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# Population requirement for primary knee replacement surgery: a cross-sectional study

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**Objectives.** To determine the population requirement for total knee replacement (TKR) in England

**Methods.** Population-based study using an age/sex-stratified random sample of 28 080 individuals aged 35 yr and over. Incident disease was estimated from prevalence by statistical modelling. The New Zealand priority criteria for major joint replacement were used for case selection.

**Results.** Patients with knee disease were less likely than those with equally severe hip disease to have been referred to a specialist, to have consulted an orthopaedic surgeon or to be on a waiting list for joint replacement. The estimated annual requirement of TKRs in England, based on New Zealand Scores alone, was 55 800 (95% CI 40 700–70 900), contrasting sharply with an annual provision of 29 300 actually observed. However, in contrast to previously reported hip replacement data, when patient willingness to undergo surgery was considered, this estimate decreased considerably.

**Conclusions.** There appears to be an underprovision of TKR in England. This may be due in part to differences in perception of disease severity and likely response to surgery between patients and general practitioners on one hand, and rheumatologists and orthopaedic surgeons on the other.

KEY WORDS: Knee replacement surgery, Needs assessment, Population requirements.

Total knee replacement (TKR) is an effective intervention for patients with severe knee disease. Systematic reviews have shown that all forms of primary knee joint replacement result in large improvements in patient-related outcome measures for the majority of those undergoing these procedures [1, 2]. Although the number of TKRs performed in England has been rising each year over the last two decades [3], one population-based study [4] and some commentators [5] have suggested that there is still a large unmet need for primary TKR in England. However, the current evidence base is limited. Some prevalence data on severe knee disease in the community are available [4], but incidence data to estimate the annual population requirement for knee replacement are lacking. Consensus criteria for case selection for TKR have been published [6, 7], but data on the impact of these criteria on annual rates are unavailable, and the

implications of different thresholds for surgery, patient preference and other modifiers of the decision to recommend surgery are unclear.

In a previous paper [8] we used prevalence data of hip disease from the Somerset and Avon Survey of Health (SASH) [9] to estimate the annual population requirement for primary hip replacement in England. To inform the current discussion, we used the same methods and assumptions to estimate the population requirement for primary TKR. In addition, we compared healthcare utilization by people with hip and knee disease.

## Patients and methods

### *Sampling of patients*

SASH is a population-based cross-sectional study described elsewhere [8, 9]. We used a multistage sampling strategy [10].

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Forty practices were selected from Avon and Somerset. From each practice, 702 people aged 35 yr and over were randomly selected using age/sex stratification, resulting in a sample of 28 080 people with the numbers of men and women in each 10-yr age band reflecting the population distribution of Avon and Somerset [9]. After exclusion of 2034 people who had moved out of the study area, suffered from a severe mental illness or a terminal illness, or were deceased, 26 046 people were included in the study. Approval was obtained from the relevant Local Research Ethics Committees (Southmead, Frenchay, United Bristol Health Trust, Weston and Somerset) [8].

### Screening process

All 26 046 people were sent a screening questionnaire comprising questions on general health, utilization of health services and symptoms of hip and knee disease. Non-respondents were sent two reminders and contacted by phone, if necessary [9]. We screened people for knee pain using a modified version of the question used in the first National Health and Nutrition Examination Survey [11]: 'During the past 12 months, have you had pain in or around either of your knees on most days for 1 month or longer?' Participants who reported knee pain were invited for further examination either at a clinic or by home visit. Examinations were organized in two phases by location of participating practices (Fig. 1). During phase 1, the first 1249 participants who reported knee pain were invited for examination. During phase 2, 2062 participants were invited. In this phase, 904 participants under the age of 65 yr were excluded from invitation because their walking capacity was

not severely limited (self-reported walking time an hour or more) or was limited due to self-reported conditions unrelated to joint disease; these individuals were excluded from the extrapolations described below.

### Orthopaedic assessment

Interviewer-administered questionnaires were completed on knee pain and stiffness, activities of daily living, use of health services and referral to specialist care. Participants were asked whether they had received drug therapy for their knee pain in the previous year, whether they suffered from symptoms that might make them unfit for surgery (chest tightness, wheeze, breathlessness, chest pain or palpitations) and whether they would accept surgery if it were offered, with a follow-up question to elicit the reasons for their view. A clinical examination of hip, knee and lower back was carried out by a physician and a team of nurses with orthopaedic experience who had undergone a standard training programme.

### Criteria for case selection

As in the previous report on hip replacements [8], the New Zealand priority criteria for major joint replacement surgery [7] (New Zealand Score) were used for case selection for primary TKR. In a pilot study, agreement of the developed criteria with overall clinical judgement was found to be excellent [12]. The final composite score included subscores on pain (40 points), disability (20 points), clinical findings (20 points), multiple joint disease and ability to live independently (20 points), and ranged from 0 to 100 with higher scores reflecting more severe disease. No agreed cut-off point for case selection had been proposed originally. To reflect severe and moderate disease, however, we chose *a priori* threshold scores of 55 (primary cut-off) and 43 (secondary cut-off), respectively, as were used in the previous report on hip replacement [8]. Examples for degrees of pain and disability associated with these cut-off points have been published previously [8].

### Statistical methods

Incidence and prevalence calculations were identical to those published for hip disease [8]. We calculated age- and sex-specific prevalence of already replaced knees for those responding to the screening questionnaire. Then we estimated the prevalence of knee disease warranting total joint replacement (cut-off points 43 and 55 on the New Zealand Score) using extrapolations from the examined group of participants to the overall group reporting symptoms with age/sex-specific sampling fractions and the assumption that attendees and non-attendees were similar. New Zealand Scores were not assigned to knees that had already been replaced (Fig. 1).

Examiners found it difficult to complete the examination in people with severe knee disease, resulting in incomplete clinical data [odds ratio (OR) for missing clinical information per 10-point increase of New Zealand disability subscore 2.85, 95% confidence interval (CI) 2.14–3.81]. Excluding participants with incomplete data would have led to an underestimation of the population requirement for knee replacement. We therefore imputed scores for 193 right and 198 left knees with incomplete data (Fig. 1), using a multivariable linear regression model with the subscales on pain, disability, multiple joint disease and ability to live independently as predictor variables. Based on data from 1859 participants with complete information, we found excellent agreement between predicted and original scores (intraclass correlation coefficient 0.988, 95% CI 0.987–0.989).

Incidence was calculated by the method of Leske *et al.* [13], using the increase in prevalence between consecutive age bands to calculate age-specific incidence. Its assumptions have

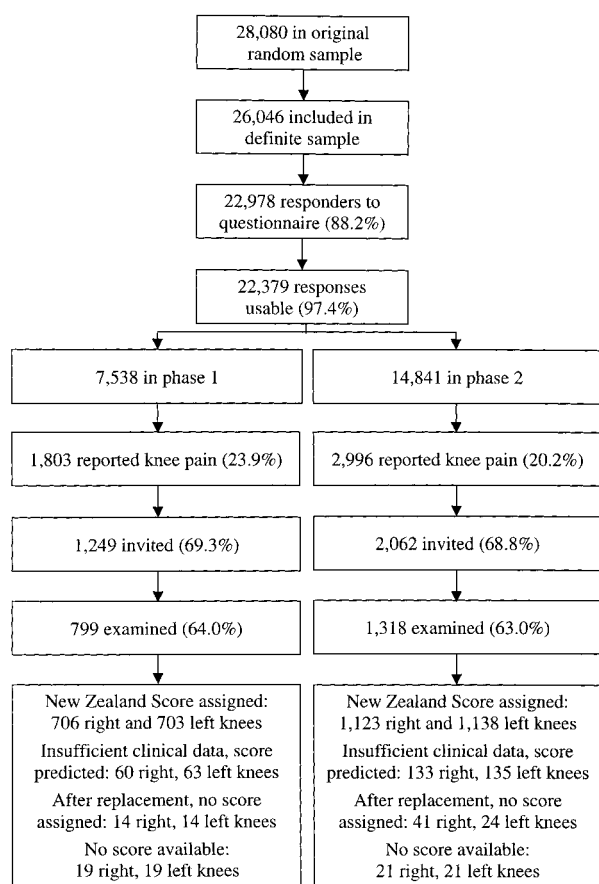


FIG. 1. Study flow diagram.

been discussed before [8]. We considered prevalence data for replaced and severely diseased knees (New Zealand Scores  $\geq 43$  or 55 points) separately and smoothed both by fitting quadratic models across age-groups in logistic regression analysis. Then we included age/sex-specific death rates. The annual number of TKRs needed in the population of England was calculated by multiplying point estimates and 95% CIs of age/sex-specific incidences by population figures for England. This number was modified by excluding those assumed to be unfit for surgery (self-reported chest tightness, wheeze, breathlessness, chest pain or palpitations many times a day or all the time), those who had not had a trial of medical therapy in the past year and those who indicated they might not accept surgery if offered. Since individuals were sampled within practices, we examined the effects of clustering on the standard error of the age- and sex-specific prevalence of self-reported knee pain [8].

For exploratory analyses, we defined index joints as the symptomatic hip or knee with the highest New Zealand Score (1302 index hips and 2056 index knees). We used logistic regression models to compare the use of health services and referral to specialist care for knee disease with that hip disease, using robust standard errors, which allowed for correlation within participants who suffered from both knee and hip disease, and adjusting for disease severity. In a further analysis we also adjusted for age, gender, and willingness and fitness for surgery; because of missing data this analysis was based on 2928 index joints only. Finally, we extracted the annual number of primary TKRs performed in English NHS hospitals from first episodes of 1997 Hospital Episode Statistics (codes W40.1, W41.1 and W42.1) [3]. The number of procedures performed independently was estimated using data from a 1997 national survey of private hospitals in England [14].

## Results

Figure 1 shows the flow of participants through the study. A total of 22 978 responded to the screening questionnaire, and 22 379 completed the question on knee pain; 4799 reported knee pain on most days for 1 month or longer in the past year (21.4%, 95% CI 20.9–22.0). Prevalence of knee pain increased with age, from 12.4% in those aged 35 to 44 yr (95% CI 11.6–13.3), to 37.8% in those aged 85 yr and above (95% CI 33.5–42.1), and was higher in women (23.6%, 95% CI 22.9–24.4) than in men (18.9%, 95% CI 18.1–19.6). The cluster design had negligible effects on the width of 95% CIs of age/sex-specific prevalences, with a median design factor of 1.12.

A total of 3311 participants with knee pain were invited for further examination (69.0%), and 2117 attended (63.9%). As reported for hip disease [8], attendees were more likely than non-attendees to have sought care for knee disease (data available on request); however, the differences were smaller than for hip disease. Attendance rates ranged from 46.0% in women aged 35–44 yr to 79.9% in men aged 65–74 yr.

Table 1 presents age/sex-specific estimates of the prevalence of TKR and severe knee disease. The prevalence of primary TKRs was 8.4 joints per 1000 people aged 35 yr and over (95% CI 7.2–9.5), considerably lower than that of total hip replacements. Using the primary cut-off of 55 points on the New Zealand Score, we found an

TABLE 1. Crude age/sex-specific prevalence of primary total knee replacement and severe knee disease (New Zealand Scores  $\geq 55$  points)

Gender	Age band (yr)	Rate per 1000 (95% CI)	
		Total knee replacement	Severe knee disease
Female	35–44	0.3 (0.0–1.0)	3.6 (0.2–7.0)
	45–54	2.6 (0.7–4.5)	9.4 (4.0–14.8)
	55–64	6.5 (3.3–9.7)	25.0 (17.0–33.1)
	65–74	15.0 (10.1–19.9)	60.1 (48.0–72.1)
	75–84	38.8 (29.0–48.7)	123.4 (101.5–145.3)
	$\geq 85$	41.9 (21.7–62.0)	122.0 (74.4–169.6)
	Total	10.7 (8.9–12.5)	37.3 (33.0–41.5)
Male	35–44	0.7 (0.0–1.8)	2.7 (0.0–5.7)
	45–54	1.6 (0.0–3.3)	14.4 (8.4–20.4)
	55–64	7.2 (3.7–10.7)	20.3 (12.9–27.8)
	65–74	8.5 (4.4–12.7)	21.9 (14.0–29.8)
	75–84	17.7 (9.1–26.4)	35.3 (19.8–50.8)
	$\geq 85$	20.3 (0.0–43.2)	30.6 (0.0–70.9)
	Total	5.5 (4.1–7.0)	15.6 (12.7–18.6)

estimated population prevalence of knee disease requiring total joint replacement of 27.4 joints per 1000 people aged 35 yr and over (95% CI 24.7–30.1), increasing to 64.3 with a cut-off of 43 points (95% CI 60.8–67.7).

Prevalence figures translated into an estimated incidence of 55 800 knees for a cut-off of 55 points (95% CI 40 700–70 900) and 101 500 knees for a cut-off of 43 points (95% CI 80 200–122 700), respectively, requiring TKR annually in England, contrasting sharply with the annual number of primary TKRs actually performed in 1997: 24 200 in the NHS [3] and an additional estimated 5100 in independent hospitals [14]. Figure 2 shows the effect on estimates when suitability for surgery and patients' preferences were accounted for, comparing results with those previously published for hips [8]. The number of people requiring TKRs decreased to about half of the initial estimate after exclusion of those who were unfit for surgery, had not had a trial of medical therapy and who had indicated they did not want a surgical intervention (29 100, 95% CI 16 300–41 900).

Willingness to consider surgery had a particular impact on incidence estimates. About one-third of participants considered for TKR indicated that they would not accept surgery if offered, irrespective of the cut-off point used. Table 2 documents some of the reasons for their view. The majority of participants was concerned about the risks and benefits of TKR. In multivariable logistic regression analysis, willingness to undergo surgery was more frequent in severe disease (OR per 10-point increase of the New Zealand Score, 1.57, 95% CI 1.47–1.66), but less frequent in the elderly (OR per 10-yr increase in age, 0.71, 95% CI 0.65–0.77) and in women (OR 0.60, 95% CI 0.49–0.74).

Data on health services utilization and referral to specialist care, comparing knee with hip disease, is summarized in Fig. 3. After adjustment for severity of disease those with knee disease were more likely than those with hip disease to have sought care from their GP, but less likely to have been referred to specialist care, to have consulted an orthopaedic surgeon or to be on a waiting list for joint replacement. Differences remained

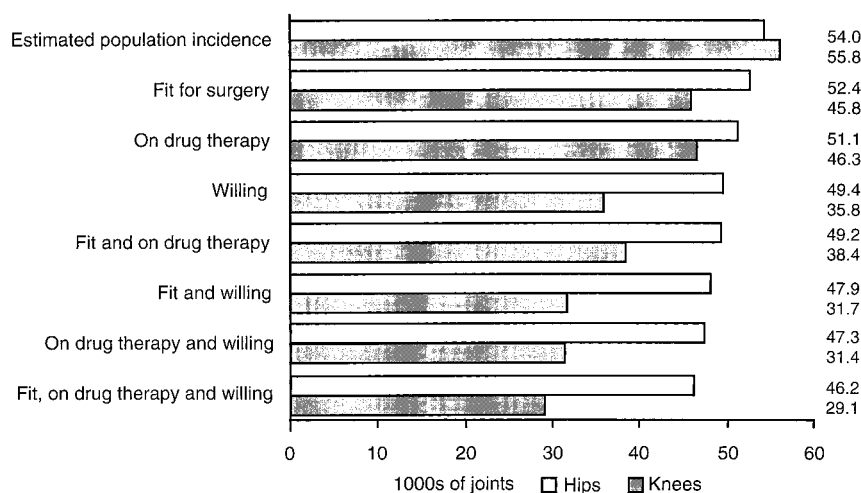


FIG. 2. Estimated annual number of incident knee and hip disease requiring primary total joint replacement surgery for those aged 35–85 yr in England. Expressed as 1000s of joints.

TABLE 2. Reasons for reluctance to undergo knee replacement surgery for participants with New Zealand Scores  $\geq$  55 points

	n (%)
Considered for total knee replacement	181
Unwilling to consider surgery	58 (32.0)
Information on reasons available	56
Concern about risks and benefits of surgery	26 (46.4)
Symptoms perceived as not severe enough	19 (33.9)
Too old	18 (32.1)
Comorbid conditions	12 (21.4)
Other reasons	7 (12.5)

The first 40 participants of phase 1 considered for TKR were excluded because they were not asked about reasons for refusing surgery. The sum of percentages does not add to 100% because more than one reason could be indicated.

after additional adjustment for age, gender, willingness and fitness for surgery (Fig. 3), and after restriction to severe disease only (data available on request).

### Discussion

Knee disease is very common in adults. In agreement with other UK-based studies [15], we found an overall prevalence of chronic knee pain of 21.4% in those aged

35 yr and over. However, the majority of people with knee pain do not suffer from severe disease. A variety of outcome instruments are available to help grade the severity of symptoms, such as Lequesne’s index [16] or WOMAC [17], but these instruments were not developed for case selection for TKR. In contrast, the priority criteria from Ontario, Canada [6] and New Zealand [7] were produced for this very reason.

The New Zealand Criteria [7] provide a numerical score which can be used to define indications for surgery from population-based data [9]. The question which then arises is what threshold of severity should be used to indicate likely need for joint surgery? The prevalence of participants with a New Zealand Score of 43 or more, which indicates a significant degree of pain and disability, was 4.2%, about one-fifth of the 21.4% reporting knee pain. When we increased the threshold to 55, which indicates severe disease of a sort that we consider severe enough to warrant surgery, the prevalence fell further, to 1.9%. Interventions such as TKR are provided on an incident basis, so we converted prevalence figures to incidence data. Using the higher cut-off point this translated to a calculated annual need for 55 800 TKRs, about twice the rate currently provided in England. Rates vary greatly in different countries [18], and our

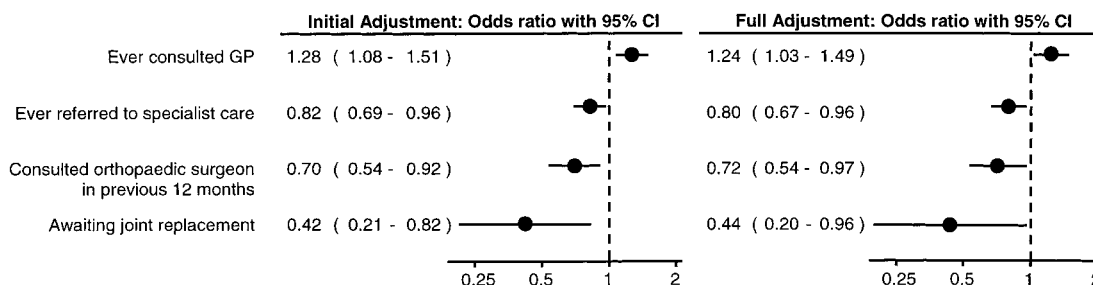


FIG. 3. Presented are ORs of use of health services and referral for knee compared with hip disease adjusted for disease severity (initial adjustment), and disease severity, age, gender, willingness and fitness for surgery (full adjustment). The questions asked related to the use of health services or referral specifically for the diseased index joint (2056 knees vs 1302 hips). An OR > 1 indicates that health services are more frequently used for knee disease, an OR < 1 indicates the opposite.

estimate of the likely population need accords well with the rates found in the USA [19], where adequate provision is assumed: 92 per 100 000 of the overall population, corresponding to about 58 000 operations performed annually in England.

When estimates were adjusted for potential modifiers of the decision to recommend surgery (fitness, willingness and previous drug therapy), the incidence estimates decreased to nearly one-half of the initial figures. Reluctance to undergo surgery appeared to have a particular impact. The most frequent reason for reluctance were concerns about the risks and benefits of TKR and the perception that symptoms were not severe enough to warrant surgery. Interestingly, women and older people were particularly unwilling to undergo knee surgery. Gender differences in attitudes towards surgery [20] and lay views that even severe knee disease is an expected accompaniment of ageing [18] may be responsible for this.

Although patient preference may play an important role, barriers at the level of care providers may also be involved. We found interesting differences between hip and knee disease in the pattern of health services utilization along the whole pathway to joint replacement [18], with a lower provision of care for knee disease. Referral patterns by primary care physicians may be of particular importance. Differences remained, however, when we adjusted for referral to specialist care (data available on request), indicating that differential provision of care may also be an issue at the level of specialists. Part of this difference may be due to the fact that hip disease often deteriorates rapidly, with a relatively sudden increase in the level of pain [21], while knee disease may follow a course of slower deterioration, giving patients and doctors more time to adjust to and accept increasing severity [22].

TKR was initially considered a poor intervention [5]. Many of the early designs failed, with hinged prosthesis designs causing particular problems. Current unrestrained designs are considered very successful, however [5]. Observational evidence suggests that these designs now result in long-term symptomatic benefit and survival rates that are comparable with those of contemporary hip replacements [23–27]. Negative perceptions among patients, and the differential rates of referral observed for knee and hip disease, which suggest negative attitudes among physicians as well, may be the now inappropriate legacy of the early failings of TKR. However, other recent data from our group suggest that patient outcomes may not always be as good as we might expect [28], so these findings indicate that TKR may be an intervention for which the views of rheumatologists, surgeons and evidence-based medicine sometimes conflict with those of the patients and their general practitioner.

The limitations of our approach to estimate population requirements for joint replacement have been discussed previously [8]. However, several limitations deserve further attention. First, there is no satisfactory evidence base to define criteria for case selection for TKR [18]. The consensus criteria [7] we chose are standardized and validated [12]; however, and the cut-off

points applied as possible thresholds for surgery (43 and 55 points on the New Zealand Score) correspond well to the severity of disease observed in the majority of patients assessed prior to total joint replacement in England [29, 30]. In one study recently performed on 203 randomly drawn patients from a waiting list for hip and knee replacement, about 60% had New Zealand Scores > 55, and approximately 80% > 43 [30]. In addition, radiographic findings may play a role in the decision to recommend surgery [31], but we have not incorporated radiographic findings into these criteria in view of the low attendance rate for radiographic examinations, low correlation between radiographic findings and clinical disease severity, and uncertainty as to how best to integrate radiographic information into the score.

Secondly, severe knee disease may be associated with comorbid conditions (such as severe obesity) [32], which may in turn increase mortality risk [33]. This would lead to an underestimation of the actual incidence of severe disease, though not affect the incidence estimates for the requirement for knee replacement. Thirdly, we had to include already replaced joints in our calculations in addition to those considered to warrant total joint replacement. Differences in current operation rates for hip and knee disease will therefore influence our incidence estimates. Because of the smaller prevalence pool of TKRs as compared with total hip replacements, our estimates tend to be more conservative than those previously published for hips [8]. Fourthly, we attempted to adjust incidence estimates for potential modifiers of the decision to recommend surgery. These modifiers were assessed by means of a standardized interview rather than through conversations with patients and orthopaedic surgeons. This does not reflect true clinical decision-making and may bias our adjustments. However, our approach was standardized and identical for hip and knee disease, and identified important differences.

In conclusion, we suggest that there is considerable underprovision of TKR in England. Our study indicates that this may not simply be due to a failure of the National Health Service to satisfy demand, but also because of reluctance by patients and doctors to consider surgery, even for severe knee disease. This suggests an urgent need for a review of policies for the management of knee disease in England.

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