

Socioeconomic inequalities in patient-reported outcome measures of Dutch primary hip and knee arthroplasty patients for osteoarthritis



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SUMMARY

Objective: To study socio-economic inequalities in patient-reported outcomes in primary hip and knee arthroplasty (THA/TKA) patients for osteoarthritis, using two analytical techniques.

Methods: We obtained data from 44,732 THA and 30,756 TKA patients with preoperative and 12-month follow-up PROMs between 2014 and 2020 from the Dutch Arthroplasty Registry. A deprivation indicator based on neighborhood income, unemployment rate, and education level was linked and categorized into quintiles. The primary outcome measures were the EQ-5D-3L index and Oxford Hip/Knee Score (OHS/OKS) preoperative, at 12-month follow-up, and the calculated change score between these measurements. We contrasted the most and least deprived quintiles using multivariable linear regression, adjusting for patient characteristics. Concurrently, we calculated concentration indices as a non-arbitrary tool to quantify inequalities.

Results: Compared to the least deprived, the most deprived THA patients had poorer preoperative (EQ-5D -0.03 (95%CI -0.02, -0.04), OHS -1.26 (-0.99, -1.52)) and 12-month follow-up health (EQ-5D -0.02 (-0.01, -0.02), OHS -0.42 (-0.19, -0.65)), yet higher mean change (EQ-5D 0.02 (0.01, 0.03), OHS 0.84 (0.52, 1.16)). The most deprived TKA patients had similar results. The higher mean change among the deprived resulted from lower preoperative health in this group (confounding). After accounting for this, the most deprived patients had a lower mean change. The concentration indices showed similar inequality effects and provided information on the magnitude of inequalities over the entire socio-economic range.

Conclusion: The most deprived THA and TKA patients have worse preoperative health, which persisted after surgery. The concentration indices allow comparison of inequalities across different outcomes (e.g., revision risk).

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Introduction

Health inequalities are unfair and potentially avoidable health differences between population groups. Socioeconomic status (SES), a composite measure typically covering education, income, and occupation, is recognized as a universal driving force of health inequalities.^{1,2} Unequal distribution of health is considered a human

rights infringement, but it also hampers economic prosperity and social development.^{3,4} Traditionally, clinical outcomes such as mortality, are used to measure health inequalities. However, a useful alternative may be patient-reported outcome measures (PROMs), which are standardized surveys used to quantify generic or disease-specific health status from the patient's perspective.⁵

Hip and knee arthroplasty (THA, TKA) are commonly performed surgical procedures, resulting in pain relief and improved mobility in individuals with end-stage osteoarthritis.^{6,7} Despite being standardized procedures, striking socio-economic inequalities have been demonstrated in these patients. Deprived patients report inferior PROMs after THA or TKA, even after adjusting for patient and surgical characteristics.^{8–16} Some studies observed worse PROMs in deprived patients prior to surgery due to patient or provider

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selection.^{8,9,11,15} Surgical recovery can be expressed as the change score, which is the difference between post- and preoperative PROMs. When analyzing this score, studies commonly control for preoperative PROMs because of their significant association with the change score.¹¹ However, adjustment obscures our understanding of how the effect of deprivation prior to surgery might influence the effect of deprivation during recovery. One exploratory study recognized this issue and stratified patients by preoperative health, in order to expose deprivation effects on the mean change score.⁹

Furthermore, to analyze inequalities, outcomes of the top 20% (most affluent) and bottom 20% (most deprived) patients are usually contrasted.^{17,18} However, this approach does not provide insight into the amount of inequality in the overall population and does not allow for comparison of the size of inequalities across different outcomes. Additionally, it is impossible to determine the role of attributable factors (e.g., patient characteristics), which could inform efforts aimed at reducing inequalities. For this purpose, economists developed inequality measures such as the concentration index, which can be transferred to public health sciences.¹⁹ This index, closely related to the Gini coefficient, provides a non-arbitrary estimate of the ‘volume’ of health inequality in a population according to a deprivation indicator.¹⁸

In this study, we aimed to analyze socio-economic health inequalities in THA and TKA patients using Dutch registry data, unraveling the effect of deprivation on pre- and postoperative PROMs. Additionally, we used the concentration index to express possible inequalities and assess the impact of deprivation amidst other potentially influential factors.

Methods

An observational cohort study was performed using anonymized prospectively collected data from the Dutch Arthroplasty Registry (LROI). Ethical approval is not required by Dutch law for this type of study. We adhered to the STROBE guideline for observational studies.

Data and inclusion criteria

In the Netherlands, clinical registration of data from THA and TKA patients is professionally endorsed. The LROI has a completion rate of over 95%.²⁰ Variables include patient and surgical characteristics and outcomes. The collection of internationally validated general health and disease-specific PROMs has been strongly recommended since 2014. Since then, the collection of PROMs from patients undergoing surgery increased notably, and stabilized in 2017, with approximately 40% of primary THA and TKA patients having preoperative and 12-month follow-up outcomes.²¹

All patients who had primary THA or TKA for osteoarthritis from 2014 to 2020, and of whom preoperative and 12-month follow-up PROMs were available were included. We selected only patients who received arthroplasty for osteoarthritis, as this is the largest and most homogeneous group of elective orthopedic patients in which PROMs are collected. 11% of THA patients and 12% of TKA patients also underwent contralateral joint replacement during this period; the second record was ignored to avoid data dependencies.

Variables

The following patient- and surgical data was extracted from the registry: age, biological sex, body mass index (BMI), Charnley score,²² American Society of Anesthesiologists (ASA) score,²³ previous surgery of

the replaced joint, smoking status, type of hospital, fixation method, and surgical approach. The Charnley score represents the extent of osteoarthritis disease, ranging from “A” (one joint affected) to “C” (multiple joints affected or severely impaired quality of life due to the disease). The hospital type is categorized into private, general, or university hospitals. Fixation methods were categorized into cemented, uncemented, or hybrid. Approach methods for THA were categorized into anterior, anterolateral, posterolateral, direct lateral, and other; for TKA into medial para-patellar and other.

Deprivation indicator

As a deprivation indicator, a small neighborhood SES score was linked to the data using the 4-digit postal code of the home address of each patient.²⁴ The Netherlands Institute for Social Research, a government organization, calculates this SES score for each 4-digit postal code area with a minimum of 100 inhabitants (mean 4300 inhabitants). This standardized continuous score is derived from the mean income per household, % households with a low income, % unemployed inhabitants, and % households with a low education per postal code area. We categorized this score into quintiles, using cumulative z-distribution thresholds for the 20th, 40th, 60th, and 80th percentile. For the descriptive analysis, we regrouped the 5 quintiles into 3 groups: most deprived (quintile 1), medium deprived (quintile 2–4), and least deprived (quintile 5), following guidelines of the World Health Organisation.²⁵

Outcomes (PROMs)

The Dutch Orthopaedic Association advises to collect PROMs at three time points: a maximum of 6 months before surgery, postoperatively at 3-months follow-up (range 2–4 months) for THA patients, at 6-months follow-up (5–7 months) for TKA patients, and at 12-months follow-up (11–13 months) for both procedures. Preoperative PROMs are generally completed at the outpatient clinic, whilst postoperative PROMs are completed electronically after invitation per email or with pen and paper.

The LROI contains multiple PROMs; we selected the EQ-5D-3L, the Oxford Hip Score (OHS), and the Oxford Knee Score (OKS). The EQ-5D-3L questionnaire has 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, on which patients score their general health. With the scores on the 5 dimensions, an index value was calculated using the Dutch National Value set.²⁶ This value ranges from –0.329 to 1.0, indicating the poorest and full health, respectively. The OHS and OKS are 12-item questionnaires which assess functioning and pain in patients with osteoarthritis of the hip or knee, respectively. The OHS and OKS range from 0 to 48, indicating most and no disability, respectively.

Missing data

Missing Charnley scores were conservatively estimated as “A”, as the indication for joint replacement was osteoarthritis. Ages < 10 years and > 105 years, and BMI values < 10 and > 70, were considered erroneous and were recoded as ‘missing’ conform to the guidelines of the LROI. Missing values in one or more of the extracted variables were present in 4% of THA and TKA patients with complete preoperative and 12-month follow-up PROMs. Visual plots indicated random missingness ([supplementary Figs. I and II](#)). Therefore, we excluded patients with missing data and did a complete case analysis.

Statistical analysis

For the descriptive analysis of the association between deprivation and patient/surgical characteristics, we used the Analysis of Variance (ANOVA (t-test)) and chi-squared test.

Multivariable linear regression models were used to estimate the association of deprivation with preoperative, 12-month follow-up, and change score between these measurements, expressed with the EQ-5D index and OHS/OKS. The least deprived quintile was used as the reference category. The coefficients of the change score analysis reflect differences in mean change scores by deprivation quintiles, which we refer to as the “mean change” henceforth. Analyses were repeated with adjustments for sex, age, BMI, ASA score, Charnley score, and type of hospital. Age and sex were regarded as potential confounders, as their relation with arthroplasty outcomes has been found consistently, and they were unlikely to act as intermediate variables in the studied association.^{27,28} BMI, ASA score, Charnley score, and the type of hospital may act as confounders and intermediate variables.^{29,30} To help assess clinical relevance, the coefficients were compared with coefficients of other included variables in the analyses. The full models are included in [supplementary file 1, Tables 1–4](#).

To analyze the effect of the preoperative score on the mean change, separately from the role of deprivation, patients were stratified according to the preoperative score in quintiles. Subsequently, we present the mean change for each preoperative quintile according to the deprivation indicator. Confounding is regarded to be present if deprivation is associated with the preoperative score and if, within the separate preoperative strata, deprivation influences the mean change.

We calculated concentration indices, a bivariate quantity which relates the inequality in outcomes (here: PROMs) to the ranking of the individual's SES in the entire population.³¹ As the polarity of the outcome and its scale impacts the computed concentration index, we employed Erreyger's standardization for convenience of interpretation and to enable comparisons between results obtained from different PROMs.^{32,33} The index range is –1.0 to +1.0, where a positive value indicates that better health is concentrated among higher-ranked

individuals. Zero represents perfect equality. More details on the used formulas are included in [supplementary file II](#).

The concentration index was ‘decomposed’ to identify what percentage particular variables contribute to the observed inequality.^{32,34} This standard technique uses a multivariable linear regression model to determine the sensitivity of each variable to the outcome. The relative (percentage) contribution of each variable to the concentration index is the product of its sensitivity to the outcome and the degree of socio-economic inequality in the variable of interest. Similarly, relative positive and negative percentages reflect an increase and decrease respectively in overall inequalities. Zero means no contribution to inequality. The same variables were used as in the regression analysis; of particular interest were the variables which might act as confounders and intermediates.

All statistical analyses were performed in Stata (version 17.0). Coefficients and indices are presented with 95% confidence intervals (95% CIs). A p-value < 0.05 was considered significant. We explored the potential presence of response selection by comparing differences in patient characteristics by deprivation when including non-responders to PROMs. We also checked results in several patient respondent groups: respondents with preoperative and 3-/6-month PROMs, respondents with preoperative PROMs regardless of having other measurements, and respondents with 12-month follow-up PROMs regardless of having other measurements. As results were nearly identical to primary analyses, these were not separately presented ([supplementary file I, Tables 1–5](#)).

Results

Descriptive analysis

Data from 44,732 THA and 30,756 TKA arthroplasty patients met our inclusion criteria ([Fig. 1](#)). In both THA and TKA patients, 89% had complete EQ-5D and OHS/OKS response, and for 11%, either was missing.

Most arthroplasty patients were female (THA 63%, TKA 61%). The most deprived THA patients were on average 1 year older than the least deprived patients (69.7, SD 9.5 vs 68.6, SD 9.5); this difference

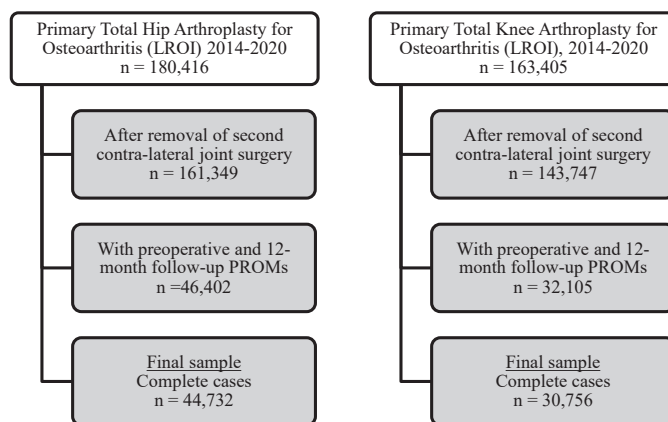


Fig. 1

Inclusion flowchart of patients with PROMs.

	Q1 (most depr.)	Q2-4 (med. depr.) ^a	Q5 (least depr.)	p-value
<i>Total</i>	8,522 (19)	28,409 (64)	7,801 (17)	
<i>Age, mean (SD)</i>	69.7 (9.5)	68.9 (9.3)	68.6 (9.5)	< 0.001
<i>BMI^b, mean (SD)</i>	27.8 (4.5)	27.4 (4.4)	26.7 (4.2)	< 0.001
<i>Sex, n (%)</i>				
Female	5,560 (65)	17,844 (63)	4,927 (63)	< 0.001
<i>ASA^c, n (%)</i>				
I	1,248 (15)	5,399 (19)	1,699 (22)	< 0.001
II	5,491 (64)	18,313 (65)	4,952 (64)	
III-IV	1,783 (21)	4,697 (17)	1,150 (15)	
<i>Charnley, n (%)</i>				
A	4,168 (49)	13,652 (48)	3,930 (50)	< 0.001
B1	2,804 (33)	9,851 (35)	2,640 (39)	
B2	1,253 (15)	4,010 (14)	1,077 (14)	
C	297 (4)	896 (3)	154 (2)	
<i>Smoking, n (%)</i>				
Yes	883 (10)	2,593 (9)	602 (8)	< 0.001
<i>Previous surgery of the joint, n (%)</i>				
Yes	155 (2)	458 (2)	145 (2)	0.201
<i>Type of hospital, n (%)</i>				
Private Hospital	463 (5)	2,503 (9)	830 (11)	< 0.001
General Hospital	7,805 (92)	25,503 (90)	6,887 (88)	
University Hospital	254 (3)	403 (1)	84 (1)	
<i>Fixation, n (%)</i>				
Uncemented	5,349 (63)	20,096 (71)	5,864 (75)	< 0.001
Cemented	2,387 (28)	5,779 (20)	1,393 (18)	
Hybrid	786 (9)	2,534 (9)	544 (7)	
<i>Approach, n (%)</i>				
Anterior	2,648 (31)	10,041 (35)	3,420 (44)	< 0.001
Anterolateral	409 (5)	1,223 (4)	271 (4)	
Direct Lateral	556 (7)	1,676 (6)	520 (7)	
Posterolateral	4,837 (57)	15,122 (53)	3,517 (45)	
Other	72 (1)	347 (1)	73 (1)	
<i>EQ-5D index, mean (SD)</i>				
Preoperative	0.54 (0.28)	0.57 (0.27)	0.59 (0.26)	
12-month follow-up	0.85 (0.20)	0.87 (0.18)	0.88 (0.17)	
Mean change	0.30 (0.30)	0.29 (0.28)	0.28 (0.28)	
<i>OHS/OKS, mean (SD)</i>				
Preoperative	22.19 (8.62)	23.19 (8.32)	24.12 (8.35)	
12-month follow-up	41.54 (7.37)	42.29 (7.18)	42.55 (7.25)	
Mean change	19.39 (9.76)	19.06 (9.69)	18.42 (9.83)	

Only patients with complete patient and surgical characteristics were included. ANOVA (t-test) and chi-squared tests were performed for continuous and categorical variables respectively.

^a For convenience purposes the middle 3 deprivation quintiles [Q2, 3, 4] were collapsed under medium socio-economic status (SES).

^b BMI = Body Mass Index.

^c ASA = American Society of Anesthesiology score.

Table 1A

Osteoarthritis and Cartilage

Demographics of hip arthroplasty patients with PROMs by socio-economic status.

	Q1 (most depr.)	Q2-4 (med. depr.) ^a	Q5 (least depr.)	p-value
<i>Total</i>	6,497 (21)	19,689 (64)	4,570 (15)	
<i>Age, mean (SD)</i>	68.7 (8.7)	68.3 (8.5)	69.0 (8.4)	< 0.001
<i>BMI^b, mean (SD)</i>	30.1 (5.0)	29.4 (4.8)	28.9 (4.6)	< 0.001
<i>Sex, n (%)</i>				
Female	4,096 (63)	11,878 (60)	2,769 (61)	< 0.001
<i>ASA^c, n (%)</i>				
I	655 (10)	2,716 (14)	682 (15)	< 0.001
II	4,288 (66)	13,187 (67)	3,066 (67)	
III-IV	1,554 (24)	3,786 (19)	822 (18)	
<i>Charnley, n (%)</i>				
A	3,138 (48)	9,386 (48)	2,151 (47)	0.072
B1	2,370 (36)	7,391 (38)	1,756 (38)	
B2	761 (12)	2,174 (11)	525 (12)	
C	228 (4)	738 (4)	138 (3)	
<i>Smoking, n (%)</i>				
Yes	594 (9)	1,498 (8)	284 (6)	< 0.001
<i>Previous surgery of the joint, n (%)</i>				
Yes	1,910 (29)	6,267 (32)	1,328 (29)	< 0.001
<i>Type of hospital, n (%)</i>				
Private Hospital	417 (6)	2,011 (10)	490 (11)	< 0.001
General Hospital	5,914 (91)	17,473 (89)	4,030 (88)	
University Hospital	166 (3)	205 (1)	50 (1)	
<i>Fixation, n (%)</i>				
Uncemented	210 (3)	503 (3)	312 (7)	< 0.001
Cemented	6,056 (93)	18,725 (95)	4,123 (90)	
Hybrid	231 (4)	461 (2)	135 (3)	
<i>Approach, n (%)</i>				
Medial parapatellar	6,365 (98)	19,065 (97)	4,378 (96)	< 0.001
Other	132 (2)	624 (3)	192 (4)	
<i>EQ-5D index, mean (SD)</i>				
Preoperative	0.58 (0.27)	0.61 (0.25)	0.64 (0.24)	
12-month follow-up	0.82 (0.21)	0.84 (0.19)	0.85 (0.18)	
Mean change	0.24 (0.28)	0.23 (0.27)	0.22 (0.26)	
<i>OHS/OKS, mean (SD)</i>				
Preoperative	22.29 (7.49)	23.50 (7.31)	24.28 (7.50)	
12-month follow-up	37.94 (8.60)	39.12 (7.89)	39.57 (7.63)	
Mean change	15.56 (9.07)	15.60 (8.86)	15.29 (8.90)	

Only patients with complete patient and surgical characteristics were included. ANOVA (t-test) and chi-squared tests were performed for continuous and categorical variables respectively.

^a For convenience purposes the middle 3 deprivation quintiles [Q2, 3, 4] were collapsed under medium socio-economic status.

^b BMI = Body Mass Index.

^c ASA = American Society of Anesthesiology score.

Table 1B

Osteoarthritis and Cartilage

Demographics of knee arthroplasty patients with PROMs by socio-economic status.

was not present in TKA patients (68.7, SD 8.7 vs 69.0, SD 8.4). In both THA and TKA patients, deprivation was associated with higher BMI and ASA scores and undergoing surgery in non-private hospitals. In THA patients, the deprived patients received no cementation compared to cementation more often than affluent patients (most deprived: 63% vs 28%; least deprived: 75% vs 18%). Similarly, surgery was mainly performed via the posterolateral compared to the anterior approach (most deprived: 57% vs 31%, least deprived: 45% vs 44%) (Tables 1A and 1B).

The most deprived patients had slightly lower PRO response rates than medium (quintile 2–4) and least (quintile 5) deprived patients, implying that the complete LROI dataset shows a slightly higher

prevalence of THA and TKA among the deprived. The abovementioned deprivation patterns among responders did not change if non-responders to PROMs were added (supplementary file 1, Table 6).

Epidemiological analysis of deprivation

The outcome contrast between most and least deprived quintiles was the largest preoperative, in both THA and TKA patients, with similar magnitude. These differences were slightly attenuated after adjustment for patient characteristics. The most deprived THA patients had 0.03 (95% CI: 0.02, 0.04) lower EQ-5D index values and 1.26 (95% CI: 0.99, 1.52) lower OHS scores. In TKA patients, this difference was 0.04 (95% CI: 0.03, 0.05) on the EQ-5D and 1.38 (95% CI: 1.09, 1.66) on the OKS. The difference between most and least deprived quintiles halved at 12 months follow-up. The most

	Preoperative		12-month follow-up		Mean change ^a	
	Unadjusted Difference (95% CI)	Adjusted Difference (95% CI)	Unadjusted Difference (95% CI)	Adjusted Difference (95% CI)	Unadjusted Difference (95% CI)	Adjusted Difference (95% CI)
THA, EQ-5D index <i>n</i> = 39,744						
5 (least deprived)	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
4	-0.01 (-0.02, 0.00)	-0.01 (-0.02, 0.00)	0.00 (-0.01, 0.00)	0.00 (-0.01, 0.00)	0.01 (0.00, 0.02)	0.01 (0.00, 0.02)
3	-0.02 (-0.03, -0.01)	-0.02 (-0.02, -0.01)	-0.01 (-0.02, 0.00)	-0.01 (-0.01, 0.00)	0.01 (0.00, 0.02)	0.01 (0.00, 0.02)
2	-0.03 (-0.04, -0.02)	-0.02 (-0.03, -0.01)	-0.01 (-0.02, -0.01)	-0.01 (-0.01, 0.00)	0.02 (0.01, 0.03)	0.01 (0.01, 0.02)
1 (most deprived)	-0.05 (-0.06, -0.04)	-0.03 (-0.04, -0.02)	-0.03 (-0.03, -0.02)	-0.02 (-0.02, -0.01)	0.02 (0.01, 0.03)	0.02 (0.01, 0.03)
OHS <i>n</i> = 39,991						
5 (least deprived)	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
4	-0.47 (-0.74, -0.20)	-0.38 (-0.64, -0.12)	-0.05 (-0.29, 0.18)	0.03 (-0.20, 0.26)	0.42 (0.10, 0.74)	0.41 (0.09, 0.73)
3	-0.86 (-1.13, -0.60)	-0.64 (-0.9, -0.39)	-0.28 (-0.51, -0.05)	-0.09 (-0.32, 0.13)	0.58 (0.28, 0.89)	0.55 (0.24, 0.86)
2	-1.26 (-1.52, -1.01)	-0.92 (-1.17, -0.67)	-0.39 (-0.62, -0.17)	-0.10 (-0.32, 0.11)	0.87 (0.57, 1.18)	0.82 (0.51, 1.12)
1 (most deprived)	-1.95 (-2.23, -1.68)	-1.26 (-1.52, -0.99)	-0.98 (-1.21, -0.74)	-0.42 (-0.65, -0.19)	0.98 (0.66, 1.30)	0.84 (0.52, 1.16)
TKA, EQ-5D index <i>n</i> = 27,391						
5 (least deprived)	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
4	-0.01 (-0.02, 0.00)	-0.01 (-0.02, 0.00)	0.00 (-0.01, 0.01)	0.00 (-0.01, 0.01)	0.01 (0.00, 0.02)	0.01 (0.00, 0.02)
3	-0.02 (-0.03, -0.01)	-0.02 (-0.03, -0.01)	-0.01 (-0.01, 0.00)	-0.01 (-0.01, 0.00)	0.02 (0.01, 0.03)	0.02 (0.00, 0.03)
2	-0.03 (-0.04, -0.02)	-0.03 (-0.04, -0.02)	-0.01 (-0.02, -0.01)	-0.01 (-0.02, 0.00)	0.02 (0.01, 0.03)	0.02 (0.01, 0.03)
1 (most deprived)	-0.06 (-0.07, -0.05)	-0.04 (-0.05, -0.03)	-0.03 (-0.04, -0.02)	-0.02 (-0.03, -0.01)	0.03 (0.02, 0.04)	0.02 (0.01, 0.03)
OKS <i>n</i> = 27,418						
5 (least deprived)	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>	<i>ref</i>
4	-0.32 (-0.63, -0.01)	-0.27 (-0.57, 0.02)	-0.17 (-0.51, 0.17)	-0.15 (-0.48, 0.17)	0.15 (-0.22, 0.53)	0.12 (-0.25, 0.49)
3	-0.78 (-1.07, -0.48)	-0.66 (-0.94, -0.38)	-0.33 (-0.65, -0.01)	-0.24 (-0.55, 0.07)	0.45 (0.09, 0.80)	0.42 (0.06, 0.77)
2	-1.08 (-1.37, -0.79)	-0.81 (-1.09, -0.54)	-0.78 (-1.09, -0.47)	-0.54 (-0.84, -0.24)	0.30 (-0.05, 0.65)	0.27 (-0.07, 0.62)
1 (most deprived)	-1.94 (-2.24, -1.65)	-1.38 (-1.66, -1.09)	-1.67 (-1.99, -1.34)	-1.14 (-1.46, -0.83)	0.27 (-0.09, 0.64)	0.23 (-0.13, 0.60)

Linear regression was used to analyse difference between the socio-economic status quintiles in patients with preoperative and 12-month follow-up PROMs. The least deprived category was used as reference. Adjustments were made for sex, age, BMI, American Society of Anesthesiology score, Charnley score, and type of hospital. Coefficients are reported with the respective 95% CIs.

^a The mean change is based on the difference (change) score between the 12-month follow-up and preoperative score.

Table 2

Socio-economic gradient in EQ-5D index and OHS/OKS scores.

Osteoarthritis and Cartilage

deprived THA patients had 0.02 (95% CI: 0.01, 0.02) lower EQ-5D values and 0.42 (95% CI: 0.19, 0.65) lower OHS scores. Differences in EQ-5D (0.02 (95% CI: 0.01, 0.03)) were similar in TKA patients but were larger on the OKS (1.14 (95% CI: 0.83, 1.46)) (Table 2).

The mean change was higher in the most deprived patients. Adjustments for patient characteristics did not affect this. The most deprived THA patients had 0.02 (95% CI: 0.01, 0.03) higher EQ-5D and 0.84 (95% CI: 0.52, 1.16) higher OHS mean change scores. Differences in the EQ-5D were similar in TKA patients, however, the OKS showed no significant deprivation effect on the mean change. The most deprived TKA patients had 0.02 (95% CI: 0.01, 0.03) higher EQ-5D and 0.23 (95% CI: -0.13, 0.60) higher OKS mean change.

The preoperative, 12-month follow-up and mean change regression coefficients assigned to the most deprived group generally exceeded the coefficients assigned to Charnley score “C” (supplementary file 1, Tables 1–4). This was not consistently the case for other variables included in the analyses.

Confounding effects of deprivation

Through stratification, we evaluated whether the lower preoperative scores in the deprived patients confounded the finding that deprived patients experience a larger mean change. We stratified patients according to the preoperative score (in quintiles) and deprivation. Subsequently, within each preoperative stratum, we calculated the mean change for each deprivation quintile. Independent from deprivation, a lower preoperative state in the case of THA and TKA led to a larger mean change. The EQ-5D and OHS/OKS mean change were lower in the most compared to the least deprived quintile of patients for all preoperative scores. With

increasing preoperative scores, this difference in mean change of both outcomes decreased. While the pattern was identical, differences were larger in TKA compared to THA patients (Fig. 2).

Economic inequality analysis

The sign of the concentration index indicates the direction of the association between SES and outcomes, whilst the magnitude reflects both the strength of the relationship and variability in the outcome. Positive (negative) indices indicate that outcomes are more centered among the affluent (deprived). The concentration indices also indicated outcome inequalities: cross-sectional outcomes were more centered among the affluent, while the mean change generally was centered among the deprived. In THA and TKA patients, preoperative concentration indices calculated on the EQ-5D and OHS/OKS were +0.03, and they decreased slightly at 12-month follow-up to +0.02, except for the OKS which remained at +0.03. The concentration indices of the mean change were -0.01 in all outcomes except for the OKS, which was not significantly different from zero. The 95% CIs were narrow for all indices, with a maximum range of 0.01 (Table 3).

Economic decomposition analysis

Subsequently, we decomposed the concentration indices to identify the relative contribution of each variable on the observed inequality and what remaining inequalities can be attributed to SES. The relative contributions of entered variables were similar for the EQ-5D index and Oxford set (supplementary file 1, Tables 6–10). In THA and TKA patients, the entered variables explained 24–45% of the

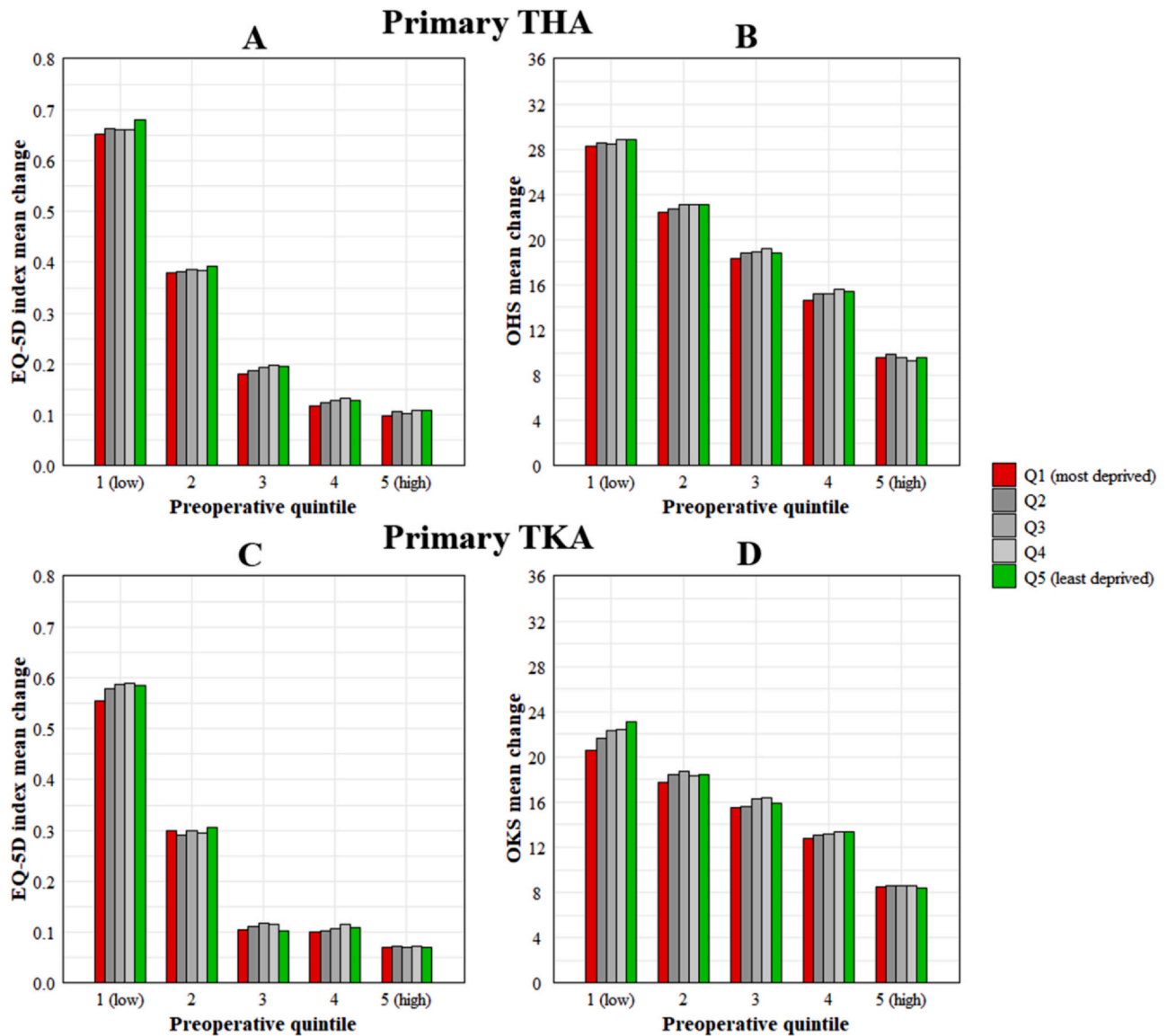


Fig. 2

Stratification of mean change scores according to the deprivation quintiles, preoperative EQ-5D index, and OHS/OKS quintiles in hip (A, B) and knee (C, D) patients.

observed inequality in the cross-sectional (preoperative, 12-month follow-up) EQ-5D index, while the rest was attributed to SES. Variables with relatively large contributions were ASA III–IV (9–16%) and the lowest BMI quintile (8–9%). The other potential confounding/intermediate variables (type of hospital, Charnley score) had negligible contributions. The remaining SES inequalities were explained mainly by the most deprived (41–63%) and 2nd most deprived quintiles (11–19%).

As with the linear regression model, the explanatory variables accounted for a small part of the observed inequality (15–23%) on the mean change. The second-largest contributor was the lowest BMI quintile, explaining 9% in THA and TKA patients. Other variables had negligible contributions. The remaining SES inequalities were mostly explained by the most deprived (67–77%) and 2nd most deprived quintiles (25–30%) (Fig. 3).

Discussion

In this study, we established the presence of systematic socioeconomic health inequalities in Dutch primary THA and TKA patients using two complementary techniques from epidemiological and economic origin. Overall, results among THA and TKA patients were strikingly similar. Deprivation was strongly associated with poorer health prior to and, although to a lesser extent, after surgery. After accounting for the confounding effect of the preoperative score, deprivation was also associated with a lower mean change. The observed inequalities were only in part explained by patient and surgical characteristics in epidemiological and economic analysis. Interestingly, in the epidemiological analysis, the differences between the lowest and highest deprivation quintile superseded the Charnley score both before and after surgery, which are routinely

Concentration indices	
Primary THA	
Preoperative	
EQ-5D index	0.03 (0.03, 0.03)
OHS	0.03 (0.03, 0.04)
12-month follow-up	
EQ-5D index	0.02 (0.01, 0.02)
OHS	0.02 (0.01, 0.02)
Mean change ^a	
EQ-5D index	-0.01 (-0.01, 0.00)
OHS	-0.01 (-0.01, -0.01)
Primary TKA	
Preoperative	
EQ-5D-3L index	0.03 (0.03, 0.04)
OKS	0.03 (0.03, 0.04)
12-month follow-up	
EQ-5D index	0.02 (0.02, 0.02)
OKS	0.03 (0.02, 0.03)
Mean change ^a	
EQ-5D index	-0.01 (-0.01, -0.01)
OKS	0.00 (-0.01, 0.00)

Concentration indices were calculated in patients with preoperative and 12-month follow-up PROMs. Indices are reported with the respective 95% CIs.
^a The mean change is based on the difference (change) score between the 12-month follow-up and preoperative score.

Table 3 Osteoarthritis and Cartilage
Size of inequalities measured with concentration indices in EQ-5D index and OHS/OKS scores.

taken into account (supplementary file 1, Tables 1–4). Within the medical domain, no examples currently exist as a reference for the size of the inequalities measured with the concentration index; our results are the first and may therefore serve as a benchmark.

The association of deprivation with worse PROMs before and after arthroplasty is aligned with previous studies.^{8–16} However, to our knowledge, only Clement et al.⁸ revealed the double mechanism of deprivation in affecting preoperative health and health change. This study however only had a small sample size and collected data from a single medical center, resulting in limitations in terms of generalizability.

Preoperative inequalities

Preoperative outcome inequality may depend on several independent mechanisms. The first mechanism is selection: different thresholds of pain and dysfunction for surgery may be used by the provider and patient.³⁵ Surgeons may apply more stringent criteria in deprived patients to compensate for the higher prevalence of patient characteristics impairing postoperative outcomes or causing complications. Selecting the most severe cases leads to a higher mean change, as our results confirm. Provider selection may also already occur at the referral stage by the general practitioner.^{36,37} Furthermore, deprived patients may delay seeking help, as they are more accepting of chronic pain and functional limitations compared to non-deprived patients.³⁸ Neuburger et al.¹⁵ confirmed this and reported more and a longer duration of symptoms at the time of surgery in deprived THA and TKA patients in the United Kingdom.

Additionally, deprived patients receive fewer arthroplasties relative to the number of patients in need.^{39,40} This could potentially be explained by access barriers posed by high deductibles, which also applies to the Netherlands. For example, high deductibles are associated with decreased use of psychotherapy in low-income adults.⁴¹ Far less research has been conducted on other factors that may influence access, such as medical knowledge, cultural beliefs,

travel distance, avoidance of seeking care, and access stops when hospitals run out of planned production volume.⁴²

Postoperative inequalities

The recovery disadvantage in the deprived, whilst accounting for preoperative health status, must depend on other mechanisms. On the patient side, we think of risk factors such as higher BMI and ASA scores, which are more prevalent in the most deprived patients.^{43,44} The decomposition analysis showed that these factors explained part of the observed health disadvantage. However, after adjusting for these factors, the majority of the deprivation effect persisted in both epidemiological and economic analyses, which has also been observed in other studies.^{8,11,15,16}

Several clinical pathways may be responsible for this effect, and could be modifiable in order to reduce health inequality. A specific physician-related factor may be the surgical strategy. We observed that the cementation strategy (cemented vs. uncemented) and surgical approach (posterolateral vs. anterior) in THA patients was different according to deprivation status. At the time of drafting the present study, Dutch orthopedic guidelines consider both approaches and cementation strategies equal.⁴⁵ An explanation may be that the least deprived actively search for surgeons using potentially superior surgical techniques, such as the anterior approach. However, it seems unlikely that this mechanism alone is responsible for the reported difference. We cannot rule out physician-induced inequalities given the substantial surgical approach differences and the strong deprivation association. Unfortunately, data to analyze at the level of regions, hospitals or physician groups was currently unavailable which may have revealed the role of being treated in certain hospitals.

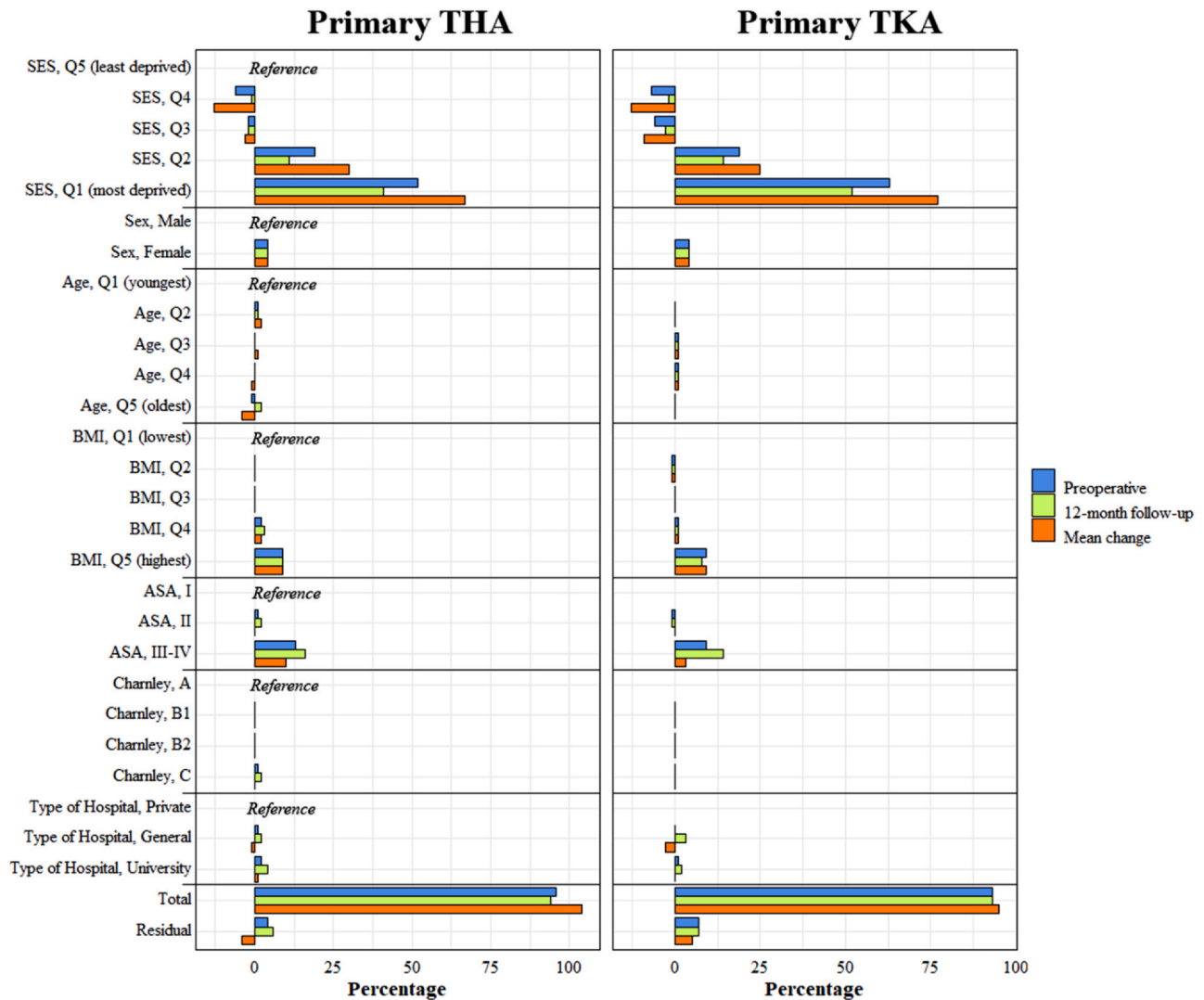
Next, hospital quality variations may occur. This was observed at Dutch obstetrics departments, where considerable inter-hospital variation in inequality was observed.⁴⁶ A possible explanation is that some hospitals adhere more strictly to protocols, which in orthopedics may include Enhance Recovery After Surgery programs.⁴⁷ Also, hospitals providing services to a relatively high proportion of deprived patients may provide more equitable care.

Finally, we found slightly larger inequalities in TKA compared to THA patients during follow-up with OKS/OHS that were not found with EQ-5D. We assume the EQ-5D and OKS/OHS have a different ‘target’ area: the OKS/OHS are more sensitive to capture problems in relatively healthier patients.¹⁹ A previous study similarly found lower improvements for education level on role-physical functioning, general health (SF-36) and the Physical Component Summary scale in TKA but not in THA patients.¹⁴ This might be because TKA patients require more rehabilitation than THA patients, which is subject to lower performance as it depends on instruction and self-care.

Besides the ‘true’ effects of deprivation on reported health, we should be aware of differences in response attitude. Previously, more educated, older Europeans were more likely to rate a given health state negatively.⁴⁸ This emphasizes the potential of systematically lower cross-sectional PROM scores by the more affluent and in return, attenuation of inequality effects. Response shift, which is a change in response attitude over time, could influence the change scores.⁴⁹ It is possible that a life-changing intervention, such as arthroplasty, has a different impact on values and priorities in deprived compared to affluent patients, which may result in a different self-evaluation of health at follow-up.

Concentration indices

Overall, the epidemiological measures and the concentration indices showed similar deprivation effects. The concentration indices emphasized that inequalities were present over the entire

**Fig. 3**

Decomposition of inequalities in the EQ-5D index. Percentages represent the relative contribution of the entered variable on the total amount of inequalities measured with the concentration indices. The category with the least expected contribution was used as the reference category. The residual is the amount of socioeconomic inequality not explained by the model.

socioeconomic range and provide an indication of the magnitude of inequalities. No obvious comparator currently exists within the medical domain. Adding such an economic measure could be valuable for registry purposes, as it facilitates the comparison of inequalities in different outcomes and between providers and health systems.

Strengths and limitations

A strength of the present study is the use of national registry data, which provides generalizable results for Dutch THA and TKA patients. Furthermore, longitudinal data was employed (before surgery to 12 months follow-up). The data was analyzed using regression models in combination with concentration indices, of which the latter has not been applied to a medical population before. A limitation of this study is the exclusion of non-responders, those with only preoperative or 12-month follow-up data, and patients with

missing data. However, several sensitivity analyses were conducted, leading to findings similar to the main analyses. A second limitation is that socio-economic status was measured with area-based information, which may not always accurately reflect SES at the individual level. However, area-based information generally leads to an underestimation of the associations between individual information of SES and outcomes.^{50,51} We did not have hospital data and were therefore unable to analyze their role in the observed inequalities. Lastly, the LROI does not collect data on ethnicity, which often is an important determinant of health inequalities, and might associate with observed differences according to SES.

Conclusion

The most deprived quintile of THA and TKA patients for the indication osteoarthritis had the worst EQ-5D index and OHS/OKS scores before and after surgery, which persisted into recovery. The

observed inequalities were similar in size compared to having Charnley “C”, i.e. multiple joints affected by osteoarthritis or severely impaired quality of life due to the disease. Concentration index analysis showed that the inequality pattern exists across the full range of SES. The addition of this analysis may provide a benchmark of the magnitude of inequalities in orthopedic surgery and allows comparison of inequalities across different outcomes such as revision risk and mortality. These analytical tools, especially if hospital characteristics are added, may guide quality improvement initiatives aimed at reducing inequalities.

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CRedit authorship contribution statement

Study Conception and design: JB, MR, JV, GB. Analysis and interpretation of the data: JB, MR, JV, MJ, GB. Drafting of the article: JB, GB. Critical revision of the article for important intellectual content: JB, MR, JV, LS, MJ, GB. Final approval of the article: JB, MR, JV, LS, MJ, GB. Statistical expertise: JB, MJ, and GB. Obtaining funding: JB, MR, JV, GB. Collection and assembly of data: JB. Data acquisition: JB, MR, JV, LS, MJ, and GB; JB and GB take responsibility for the integrity of the work as a whole.

Data availability

By the terms of data usage from the Dutch Arthroplasty Registry, no additional data can be made available by the authors.

Declaration of Competing Interest

JB, MR, JV, and MJ declare they had financial support from the EuroQol Research Foundation for the submitted work. LV and GB declare to have no conflicts of interest.

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None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.joca.2023.07.004](https://doi.org/10.1016/j.joca.2023.07.004).

References

- Mackenbach J. Health inequalities: Europe in profile; 2006.
- O'Neill J, Tabish H, Welch V, Petticrew M, Pottie K, Clarke M, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *J Clin Epidemiol* 2014;67:56–64.
- Marmot M. Social determinants of health inequalities. *Lancet* 2005;365:1099–104.
- Phelan JC, Link BG, Tehranifar P. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *J Health Soc Behav* 2010;51(Suppl: S28–S40).
- Spronk I, Haagsma JA, Lubetkin EI, Polinder S, Janssen MF, Bonsel GJ. Health inequality analysis in Europe: exploring the potential of the EQ-5D as outcome. *Front Public Health* 2021;9, 744405.
- The Organisation for Economic Co-operation and Development (OECD) health at a glance 2019.
- Kamaruzaman H, Kinghorn P, Oppong R. Cost-effectiveness of surgical interventions for the management of osteoarthritis: a systematic review of the literature. *BMC Musculoskelet Disord* 2017;18:183.
- Clement ND, Jenkins PJ, MacDonald D, Nie YX, Patton JT, Breusch SJ, et al. Socioeconomic status affects the Oxford knee score and short-form 12 score following total knee replacement. *Bone Jt J* 2013(95-B):52–8.
- Clement ND, Muzammil A, Macdonald D, Howie CR, Biant LC. Socioeconomic status affects the early outcome of total hip replacement. *J Bone Jt Surg Br* 2011;93:464–9.
- Dowsey MM, Nikpour M, Choong PF. Outcomes following large joint arthroplasty: does socio-economic status matter? *BMC Musculoskelet Disord* 2014;15:148.
- Gonzalez AI, Nguyen U-SDT, Franklin P, Barea C, Hannouche D, Lübbecke A. 1-Year trajectories of patients undergoing primary total hip arthroplasty: patient reported outcomes and resource needs according to education level. *BMC Musculoskelet Disord* 2022;23:84.
- Goodman SM, Mandl LA, Parks ML, Zhang M, McHugh KR, Lee YY, et al. Disparities in TKA outcomes: census tract data show interactions between race and poverty. *Clin Orthop Relat Res* 2016;474:1986–95.
- Jenkins PJ, Perry PR, Yew Ng C, Ballantyne JA. Deprivation influences the functional outcome from total hip arthroplasty. *Surgeon* 2009;7:351–6.
- Keurentjes JC, Blane D, Bartley M, Keurentjes JJ, Fiocco M, Nelissen RG. Socio-economic position has no effect on improvement in health-related quality of life and patient satisfaction in total hip and knee replacement: a cohort study. *PLoS One* 2013;8, e56785.
- Neuburger J, Hutchings A, Allwood D, Black N, van der Meulen JH. Sociodemographic differences in the severity and duration of disease amongst patients undergoing hip or knee replacement surgery. *J Public Health* 2012;34:421–9.
- Neuburger J, Hutchings A, Black N, van der Meulen JH. Socioeconomic differences in patient-reported outcomes after a hip or knee replacement in the English National Health Service. *J Public Health* 2012;35:115–24.
- Mackenbach JP, Kunst AE. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Soc Sci Med* 1997;44:757–71.
- Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. *Soc Sci Med* 1991;33:545–57.
- Szende AJB, Cabases J (Eds.). Self-reported population health: an international perspective based on EQ-5D; 2014.
- van Steenberghe LN, Denissen GAW, Spooren A, van Rooden SM, van Oosterhout FJ, Morrenhof JW, et al. More than 95% completeness of reported procedures in the population-based Dutch Arthroplasty Register. *Acta Orthop* 2015;86:498–505.
- Dutch Orthopaedic National Quality Registry (LROI) Annual report 2021. Available at: (www.lroi-rapportage.nl).
- Charnley J. The long-term results of low-friction arthroplasty of the hip performed as a primary intervention. *J Bone Jt Surg Br* 1972;54:61–76.
- Dripps RD. New classification of physical status. *Anesthesiology* 1963;24:111.
- Dutch Institute of Social Research (Sociaal Cultureel Planbureau (SCP)) Socioeconomic status score per postal code area, accessible by request. (<https://bronnen.zorggegevens.nl/Bron?naam=Sociaal-Economische-Status-per-postcodegebied>).
- World Health Organisation (WHO) handbook on health inequality monitoring: with a special focus on low- and middle-income countries; 2013. Available at: (https://apps.who.int/iris/bitstream/handle/10665/85345/9789241548632_eng.pdf?sequence=1).
- Lamers LM, McDonnell J, Stalmeier PF, Krabbe PF, Busschbach JJ. The Dutch tariff: results and arguments for an effective design for national EQ-5D valuation studies. *Health Econ* 2006;15:1121–32.
- Peters RM, van Steenberghe LN, Stewart RE, Stevens M, Rijk PC, Bulstra SK, et al. Which patients improve most after total hip arthroplasty? Influence of patient characteristics on patient-reported outcome measures of 22,357 total hip arthroplasties in the Dutch Arthroplasty Register. *Hip Int* 2021;31:593–602.
- Tolk JJ, Waarsing JEH, Janssen RPA, van Steenberghe LN, Bierma-Zeinstra SMA, Reijman M. Development of preoperative prediction models for pain and functional outcome after total knee arthroplasty using The Dutch Arthroplasty Register Data. *J Arthroplast* 2020;35(690–698), e692.
- Feldman CH, Dong Y, Katz JN, Donnell-Fink LA, Losina E. Association between socioeconomic status and pain, function and pain catastrophizing at presentation for total knee arthroplasty. *BMC Musculoskelet Disord* 2015;16:18.
- Hoelen T-CA, Schotanus M, van Kuijk S, Bastiaenen C, Boonen B, Most J. The relation between socioeconomic status and patient symptoms before and one year after lower extremity arthroplasty. *J Orthop* 2023;39:11–7.
- Kakwani N, Wagstaff A, van Doorslaer E. Socioeconomic inequalities in health: measurement, computation, and statistical inference. *J Econom* 1997;77:87–103.
- Erreygers G. Correcting the concentration index. *J Health Econ* 2009;28:504–15.
- Wagstaff A. The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. *Health Econ* 2005;14:429–32.
- Wagstaff A, van Doorslaer E, Watanabe N. On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. *J Econom* 2003;112:207–23.
- Gademag MGJ, Hofstede SN, Vliet Vlieland TPM, Nelissen RGH, Marang-van de Mheen PJ. Indication criteria for total hip or knee arthroplasty in osteoarthritis: a state-of-the-science overview. *BMC Musculoskelet Disord* 2016;17, 463–463.
- Reinhöfer KE, Dieppe P, Stürmer T, Gröber-Grätz D, Flören M, Günther KP, et al. Indications for total hip replacement: comparison of assessments of orthopaedic surgeons and referring physicians. *Ann Rheum Dis* 2006;65:1346–50.
- Jinks C, Vohora K, Young J, Handy J, Porcheret M, Jordan KP. Inequalities in primary care management of knee pain and disability in older adults: an observational cohort study. *Rheumatology* 2011;50:1869–78.

38. Delpierre C, Lauwers-Cances V, Datta GD, Lang T, Berkman L. Using self-rated health for analysing social inequalities in health: a risk for underestimating the gap between socioeconomic groups? *J Epidemiol Community Health* 2009;63:426–32.
39. Edwards NM, Varnum C, Overgaard S, Pedersen AB. The impact of socioeconomic status on the utilization of total hip arthroplasty during 1995–2017: 104,055 THA cases and 520,275 population controls from national databases in Denmark. *Acta Orthop* 2021;92:29–35.
40. Judge A, Welton NJ, Sandhu J, Ben-Shlomo Y. Equity in access to total joint replacement of the hip and knee in England: cross sectional study. *BMJ* 2010;341:c4092.
41. Lopes FV, Riumallo Herl CJ, Mackenbach JP, Van, Ourti T. Patient cost-sharing, mental health care and inequalities: a population-based natural experiment at the transition to adulthood. *Soc Sci Med* 2022;296, 114741.
42. Oliver A, Mossialos E. Equity of access to health care: outlining the foundations for action. *J Epidemiol Community Health* 2004;58:655–8.
43. Boyce L, Prasad A, Barrett M, Dawson-Bowling S, Millington S, Hanna SA, et al. The outcomes of total knee arthroplasty in morbidly obese patients: a systematic review of the literature. *Arch Orthop Trauma Surg* 2019;139:553–60.
44. Hooper GJ, Rothwell AG, Hooper NM, Frampton C. The relationship between the American Society Of Anesthesiologists physical rating and outcome following total hip and knee arthroplasty: an analysis of the New Zealand Joint Registry. *J Bone Jt Surg Am* 2012;94:1065–70.
45. Dutch Orthopedic Society (NOV) 2022; 2022. Available at: <https://www.orthopeden.org/kwaliteit/kwaliteitsbeleid/richtlijnen>.
46. Poeran J, Borsboom GJ, de Graaf JP, Birnie E, Steegers EA, Bonsel GJ. Population attributable risks of patient, child and organizational risk factors for perinatal mortality in hospital births. *Matern Child Health J* 2015;19:764–75.
47. Frassanito L, Vergari A, Nestorini R, Cerulli G, Placella G, Pace V, et al. Enhanced recovery after surgery (ERAS) in hip and knee replacement surgery: description of a multidisciplinary program to improve management of the patients undergoing major orthopedic surgery. *Musculoskelet Surg* 2020;104:87–92.
48. d'Uva TB, O'Donnell O, van Doorslaer E. Differential health reporting by education level and its impact on the measurement of health inequalities among older Europeans. *Int J Epidemiol* 2008;37:1375–83.
49. Razmjou H, Yee A, Ford M, Finkelstein JA. Response shift in outcome assessment in patients undergoing total knee arthroplasty. *J Bone Jt Surg Am* 2006;88:2590–5.
50. Mesterton J, Willers C, Dahlström T, Rolfson O. Comparison of individual and neighbourhood socioeconomic status in case mix adjustment of hospital performance in primary total hip replacement in Sweden: a register-based study. *BMC Health Serv Res* 2020;20:645.
51. Subramanian SV, Chen JT, Rehkopf DH, Waterman PD, Krieger N. Comparing individual- and area-based socioeconomic measures for the surveillance of health disparities: a multilevel analysis of Massachusetts births, 1989–1991. *Am J Epidemiol* 2006;164:823–34.