we vergelijkbare onderzoeksmethoden als de methoden in Hoofdstuk 2, maar dan gericht op het identificeren van patiënten met heupartrose met behulp van gecodeerde en narratieve gegevens in EPD's. Het ontwikkelen van een valide algoritme was moeilijker voor heupartrose dan voor knieartrose (positief voorspelde waarde = respectievelijk 72% en 94%). Dit komt waarschijnlijk door de grote diagnostische complexiteit van heuppijn in de huisartsenpraktijk. We ontdekten dat de prevalentie- en incidentieschattingen van knie- en heupartrose twee keer zo hoog waren bij het gebruik van narratieve gegevens bovenop gecodeerde gegevens. Dit laat zien dat de huidige prevalentie- en incidentieschattingen met behulp van routine zorggegevens met alleen gecodeerde gegevens een onderschatting zijn. Comorbiditeiten, zoals verhoogde bloeddruk, hyperlipidemie en artrose in andere gewrichten, vergrootten de kans dat een patiënt met knie- of heupartrose met een code voor artrose in hun EPD werd geregistreerd, wat suggereert dat huisartsen eerder geneigd zijn een code voor knie- of heupartrose te geven wanneer hun patiënt in het risicoprofiel voor knie- of heupartrose past. Bovendien was 40% van de patiënten met een code voor knie- of heupartrose in hun EPD ongeveer twee tot drie jaar eerder al gediagnosticeerd met knie- of heupartrose, maar alleen gerapporteerd in narratieve gegevens en niet in de gecodeerde gegevens. Deze bevinding laat zien dat het gebruik van narratieve gegevens naast gecodeerde gegevens accuratere en tijdigere prevalentie- en incidentieschattingen oplevert. Het eerder kunnen identificeren van knie- en heupartrosepatiënten in EPD's kan beleidsmakers helpen om zorgmiddelen beter te plannen en te prioriteren en op deze manier de zorg betaalbaar te houden. Met behulp van onze algoritmen kunnen zowel narratieve gegevens als gecodeerde gegevens uit EPD's worden gebruikt voor meer realistische epidemiologische schattingen van knie- en heupartrose op basis van routine zorggegevens.

In **Hoofdstuk 4** hebben we een retrospectieve cohortstudie uitgevoerd met behulp van Nederlandse routinematige gezondheidszorggegevens uit huisartsenpraktijken om patronen in de huisartsenzorg voor knieartrose vast te stellen. We gebruikten het algoritme dat we hebben ontwikkeld in hoofdstuk 2 om patiënten met knieartrose te selecteren op basis van zowel narratieve gegevens als gecodeerde gegevens uit EPDs. Van de 503 in aanmerking komende patiënten hebben we de door de huisarts gerapporteerde zorg verzameld uit de EPD's over een periode van zes maanden voor de diagnose tot drie jaar na de diagnose knieartrose. Een verwijzing door de huisarts naar het ziekenhuis voor een röntgenfoto was de meest gerapporteerde handeling (bij 63,2% van de patiënten) en kwam het vaakst voor tijdens het eerste consult in de huisartsenpraktijk. De volgende meest gerapporteerde handelingen door de huisarts waren een verwijzing naar een orthopeed in het ziekenhuis en een voorschrift of advies

voor medicatie. Een verwijzing of advies naar andere zorgverleners in de eerstelijnszorg (bijv. een fysiotherapeut) werd gerapporteerd bij slechts één derde van de patiënten en adviezen om gewicht te verliezen werden het minst gerapporteerd (1,2% van de patiënten). Dat een advies niet gerapporteerd staat in het EPD wil echter niet zeggen dat het in werkelijkheid niet gegeven is. Maar dit onderzoek liet aanwijzingen zien voor hoe een stapsgewijze benadering in de zorg voor knieartrose beter kan worden ingezet. Onderbenutting van een stapsgewijze benadering werd vaak al gezien tijdens het eerste consult bij de huisarts, bijvoorbeeld doordat patiënten tijdens het eerste consult direct werden verwezen naar de tweedelijnszorg. Deze bevindingen benadrukten het belang van een betere implementatie van niet-operatieve zorg voor knieartrose in de huisartsenpraktijk, vooral tijdens het eerste huisartsenconsult, en het belang van initiatieven om het overmatig gebruik van röntgenfoto's voor de diagnose knieartrose in de huisartspraktijk te verminderen.

Door gebruik te maken van kwaliteitsindicatoren voor monitoring en feedback over de kwaliteit van de zorg kan de zorg geoptimaliseerd worden. **Hoofdstuk 5** geeft een overzicht van kwaliteitsindicatoren voor knie- en heupartrose in verschillende zorgsettings (zoals huisartspraktijk en ziekenhuiszorg). Dit overzicht kan zorgverleners en beleidsmakers helpen om de kwaliteit van zorg op een valide manier te meten. In deze systematische review hebben we 20 studies opgenomen die kwaliteitsindicatoren voor knie- en heupartrose hebben ontwikkeld of die reeds bestaande kwaliteitsindicatoren hebben aangepast. Dit leverde in totaal 196 kwaliteitsindicatoren op die voornamelijk betrekking hebben op de processen van de zorgverlening en verschillende zorgsettings. We ontdekten dat de inhoud van deze kwaliteitsindicatoren sterk afhangt van de zorgsetting. Bovendien zijn de meeste kwaliteitsindicatoren ontwikkeld vanuit het perspectief van zorgverleners en onderzoekers; er was slechts beperkte inbreng vanuit het perspectief van de patiënt. Kwaliteitsindicatoren met betrekking tot röntgenonderzoek waren inhoudelijk inconsistent. Daarnaast waren de kwaliteitsindicatoren met betrekking tot de medicamenteuze behandeling niet actueel. Uit deze bevindingen kan worden geconcludeerd dat bij het gebruik van kwaliteitsindicatoren voor knie- en heupartrose altijd moeten worden getoetst of de indicatoren actueel zijn en betrekking hebben op de juiste zorgsetting voordat ze in de klinische praktijk worden ingezet.

Als een aanvullende inspanning om de zorg voor knie- en heupartrose te optimaliseren, evalueerden we in **Hoofdstuk 6** anderhalvelijnszorgprojecten voor knie- en heupartrose, waarbij orthopeden eenmalige consulten leverden aan patiënten in de huisartsenpraktijk voor substitutie van zorg uit de tweede lijn naar de huisartsenpraktijk. Het belangrijkste doel van deze interventie is het voorkomen van onnodige verwijzingen naar de tweede lijn. We hebben een *mixed-methods*

onderzoek uitgevoerd, bestaande uit semigestructureerde interviews, vragenlijsten over patiëntervaringen en gegevens uit EPD's van drie anderhalvelijnszorg projecten. Huisartsen en orthopeden in de anderhalvelijnszorg ervoeren een intensievere samenwerking in vergelijking met de reguliere zorg. Huisartsen ervoeren een toename in hun kennis wat leidde tot een betere selectie van verwijzingen naar orthopedie in de tweede lijn en minder zorgconsumptie. Belangrijke belemmeringen van de anderhalvelijnszorg waren dat orthopeden een hoge werkdruk en beperkte toegang tot aanvullend onderzoek ervoeren. Patiënten waren tevreden en ervoeren betere toegang tot medisch specialistische kennis in een vertrouwde omgeving in vergelijking met reguliere zorg. Het aantal verwijzingen naar fysiotherapie nam significant toe na de invoering van anderhalvelijnszorg (absoluut verschil = 15%; 95% BI = 7,19 tot 22,8), maar er was geen significant verschil in verwijzingen naar tweedelijnszorg orthopedie (absoluut verschil = 5,9%; 95% BI = 6,18 tot 17.9). De pragmatische opzet en korte follow-up duur van de projecten kunnen de betrouwbaarheid van deze bevindingen hebben beïnvloed. Desalniettemin concludeerden we dat anderhalvelijnszorg oplossing kan bieden om het vertrouwen van huisartsen in de diagnose en behandeling van knie- en heupartrose te vergroten, en dat het kan bijdragen aan een betere kwaliteit van zorg vanwege het verhoogde percentage patiënten dat wordt verwezen naar fysiotherapie.

Een andere manier om de zorg voor knie- en heupartrose te optimaliseren, is door de zorg af te stemmen op de voorkeuren van de patiënt voor patiëntgerichte zorg. In **Hoofdstuk 7** hebben we met behulp van een discreet keuze-experiment de voorkeuren van patiënten gemeten voor de kenmerken van verschillende zorgsettings van knie- en heupartrosezorg en vervolgens vergeleken met de voorkeuren van zorgverleners en werknemers van verzekeringsmaatschappijen. We vroegen patiënten met knie- of heupartrose of een nieuwe knie of heup (n=648), zorgverleners (n=76) en medewerkers van verzekeringsmaatschappijen (n=150) om herhaaldelijk te kiezen tussen zorgscenario's voor knie- en heupartrose die verschilden in zes kenmerken: wachttijden, eigen bijdrage, reisafstand, betrokken zorgverleners, consultduur en toegang tot specialistische apparatuur. Patiënten en zorgverleners hechtten het meeste belang aan een lage eigen bijdrage, terwijl medewerkers van verzekeringsmaatschappijen een gezamenlijk consult door een huisarts en orthopeed het belangrijkst vonden. Patiënten vonden de duur van het consult minder belangrijk dan zorgverleners en medewerkers van verzekeringsmaatschappijen. Daarnaast was er aanzienlijke heterogeniteit in de voorkeuren van patiënten. Op basis van deze bevindingen worden de volgende aanbevelingen gedaan voor beleidsmakers om de knie- en heupartrosezorg af te stemmen op de voorkeuren van de patiënt: 1) lage eigen bijdrage voor patiënten met knie- of heupartrose zonder een nieuwe knie of heup; 2) een gezamenlijke consult door een huisarts en orthopeed met directe toegang tot specialistisch apparatuur voor patiënten die al eerder

zorg hebben ontvangen voor hun klachten; en 3) een consult door een orthopeed voor patiënten met een nieuwe knie of heup en/of met een lage ziektespecifieke kwaliteit van leven.

Ten slotte geeft **Hoofdstuk 8** een overzicht van de belangrijkste bevindingen van dit proefschrift. Daarnaast wordt ingegaan op het hergebruik van routine zorggegevens voor onderzoek naar artrose, het optimale gebruik van door de richtlijn aanbevolen behandelingen in de huisarts-praktijk, ongepast gebruik van röntgenfoto's in de huisartsenpraktijk en patiëntvoorkeuren voor het optimaliseren van knie- en heupartrosezorg. Op basis van de onderzoeken in dit proefschrift en bestaande wetenschap worden aanbevelingen gedaan voor toekomstig onderzoek, klinische praktijk en zorgbeleid voor betere planning en prioritering van zorgmiddelen en het optimaliseren van de zorg voor knie- en heupartrose.

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Ilgin

# PHD PORTFOLIO

**Erasmus MC Department:** General Practice

**PhD period:** 12/2018 – 6/2022

| Activity | Year | ECTS |
|---|---|---|
| **Courses/Training** | | |
| Erasmus University - Measurement of Patient Preferences using Discrete Choice Experiments | 2019 | 5.0 |
| Erasmus MC - BROK® (Basic course Rules and Organisation) | 2019 | 1.5 |
| Erasmus MC - Biomedical Writing Course | 2019 | 2.0 |
| Erasmus MC - Scientific Integrity Course | 2019 | 0.3 |
| Erasmus MC - HS02a Public Health Research: Analysis of Population Health | 2019 | 1.9 |
| **Presentations** | | |
| Oral presentation WONCA congress 2021 | 2021 | 2.0 |
| Poster presentation OARSI Congress 2021 (online) | 2021 | 1.0 |
| Oral presentation OARSI Congress 2021 (online) | 2021 | 2.0 |
| Oral presentation NHG Wetenschapsdag 2021, 2x (online) | 2021 | 4.0 |
| Oral presentation British Journal of General Practice Conference 2020 (online) | 2020 | 2.0 |
| Oral presentation Smarter Choices for Better Health Conference 2021 (Rotterdam, the Netherlands) | 2019 | 2.0 |
| Poster presentation NHG Wetenschapsdag 2019 (Nijmegen, the Netherlands) | 2019 | 1.0 |
| Poster presentation OARSI Congress 2019 (Toronto, Canada) | 2019 | 1.0 |
| **Teaching** | | |
| Supervising student sessions 'How to judge a paper' | 2019, 2021 | 0.6 |
| Supervision of master research project medical student | 2020 | 4.0 |
| Supervision of master research project student Communication Science | 2021 | 4.0 |
| **Other** | | |
| Junior researcher on project for reducing X-ray referrals for knee and hip osteoarthritis in general practice, called *'Doen of Laten'* (in Dutch)<br>- Developing algorithms for monitoring and feedback for GPs in electronic health record systems<br>- Qualitative research among GPs and patients<br>- Organizing and assisting training sessions for GPs on knee and hip osteoarthritis management | 2020-2021 | 10 |
| **Total** | | **42.3** |

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Dijksma I, **Arslan IG**, Van Etten-Jamaludin FS, Elbers RG, Lucas C, Stuiver MM**.** Exercise Programs to Reduce the Risk of Musculoskeletal Injuries in Military Personnel: A Systematic Review and Meta-Analysis. *PM&R*. 2020;12(10):1028-1037

# CURRICULUM VITAE

Ilgin Arslan was born on August 31, 1994 in Rotterdam, the Netherlands. She graduated from the HAVO in 2012 and started studying physiotherapy at the University of Applied Sciences in Rotterdam. After obtaining her degree in physiotherapy in 2016, she studied Clinical Epidemiology at the University of Amsterdam and obtained her master degree in 2018. As part of her master degree she performed research at the University of Amsterdam on the effect of interventions for the prevention of musculoskeletal injuries among military personnel in collaboration with the Ministry of Defence. During and after her master degree she worked as a physiotherapist in primary care. On December 2017 she started working as a junior researcher at the Department of General Practice of the Erasmus MC in Rotterdam, followed by a PhD trajectory starting on December 2018 on the project described in this thesis. Currently, she works as a post-doctoral researcher at NIVEL (Netherlands Institute for Health Services Research) on research in the field of Health Data and Learning Health Systems.