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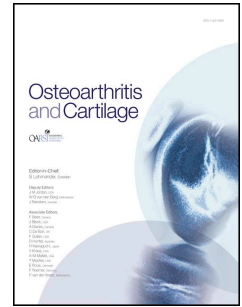


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Rates of hip and knee joint replacement amongst different ethnic groups in England:
An analysis of National Joint Registry data

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1 **Rates of hip and knee joint replacement amongst different ethnic**
2 **groups in England: An analysis of National Joint Registry data**

3
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27
28 **Key words:** Ethnicity; Hip replacement; Knee replacement; England

29
30 **Word count: 2,483 words**

31

32 **Abstract**

33 **Objective:** Despite a health care system that is free at the point of delivery, ethnic minorities
34 may not always get care equitable to that of White patients in England. We examined whether
35 ethnic differences exist in joint replacement rates and surgical practice in England.

36 **Design:** 373,613 hip and 428,936 knee National Joint Registry primary replacement patients
37 had coded ethnicity in Hospital Episode Statistics. Age and gender adjusted
38 observed/expected ratios of hip and knee replacements amongst ethnic groups were compared
39 using indirect standardisation. Associations between ethnic group and type of procedure were
40 explored and effects of demographic, clinical and hospital-related factors examined using
41 multivariable logistic regression.

42 **Results:** Adjusted standardised observed/expected ratios were substantially lower in Blacks
43 and Asians than Whites for hip replacement (Blacks 0.33 [95% CI, 0.31 to 0.35], Asians
44 0.20 [CI, 0.19 to 0.21]) and knee replacement (Blacks 0.64 [CI, 0.61 to 0.67], Asians 0.86
45 % [CI, 0.84 to 0.88]). Blacks were more likely to receive uncemented hip replacements
46 (Blacks 52%, Whites 37%, Asians 44%; $P < 0.001$). Black men and women aged < 70 years
47 were less likely to receive unicompartmental or patellofemoral knee replacements than Whites (men
48 10% vs 15%, $P = 0.001$; women 6% vs 14%, $P < 0.001$). After adjustment for demographic,
49 clinical and hospital-related factors, Blacks were more likely to receive uncemented hip
50 replacement (OR 1.43 [CI, 1.11 to 1.84]).

51 **Conclusions:** In England, hip and knee replacement rates and prosthesis type given differ
52 amongst ethnic groups. Whether these reflect differences in clinical need or differential
53 access to treatment requires urgent investigation.

54

55

56 INTRODUCTION

57 Variations in the provision of health care interventions in different groups within society are
58 commonplace.¹ In the USA particular concern has been raised about ethnicity, and the
59 relative under-provision of certain procedures amongst African Americans. In the UK the
60 major issue investigated has been reduced service utilisation amongst socio-economically
61 deprived groups,^{2,3} although ethnic minority groups are often located in the most deprived
62 areas of a community.⁴

63 Hip and knee joint replacement operations are amongst the highest volume health care
64 interventions worldwide. In England and Wales in 2013, 79,088 hip and 85,128 knee primary
65 replacements were recorded on the National Joint Registry.⁵ Osteoarthritis is the most
66 common indication for joint replacement, with about 91% of total hip joint replacements and
67 98% of total knee joint replacements being done for this reason. In the USA recent studies
68 have shown that, despite broadly similar osteoarthritis prevalence (age adjusted prevalence
69 rates for Whites was 22.3% and Blacks 21.8%),⁶ African Americans are less likely to get
70 joint replacements than White Americans.⁷⁻⁹ Various reasons have been postulated to explain
71 this, including late presentation and relative unwillingness to undergo surgery amongst Black
72 Americans.¹⁰⁻¹⁴ In the UK and USA it has been shown that people in the most deprived
73 groups are less likely to receive joint replacements than those of higher socio-economic
74 status,^{2,15} and at least one US study has suggested that there may also be racial disparities.¹⁶
75 However, there has been no large-scale investigation of ethnicity and joint replacement in the
76 UK.

77 We have used data from the National Joint Registry (NJR)⁵, linked to the Hospital Episode
78 Statistics (HES) database, to address whether the rate of primary hip and knee joint
79 replacement is the same amongst different ethnic groups in England, whether there are
80 differences in the clinical indications for primary joint replacement amongst ethnic groups
81 and if types of prosthesis and fixation methods used differ between ethnic groups.

82 METHODS

83 We linked all records of primary knee and hip joint replacements in the NJR database for
84 England and Wales and which took place between April 2003 and December 2012 to HES
85 records of patient admissions for NHS funded care in England. In so doing, we obtained
86 additional HES recorded patient demographic information on ethnic group and the
87 geographical area in which the person lived – Lower Super Output Area Level (LSOAL). We

88 only used the first primary procedure recorded for a patient and excluded any revisions or
89 subsequent primary procedure on the contra-lateral side for these patients.

90 **Ethnicity exposure**

91 Each NJR record was linked to all existing HES episodes of admission for that individual
92 since 2001 to minimise missing data on ethnicity (HES changed the way ethnicity was
93 categorised from 2001. To ensure consistency in ethnic groupings, we limited eligible HES
94 records for linkage to the NJR to those from 2001 onwards). If the coding of ethnicity
95 differed across episodes we used the most frequently indicated ethnic category. The numbers
96 of patients in some ethnic groups was small, therefore for this data analysis, the ethnic groups
97 were categorised into three main groupings: White (including British, Irish, Gypsy, and Other
98 White), Black (including Caribbean, African, Mixed White & Black African/Caribbean, and
99 Other Black origin), and other ethnicities (including Indian, British Indian, Pakistani, British
100 Pakistani, Bangladeshi, British Bangladeshi, Mixed White & Asian, and Other Asian,
101 Chinese, and “other mixed race”). We have labelled the last category “Asian” for simplicity
102 and as this is the largest ethnic group amongst the races included here, even though it is
103 clearly heterogeneous.

104 **Other covariates**

105 The residential postcode for the patient at the time of the primary operation was used to
106 determine the English Index of Multiple Deprivation (IMD) 2010 area score by LSOAL as an
107 ecological measure of deprivation.¹⁷ We created a five-category indicator going from the
108 20% most deprived (quintile 1) to 20% least deprived areas of England (quintile 5) by
109 ranking the IMD scores and categorising the distribution into quintiles. Other covariates
110 included age group (<40, 40–49, 50–59, 60–69, 70–79, ≥80 years), gender, the American
111 Society of Anaesthesiologists (ASA) six point scale of surgical fitness, and pre-operative
112 functional severity as captured by the EQ-5D-3L¹⁸ mobility item (whether they have ‘no’ or
113 ‘some’ problems in walking about or are ‘confined to bed’) coded as a 3-level ordinal
114 variable. We created a four level variable for body mass index (BMI) although this was only
115 used in a sensitivity analysis due to a high proportion of missing data; underweight
116 ($10 \leq \text{BMI} < 20 \text{ kg/m}^2$), normal ($20 \leq \text{BMI} < 25 \text{ kg/m}^2$), overweight ($25 \leq \text{BMI} < 30 \text{ kg/m}^2$), and
117 obese ($30 \leq \text{BMI} < 60 \text{ kg/m}^2$). We also looked at type of prosthesis and method of fixation as
118 clinical outcomes.

119

120 **Statistical methods**

121 We used indirect standardisation to compare the observed number of primary joint
122 replacements, for any indication, to the expected numbers in each ethnic group, using the
123 total age and gender specific risks of a procedure applied to the same ethnic specific
124 population strata as reported in the 2011 Census data.¹⁹ We explored possible differences in
125 the clinical indications for having a primary joint replacement amongst ethnic groups using χ^2
126 tests of association.

127 Subsequent analyses were restricted to the sub-set of patients with osteoarthritis as the
128 indication for the primary procedure. We used χ^2 tests to compare differences in categorical
129 variables by ethnicity and in some cases stratified by gender. Where the data suggested
130 possible interactions, we used log-linear models assuming a Poisson distribution to test for
131 this by comparing any improvement in goodness of fit of the models from likelihood ratio
132 tests with and without these terms.

133 We ran both univariable and multivariable logistic regression models to mutually adjust for
134 covariates. Model A simply examined ethnicity alone; model B adjusted for age-group,
135 gender, ASA grade and area deprivation quintile as patient related confounders; model C
136 adjusted for routine surgical behaviour unrelated to patient factors, by adjusting for what
137 proportion of all hip replacements are done using uncemented prostheses at that trust. We
138 took into account the clustering of procedures within a trust by using robust standard errors.
139 We used Wald tests to determine the overall significance of additional terms added to a
140 proposed model compared to the model without them. We undertook two further sensitivity
141 analyses by comparing the results for model C with and without adjustment for pre-operative
142 functional limitations using EQ-5D-3L mobility item (data available on about 30% of
143 patients) and BMI (data available on about 45% of patients).

144 **RESULTS**

145 The total number of eligible NJR records available for all primary diagnoses for the period
146 2003–2012 before matching to HES and after excluding Welsh and non-NHS England funded
147 operations for hips and knees were 425,726 and 481,528 primary replacements respectively.
148 Of these, 12% hip and 11% knee replacements had missing ethnicity information either
149 because a match to a valid HES record could not be made or because their HES ethnic group
150 classification was ‘unknown’. This left 373,613 hip and 428,936 knee primary replacement
151 records for any primary diagnosis with available ethnicity data. This was reduced to 330,384

152 hip and 362,505 knee patients after restricting to the first replaced side of a joint for those
153 with bilateral operations. The total number of patients in the osteoarthritis only analysis
154 sample, after restricting to patients' first primary replaced side and to those with a sole
155 diagnosis of osteoarthritis, with valid ethnicity data was 640,355 (293,325 hip and 347,030
156 knee patients).

157 Table 1 shows the observed versus expected numbers of patients having a primary hip or
158 knee joint replacement by ethnicity and stratified by gender. For both hip and knee
159 replacements, there were fewer than expected procedures amongst the Black and Asian
160 populations though this was far more marked for hip replacements. For hips, the ratio of
161 observed to expected first replacements was very similar for both men and women, but for
162 knees there were markedly fewer than expected procedures carried out on men compared to
163 women.

164 (INSERT TABLE 1 HERE)

165 Osteoarthritis was the dominant indication in all three ethnic groups for both knee and hip
166 replacement (table 2). There was some evidence that Black and Asians have a higher chance
167 of having a knee replacement for inflammatory arthritis compared to Whites ($p=0.02$). For
168 hip replacement, Black and Asians were more likely to have the procedure undertaken for
169 avascular necrosis, inflammatory arthritis, congenital dysplasia, and 'other reasons'.

170 (INSERT TABLE 2 HERE)

171 Patients from ethnic minority groups having either hip or knee replacement for osteoarthritis
172 were more likely to be younger and living in more deprived areas and, for hip replacements,
173 were fitter as measured by the ASA grade (table 3).

174 (INSERT TABLE 3 HERE)

175 Because of these age differences we then examined if the type of fixation method used for
176 either hip or knee replacement differed by age-group (<70 , ≥ 70 years), gender and ethnicity
177 (table 4). Both Black men and women were more likely to get uncemented hip prostheses
178 regardless of age-group. For knee replacements, Black and Asians were less likely to get a
179 patellofemoral or unicondylar prosthesis, though this was more marked for Black patients and
180 in the younger age-group.

181 (INSERT TABLE 4 HERE)

182 We explored the possible reasons why Blacks were more likely to receive an uncemented hip
183 prosthesis by testing different models (table 5).

184 (INSERT TABLE 5 HERE)

185 With regard to the odds of receiving an uncemented prosthesis, after adjustment for
186 demographic variables and ASA grade, the elevated odds ratio for Asians (1.60) was
187 markedly attenuated (1.21, 95% CI 0.90–1.63) and consistent with chance, whilst the odds
188 ratio for Black patients remains elevated (1.86, 95% CI 1.30–2.66), albeit weaker. Further
189 adjustment for surgical behaviour at trust level further attenuated the associations, but there
190 still remained a 43% relative elevated odds (95% CI 1.11–1.84). Our sensitivity analyses
191 showed that the odds ratios for Blacks and Asians of receiving an uncemented prosthesis for
192 model C hardly changed after the addition of the EQ-5D-3L mobility item and BMI (odds
193 ratio remained at 1.32 for Blacks and 1.12 for Asians) although in this smaller sub-set of the
194 data (n=44,001) the 95% confidence intervals for these included the null value so could have
195 occurred by chance (see table 6).

196 (INSERT TABLE 6 HERE)

197

198 **DISCUSSION**

199 Two important observations emerge from this study. Firstly, we have found that large ethnic
200 variations in the rate of total joint replacement across ethnic groups are not explained by age
201 and gender differences. These variations are greater for hip than knee replacement. For hip
202 replacement, this difference is more marked for Asian than Black patients, whilst for knee
203 replacement the difference is reversed, being more marked for Black people but with both
204 ethnic minorities showing gender differences so that men are less likely to have received a
205 joint replacement compared to women. The second observation is that there are unexpected
206 differences in the types of prosthesis and fixation methods used between the ethnic groups,
207 with greater use of uncemented hip prostheses amongst black minority groups in particular,
208 as well as greater use of hip resurfacing in ethnic minorities, and less use of unicondylar or
209 patellofemoral knee replacements. The surprising difference in use of the more expensive
210 uncemented hip prostheses seems to be partially explained by the fact that ethnic minority
211 groups are more likely to have their joint replacement in NHS hospital Trusts that are high
212 users of uncemented prostheses.

213 Inequalities in the rates of joint replacement between ethnic groups have been described in
214 the USA, Canada, Australia, and the UK.^{2,7,20,21} It has also been observed that people in the
215 most deprived socio-economic groups are less likely to receive a joint replacement.^{2,21,22} This
216 is the first large-scale study to confirm that in the UK, as in other countries, ethnic minorities
217 are less likely to receive hip or knee joint replacements than the White majority. Unlike in the
218 USA, health care in the UK is universal, so that the challenges faced by many US-based
219 studies with respect to health insurance coverage would not affect these results, yet the
220 findings are similar to those in the USA. Inequalities (differences) in utilisation are not
221 synonymous with inequities in provision. There are many possible explanations for the
222 differences observed, including variations in the prevalence of disease (particularly
223 osteoarthritis, the dominant condition leading to hip or knee joint replacement), and
224 differences in willingness to undergo surgery amongst the different ethnic groups.¹⁰ Patient
225 willingness to undergo surgery might be shaped by cultural factors, doctor-patient
226 communication, variations in patient outcomes, or even issues related to patient trust in the
227 healthcare system.

228 Whilst we were able to adjust for the age and gender distributions of the main ethnic groups
229 using the Census data, the true denominator should be the number of people with a clinical
230 indication for joint replacement and we have not been able to identify any data on the relative
231 prevalence of osteoarthritis in the different ethnic groups in England. The major risk factors
232 for OA are age, obesity, and joint injury. Some differences in osteoarthritis prevalence in
233 ethnic groups have been observed but rates in US Black and White people are broadly
234 similar.^{7,23,24} It seems unlikely that ethnic differences in the prevalence of osteoarthritis
235 account for all of the large difference in the rates of joint replacement we have observed. It is
236 interesting to note the large gender differences in rates of knee replacement amongst the non-
237 White groups with males much less likely to undergo joint replacement than females. This
238 observation requires further investigation and may reflect ethnic and gender differences in
239 delay in presentation or willingness to undergo surgery.

240 The findings surrounding the use of prosthesis and fixation type in different ethnic groups are
241 intriguing. We were surprised by the higher use of uncemented hip prostheses amongst the
242 Black and Asian groups compared with Whites and decided to investigate why that might be
243 by use of models that factored demographic, surgical and trust related variables. We showed
244 that the hospital in which people are operated on is a major determinant of the differences in
245 hip replacement fixation method, as large, urban hospitals that serve a greater proportion of

246 these ethnic minorities tend to use a greater number of uncemented hip prostheses, though
247 this is did not fully explain the differences for Black patients.

248 Similarly it is interesting to note that Black patients, when they present for surgery, are less
249 likely to receive unicondylar or patellofemoral knee replacements.

250 The major strength of this analysis is the very large dataset available as the NJR is the largest
251 joint replacement registry in the world. However, there are several important limitations.
252 There is some misclassification of ethnicity, and ethnicity was missing from about 12% of
253 records which may have biased the results, though in general missing data is more a trust-
254 level rather than patient characteristic.²⁵ As mentioned above we have no data on clinical
255 need so our observation of lower rates of joint replacement amongst ethnic minorities
256 compared to White patients' needs to be treated with caution until we better understand the
257 epidemiology of osteoarthritis in ethnic minorities in England.

258 In conclusion, we have shown that there are large differences in the utilisation of total hip and
259 knee joint replacement in different ethnic groups in England, and in the types of prosthesis
260 and fixation used. There are also marked gender differences within non-White groups of
261 utilisation of knee replacement. We believe that this is probably explained by a combination
262 of different factors, including deprivation, prevalence of osteoarthritis, and inequitable access
263 to health care either because of ethnic differences in seeking care and willingness to undergo
264 surgery or in differential clinical behaviour in surgical referral and prioritization for surgical
265 intervention. At this stage we remain unclear as to the relevant importance of each of these
266 factors and further research should elucidate whether interventions are required to ensure
267 more equitable care.

268

269 **Author contributions:** All authors were involved in study design. Data management and all
270 analyses were undertaken by MCS. YB-S, PD, MCS, JMW and AWB contributed to data
271 interpretation. All authors contributed to preparation of the manuscript.

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284 final report. MCS had full access to all the data in the study and AWB had final responsibility
285 for the decision to submit for publication.

286

287 AWB and JMW assert, on behalf of the authors, that the manuscript is an honest, accurate,
288 and transparent account of the study being reported; that no important aspects of the study
289 have been omitted.

290

291

292

References

1. WHO Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. Final report of the Commission on Social Determinants of Health. Geneva: World Health Organization, 2008.
2. 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.
3. Dixon A, Le Grand J, Henderson J, Murray R, Poteliakhoff E. Is the British National Health Service equitable? The evidence on socioeconomic differences in utilization. *J Health Serv Res Policy* 2007; **12**(2): 104-9.
4. Barnard H, Turner C. Poverty and Ethnicity: A review of evidence. York: Joseph Rowntree Foundation, 2011.
5. National Joint Registry for England and Wales: 11th Annual Report. Hemel Hempstead: NJR Centre, 2014.
6. Bolen J, Schieb L, Hootman JM, et al. Differences in the prevalence and impact of arthritis among racial/ethnic groups in the United States, National Health Interview Survey, 2002, 2003, and 2006. *Prev Chronic Dis* 2010; **7**(3): A64.
7. Centers for Disease Control and Prevention. Racial disparities in total knee replacement among Medicare enrollees -United States, 2000-2006. *MMWR Morb Mortal Wkly Rep* 2009; **58**(6): 133-8.
8. Bang H, Chiu YL, Memtsoudis SG, et al. Total hip and total knee arthroplasties: trends and disparities revisited. *Am J Orthop* 2010; **39**(9): E95-102.
9. Collins JE, Deshpande B, Katz JN, Losina E. Race and sex specific incidence rates and predictors of total knee arthroplasty: Data from the Osteoarthritis Initiative, 7 years follow up. *Arthritis Rheum* 2014; **66**: S398.
10. Hawker GA. Who, when, and why total joint replacement surgery? The patient's perspective. *Curr Opin Rheumatol* 2006; **18**(5): 526-30.
11. Allen KD, Golightly YM, Callahan LF, et al. Race and sex differences in willingness to undergo total joint replacement: the Johnston County Osteoarthritis Project. *Arthritis Care Res (Hoboken)* 2014; **66**(8): 1193-202.
12. Ibrahim SA, Siminoff LA, Burant CJ, Kwoh CK. Differences in expectations of outcome mediate African American/white patient differences in "willingness" to consider joint replacement. *Arthritis Rheum* 2002; **46**(9): 2429-35.

13. Keysor JJ, Chang HJ, Yang T, et al. African american adults less willing to undergo joint replacement surgery: The Multicenter Osteoarthritis Study. *Arthritis Rheum* 2012; **64**: S346.
14. Vina ER, Cloonan YK, Ibrahim SA, Hannon MJ, Boudreau RM, Kwoh CK. Race, sex, and total knee replacement consideration: role of social support. *Arthritis Care Res (Hoboken)* 2013; **65**(7): 1103-11.
15. Judge A, Welton NJ, Sandhu J, Ben-Shlomo Y. Modeling the need for hip and knee replacement surgery. Part 2. Incorporating census data to provide small-area predictions for need with uncertainty bounds. *Arthritis Care Res (Hoboken)* 2009; **61**(12): 1667-73.
16. Steel N, Clark A, Lang IA, Wallace RB, Melzer D. Racial disparities in receipt of hip and knee joint replacements are not explained by need: the Health and Retirement Study 1998-2004. *J Gerontol A Biol Sci Med Sci* 2008; **63**(6): 629-34.
17. English indices of deprivation 2010. London: Department for Communities and Local Government, 2011.
18. Williams A, Kind P. The present state of play about QALYs. London: Royal College of Physicians of London, 1992.
19. Office for National Statistics. 2011 Census: Aggregate data (England and Wales) [computer file]. UK Data Service Census Support. Downloaded from:<http://infuse.mimas.ac.uk>; 2011.
20. Barnabe C, Jones A, Enns E, et al. Imbalance of prevalence and specialty care for first nations with osteoarthritis in Alberta. *J Rheumatol* 2013; **40** (6): 950.
21. Dixon T, Urquhart DM, Berry P, et al. Variation in rates of hip and knee joint replacement in Australia based on socio-economic status, geographical locality, birthplace and indigenous status. *ANZ J Surg* 2011; **81**(1-2): 26-31.
22. Bohensky MA, Ackerman I, DeSteiger R, Gorelik A, Brand CA. Lifetime risk of total knee replacement and temporal trends in incidence by health care setting, socioeconomic status, and geographic location. *Arthritis Care Res* 2014; **66**(3): 424-31.
23. Arden N, Nevitt MC. Osteoarthritis: Epidemiology. *Best Pract Res Clin Rheumatol* 2006; **20**(1): 3-25.
24. Zhang Y, Jordan JM. Epidemiology of osteoarthritis. *Clin Geriatr Med* 2010; **26**(3): 355-69.
25. Supporting data quality: NJR Strategy 2014/2016. Hemel Hempstead: NJR Centre, 2014.

TABLE LEGENDS

Table 1 Observed and expected number of patients presenting, for the first time, for primary hip/knee replacement for all causes in English NHS hospitals by ethnic group

Table 2 Clinical indications for hip and knee primary replacement patients by ethnic group

Table 3 Patient characteristics at time of first primary hip and knee joint surgery, broken down by ethnic group and gender, for patients with a primary diagnosis of osteoarthritis only

Table 4 Prosthesis fixation method for osteoarthritis first hip and knee replacement patients stratified by age-group, gender and ethnic group*

Table 5 Odds ratios for receiving an uncemented hip replacement by ethnic group adjusting for patient and trust related covariates (n=224,561)

Table 6 Logistic regression Models A-E with restricted sample size for BMI subset (n=44,001)

Table 1 Observed and expected number of patients presenting, for the first time, for primary hip/knee replacement for all causes in English NHS hospitals by ethnic group

	All NJR	White			Black [*]			Asian [*]		
	Obs	NJR Obs	Exp	Standardised Ratio (95%CI) Obs/Exp	NJR Obs	Exp	Standardised Ratio (95%CI) Obs/Exp	NJR Obs	Exp	Standardised Ratio (95%CI) Obs/Exp
Hip replacement patients[†]										
Total: Females NJR	195,800	195,800	186,698	1.05 (1.04–1.05)	1,166	3,735	0.31 (0.30–0.33)	1,588	8,122	0.20 (0.19–0.21)
Total: Males NJR	129,662	129,662	123,102	1.05 (1.05–1.06)	904	2,557	0.35 (0.33–0.38)	1,262	6,170	0.21 (0.19–0.22)
Total	330,382	325,462	309,800	1.05 (1.05–1.06)	2,070	6,292	0.33 (0.31–0.35)	2,850	14,292	0.20 (0.19–0.21)
Knee replacement patients[‡]										
Total: Females NJR	196,143	196,143	195,688	1.00 (1.00–1.01)	3,068	3,756	0.82 (0.79–0.85)	8,495	8,204	1.03 (1.01–1.05)
Total: Males NJR	149,636	149,636	145,592	1.03 (1.02–1.03)	1,044	2,670	0.39 (0.37–0.42)	4,117	6,535	0.63 (0.61–0.65)
Total	362,503	345,779	341,280	1.01 (1.01–1.02)	4,112	6,426	0.64 (0.61–0.67)	12,612	14,739	0.86 (0.84–0.88)

^{*} Based on the Census 2011 main ethnic categories; Black = Black/African/Caribbean/Black British/Mixed White & Black African/Caribbean, Asian= Asian/Asian British/Mixed White & Asian/Mixed Other/Chinese and other groups.

[†] Hip observed/expected cases based on people aged 10 and over. [‡] Knee observed/expected cases based on census and NJR cases aged 15 and over.

Table 2 Clinical indications for hip and knee primary replacement patients by ethnic group

Reason for Hip replacement	<i>Number (%) of hip patients with specified primary diagnosis*</i>			p-value
	White (n= 325,461)	Black (n= 2,070)	Asian (n= 2,852)	
Osteoarthritis	300,936 (92.5)	1,645 (79.5)	2,144 (74.1)	<0.001
Inflammatory Arthritis [†]	5,096 (1.6)	47 (2.3)	130 (4.6)	<0.001
Avascular Necrosis	8,500 (2.6)	289 (14.0)	277 (9.7)	<0.001
Congenital Dysplasia of Hip	5,135 (1.6)	99 (4.8)	142 (5.0)	<0.001
All Trauma [‡]	11,507 (3.5)	70 (3.4)	252 (8.8)	<0.001
Other hip reasons [§]	7,757 (2.4)	136 (6.6)	180 (6.3)	<0.001
Reason for Knee replacement	<i>Number (%) of knee patients with specified primary diagnosis*</i>			p-value
	White (n= 345,780)	Black (n= 4,112)	Asian (n= 12,612)	
Osteoarthritis	335,258 (97.0)	3,961 (96.3)	12,209 (96.8)	0.04
Inflammatory Arthritis	8,609 (2.5)	128 (3.1)	334 (2.7)	0.02
Other knee reasons [¶]	6,255 (1.8)	89 (2.2)	213 (1.7)	0.14

* Note that more than one diagnosis could be indicated by the clinician on the form so categories are not mutually exclusive of each other.

[†] Inflammatory Arthritis for hips combines diagnoses of *Seronegative and Seropositive rheumatoid arthritis, Other Inflammatory Arthropathy, Ankylosing Spondylitis, and Psoriatic Arthropathy.*

[‡] All Trauma includes *Chronic Trauma, Fractured acetabulum, Fractured neck of femur, Acute Trauma of Neck of Femur, Previous Hip Trauma Not Specified, Failed internal fixation, Other hip trauma.*

[§] Other hip reasons include *Slipped Upper Femoral Epiphysis, Previous Arthrodesis, previous infection, Failed Hemi arthroplasty, previous non-trauma related surgery, and Other* indicated reasons for primary hip replacement.

^{||} Inflammatory Arthritis for knees combines diagnoses of *Rheumatoid Arthritis, Seronegative and Seropositive rheumatoid arthritis, and Other Inflammatory Arthropathy.*

[¶] Other knee reasons include *failed internal fixation, previous arthrodesis, trauma, previous infection, avascular necrosis, previous trauma, and Other* indicated reasons for primary knee replacement.

Table 3 Patient characteristics at time of first primary hip and knee joint surgery, broken down by ethnic group and gender, for patients with a primary diagnosis of osteoarthritis only

	Number of first primary hip replacements by Ethnic group, gender and patient factor. Percentage of Ethnic group shown in brackets*							
	Females				Males			
	White n=172,968	Black n=818	Asian n=1,087	P-value	White n=116,960	Black n=649	Asian n=843	p-value
Age group (years)								
Under 40	1,105 (0.6)	50 (6.1)	44 (4.1)		1,211 (1.0)	48 (7.4)	57 (6.8)	
40-49	4,998 (2.9)	134 (16.1)	79 (7.3)		5,452 (4.7)	166 (25.6)	103 (12.2)	
50-59	20,534 (11.9)	156 (19.1)	181 (16.7)		17,939 (15.3)	161 (24.8)	190 (22.5)	
60-69	51,056 (29.5)	180 (22.0)	325 (29.9)		38,481 (32.9)	113 (17.4)	226 (26.8)	
70-79	64,510 (37.3)	228 (27.9)	336 (30.9)		40,523 (34.7)	130 (20.0)	213 (25.3)	
80 or more	30,765 (17.8)	70 (8.6)	122 (11.2)	<0.001	13,354 (11.4)	31 (4.8)	54 (6.4)	<0.001
Area Deprivation based on IMD 2010[†]								
Quintile 1 (most deprived)	22,113 (13.0)	308 (37.8)	214 (19.9)		14,048 (12.2)	239 (37.2)	195 (23.4)	
Quintile 2	29,958 (17.6)	21 (25.9)	222 (20.7)		19,598 (17.1)	186 (28.9)	174 (20.6)	
Quintile 3	38,650 (22.7)	136 (16.7)	259 (24.1)		26,136 (22.8)	97 (15.1)	164 (20.9)	
Quintile 4	40,804 (24.0)	86 (10.6)	181 (16.9)		28,600 (24.9)	53 (8.2)	158 (19.0)	
Quintile 5 (least deprived)	38,867 (22.8)	74 (9.1)	198 (18.4)	<0.001	26,572 (23.1)	68 (10.6)	142 (17.1)	<0.001
<i>No. with missing IMD 2010 (% of all female or male HR for ethnic group)</i>	2,576 (1.5)	3 (0.4)	13 (1.2)		2,006 (1.7)	6 (0.9)	10 (1.2)	
ASA grade								
P1 - Fit and healthy	25,899 (15.0)	137 (16.8)	187 (17.2)		22,172 (19.0)	205 (31.6)	201 (23.8)	
P2 - Mild disease not incapacitating	121,248 (70.1)	541 (66.1)	749 (68.9)		76,817 (65.7)	373 (57.5)	528 (62.6)	
P3/P4/P5 - Incapacitating or more severe	25,821 (14.9)	140 (17.1)	151 (13.9)	=0.030	17,971 (15.4)	71 (10.9)	114 (13.5)	<0.001
	Number of first primary knee replacements by Ethnic group, gender and patient factor. Percentage of Ethnic group shown in brackets*							
	Females				Males*			
	White n=186,439	Black n=2,899	Asian n=8,098	p-value	White n=144,624	Black n=998	Asian n=3,972	p-value*
Age group (years)								
Under 40	341 (0.2)	9 (0.3)	15 (0.2)		3,472 (2.4)	63 (60.2)	67 (1.7)	
40-49	4,192 (2.3)	111 (3.8)	205 (2.5)					
50-59	23,085 (12.4)	471 (16.3)	1,508 (18.6)		17,903 (12.4)	130 (13.1)	500 (12.6)	
60-69	57,361 (30.8)	1,050 (36.2)	3,109 (38.4)		51,318 (35.5)	301 (30.3)	1,279 (32.3)	
70-79	71,111 (38.1)	1,074 (37.1)	2,782 (34.4)		53,564 (37.1)	388 (39.4)	1,711 (43.1)	
80 or more	30,349 (16.3)	184 (6.4)	479 (5.9)	<0.001	18,367 (12.7)	109 (11.1)	408 (10.4)	<0.001
Area Deprivation based on IMD 2010[†]								
Quintile 1 (most deprived)	28,210 (15.2)	1,319 (46.3)	2,234 (28.0)		20,212 (14.2)	414 (42.0)	1,132 (28.7)	
Quintile 2	34,325 (18.6)	839 (29.2)	2,121 (26.5)		25,837 (18.1)	275 (27.9)	985 (25.0)	
Quintile 3	41,444 (22.6)	386 (13.4)	1,640 (19.9)		32,190 (22.3)	149 (15.1)	769 (19.5)	
Quintile 4	41,546 (22.6)	208 (6.8)	1,079 (13.7)		33,835 (23.4)	81 (8.2)	546 (13.9)	
Quintile 5 (least deprived)	38,278 (20.9)	124 (4.4)	958 (11.9)	<0.001	30,526 (21.4)	66 (6.7)	508 (12.9)	<0.001
<i>No. with missing IMD 2010 (% of all female or male KR for ethnic group)</i>	2,636 (1.5)	23 (0.7)	66 (0.8)		2,024 (1.4)	13 (1.3)	32 (0.8)	
ASA grade								
P1 - Fit and healthy	22,169 (11.9)	261 (9.0)	761 (9.4)		22,002 (15.2)	127 (12.7)	416 (10.5)	
P2 - Mild disease not incapacitating	135,513 (72.7)	2,094 (72.2)	6,021 (74.4)		100,359 (69.4)	668 (66.9)	2,752 (69.3)	
P3/P4/P5 - Incapacitating or more severe	28,757 (15.4)	544 (18.8)	1,316 (16.3)	<0.001	22,263 (15.4)	203 (20.3)	804 (20.2)	<0.001

Notes:

* Age categories *Under 40* and *40-49* combined to *Under 50* for male knee primaries as expected frequencies in chi squared test of association between age category and ethnic group fell below 5 in the original lowest age category.[†] Area deprivation percentages shown are based on the distribution of non-missing IMD cases.

Table 4 Prosthesis fixation method for osteoarthritis first hip and knee replacement patients stratified by age-group, gender and ethnic group *

	Number of first hip replacement patient by Ethnic group and gender (%) [n=288,689]							
	Females				Males			
	White n= 170,379	Black n=815	Asian n=1,074	p-value	White n=114,945	Black n=643	Asian n=833	p-value [†]
Hip fixation method (<70 years)								
Cemented	22,013 (28.8)	71 (13.7)	142 (22.8)		13,496 (21.8)	49 (10.1)	90 (15.8)	
Uncemented	36,111 (47.2)	324 (62.7)	311 (50.0)		29,656 (47.9)	267 (55.2)	300 (52.6)	
Hybrid/ Reverse hybrid	13,982 (18.3)	78 (15.1)	130 (20.9)		8,954 (14.5)	46 (9.5)	81 (14.2)	
Resurfacing	4,346 (5.7)	44 (8.5)	39 (6.3)	<0.001	9,807 (15.8)	122 (25.2)	99 (17.4)	<0.001
Hip fixation method (≥ 70 years)								
Cemented	54,681 (58.2)	133 (44.6)	244 (54.0)		27,186 (51.3)	57 (35.9)	108 (41.1)	
Uncemented	22,681 (24.2)	100 (33.6)	115 (25.4)		16,247 (30.6)	72 (45.3)	107 (40.7)	
Hybrid/ Reverse hybrid/ Resurfacing³	16,565 (17.6)	65 (21.8)	93 (20.6)	<0.001	9,599 (18.1)	30 (18.9)	48 (18.3)	<0.001
	Number of first knee replacement patients by Ethnic group and gender (%) [n=342,208]							
	Females				Males			
	White n=183,786	Black n=2,876	Asian n=8,031	p-value	White n=142,590	Black n=985	Asian n=3,940	p-value [†]
Knee fixation method (<70 years)								
Cemented	67,461 (80.6)	1,427 (87.8)	4,098 (85.4)		56,419 (78.7)	405 (83.0)	1,493 (81.4)	
Uncemented/hybrid	4,765 (5.7)	98 (6.0)	215 (4.5)		4,706 (6.6)	36 (7.4)	141 (6.4)	
Patellofemoral/Unicondylar	11,485 (13.7)	101 (6.2)	487 (10.1)	<0.001	10,525 (14.7)	47 (9.6)	224 (12.2)	0.001
Knee fixation method (≥ 70 years)								
Cemented	90,684 (90.6)	1,153 (92.2)	2,981 (92.3)		62,574 (88.2)	446 (89.7)	1,906 (90.6)	
Uncemented/hybrid	5,136 (5.1)	68 (5.4)	153 (4.7)		4,238 (6.0)	31 (6.2)	143 (5.0)	
Patellofemoral/Unicondylar	4,255 (4.3)	29 (2.3)	97 (3.0)	<0.001	4,128 (5.8)	20 (4.0)	93 (4.4)	0.007

* Based on the complete case sample for hips and knees. † After collapsing prosthesis categories indicated as original cell expected frequencies were below 5.

Table 5 Odds ratios for receiving an uncemented hip replacement by ethnic group adjusting for patient and trust related covariates (n=224,561)

Variables		Model A	Model B*	Model C†
		OR (95% CI)	OR (95% CI)	OR (95% CI)
Ethnicity	White	ref	ref	ref
	Black	2.76 (1.94–3.93)	1.86 (1.30–2.66)	1.43 (1.11–1.84)
	Asian	1.60 (1.23–2.08)	1.21 (0.90–1.63)	1.01 (0.84–1.21)
Gender	Female		ref	ref
	Male		1.37 (1.31–1.43)	1.50 (1.43–1.58)
ASA Grade	Grade 1		ref	ref
	Grade 2		0.96 (0.86–1.07)	1.01 (0.91–1.13)
	Grade 3/4/5		0.83 (0.71–0.97)	0.89 (0.78–1.02)
Age Group	Under 40		19.56 (12.36–30.97)	46.98 (33.20–66.47)
	40-49		16.99 (12.17–23.73)	36.66 (26.89–49.98)
	50-59		10.43 (8.19–13.28)	20.10 (15.39–26.25)
	60-69		4.13 (3.49–4.89)	6.29 (5.21–7.60)
	70-79		1.69 (1.56–1.84)	1.97 (1.78–2.17)
	80 and over		ref	ref
Area deprivation	Most deprived			
	Quintile 1		0.85 (0.68–1.05)	0.77 (0.67–0.88)
	Quintile 2		0.95 (0.80–1.14)	0.87 (0.78–0.97)
	Quintile 3		0.97 (0.83–1.14)	0.94 (0.85–1.04)
	Quintile 4		0.92 (0.81–1.04)	0.95 (0.88–1.03)
Least deprived	Quintile 5		ref	ref
Trust (%) uncemented	Lowest			
	Quartile 1			0.02 (0.01–0.04)
	Quartile 2			0.07 (0.05–0.10)
	Quartile 3			0.19 (0.14–0.25)
Highest	Quartile 4			ref
Wald test for added terms		p-value<0.001	p-value<0.001	p-value<0.001

* Multivariable odds ratios adjusted for gender, ASA grade, IMD score and age-group.

† Multivariable odds ratios adjusted for covariates in model B plus the proportion of uncemented primaries carried out within the local trust where primary took place.

Table 6 Logistic regression Models A-E with restricted sample size for BMI subset (n= 44,001)

Variables	Odds Ratio (95% CI) estimates for logistic regression models of uncemented hip replacement on ethnic group and adjusted for covariates shown				
	Model A [*]	Model B [†]	Model C [‡]	Model D [§]	Model E
Ethnic Group					
<i>White</i>	ref	ref	ref	ref	ref
<i>Black</i>	2.27 (1.49–3.47)	1.42 (0.90–2.25)	1.32 (0.80–2.17)	1.32 (0.80–2.18)	1.32 (0.85–2.04)
<i>Asian</i>	1.71 (1.03–2.83)	1.27 (0.77–2.11)	1.11 (0.72–1.72)	1.12 (0.72–1.73)	1.12 (0.80–1.56)
Gender					
<i>Female</i>		ref	Ref	ref	ref
<i>Male</i>		1.45 (1.34–1.57)	1.63 (1.50–1.77)	1.63 (1.50–1.77)	1.62 (1.54–1.70)
ASA Grade					
<i>Grade 1</i>		ref	ref	ref	ref
<i>Grade 2</i>		0.89 (0.78–1.01)	0.87 (0.73–1.01)	0.86 (0.74–1.01)	0.86 (0.79–0.92)
<i>Grade 3/4/5</i>		0.68 (0.54–0.86)	0.71 (0.55–0.88)	0.70 (0.55–0.89)	0.69 (0.63–0.76)
Age-Group					
<i>Under 40</i>		22.06 (12.62–38.57)	58.99 (31.52–110.42)	59.26 (31.55–111.31)	59.80 (39.27–91.06)
<i>40-49</i>		19.87 (12.56–31.45)	46.48 (29.31–73.69)	48.41 (29.27–73.58)	45.70 (37.57–55.59)
<i>50-59</i>		11.49 (8.51–15.51)	23.81 (16.81–33.73)	23.73 (16.76–33.59)	23.34 (20.90–26.07)
<i>60-69</i>		4.27 (3.50–5.21)	6.63 (5.17–8.49)	6.61 (5.16–8.46)	6.51 (5.99–7.08)
<i>70-79</i>		1.75 (1.56–1.97)	1.97 (1.71–2.26)	1.97 (1.71–2.26)	1.94 (1.80–2.10)
<i>80 and over</i>		ref	ref	ref	ref
Area Deprivation					
<i>(most) Quintile 1</i>		0.94 (0.70–1.28)	0.90 (0.70–1.15)	0.90 (0.71–1.15)	0.90 (0.83–0.98)
<i>Quintile 2</i>		0.93 (0.72–1.19)	0.90 (0.74–1.09)	0.90 (0.74–1.10)	0.90 (0.83–0.97)
<i>Quintile 3</i>		0.89 (0.71–1.12)	0.88 (0.73–1.05)	0.88 (0.73–1.05)	0.88 (0.81–0.94)
<i>Quintile 4</i>		0.85 (0.72–1.01)	0.89 (0.78–1.02)	0.89 (0.78–1.02)	0.89 (0.83–0.96)
<i>Quintile 5</i>		ref	ref	ref	ref
Proportion of uncemented primaries done within local trust (lowest 25%)					
<i>Quartile 1</i>			0.01 (0.01–0.03)	0.01 (0.01–0.03)	0.01 (0.01–0.02)
<i>Quartile 2</i>			0.06 (0.03–0.12)	0.06 (0.03–0.12)	0.06 (0.06–0.07)
<i>Quartile 3</i>			0.20 (0.11–0.37)	0.20 (0.11–0.37)	0.20 (0.19–0.22)
<i>Quartile 4</i>			ref	ref	ref
PROMS EQ-5D-3L mobility item					
<i>No problems walking about</i>				ref	ref
<i>Some problem walking about</i>				0.88 (0.77–1.01)	0.87 (0.78–0.97)
<i>Confined to bed</i>				0.81 (0.51–1.27)	0.81 (0.52–1.25)
BMI					
<i>Underweight</i>					0.81 (0.66–0.99)
<i>Normal</i>					ref
<i>Overweight</i>					1.05 (0.98–1.12)
<i>Obese</i>					1.06 (0.99–1.14)
Wald test for added terms	p-value=0.001	p-value<0.001	p-value<0.001	p-value=0.153	p-value=0.027

* Unadjusted odds ratio for ethnicity.

† Multivariable odds ratio adjusted for gender, ASA grade, IMD score, and age-group.

‡ Multivariable odds ratio adjusted for covariates in Model B plus the proportion of uncemented primaries carried out within the local trust where the primary took place.

§ Multivariable odds ratio adjusted for covariates in Model C plus PROMS preoperative EQ-5D mobility indicator.

|| Multivariable odds ratio adjusted for covariates in Model D plus patient BMI category.