A Prospective Population-Based Study of the Predictors of Undergoing Total Joint Arthroplasty

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Objective. To examine prospectively the predictors of time to total joint arthroplasty (TJA).

Methods. This was a prospective cohort study with a median followup time of 6.1 years. We included participants from an existing population-based cohort of 2,128 individuals, ages 55 years and older with disabling hip and/or knee arthritis and no prior TJA, from 2 regions of Ontario, Canada, 1 urban with low TJA rates and 1 rural with high rates. The main outcome measure was the occurrence of a TJA based on procedure codes in the hospital discharge abstract database.

Results. At baseline, the mean age of the patients was 71.5 years, 67.9% had a high school education or higher, 73.4% were women, the mean arthritis severity (Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC]) score was 41.1 (maximum possible score 100), and 20.0% were willing to consider TJA. Greater probability of undergoing TJA was associated with higher (worse) baseline WOMAC scores (hazard ratio [HR] 1.22 per 10-unit increase, $P < 0.001$), age (compared with age ≤62 years, the HR increased to 1.57 for 63–68 years, 1.46 for 69–74 years, and 1.51 for 75–81 years, and fell to 0.44 for ≥82 years; $P < 0.05$ for all), better health (HR 1.14 per 10-unit increase in Short Form 36 general health survey score, $P < 0.001$), and willingness to consider TJA (HR 4.92, $P < 0.001$). When willingness was excluded from the model, education level, but not sex or income, became a significant predictor of TJA receipt.

Conclusion. Willingness to consider TJA was the strongest predictor of the time to first TJA. Given that previous research indicates that willingness is largely explained by perceptions of the indications for and risks associated with TJA and not disease severity, this finding supports the need for population education about arthritis treatments, including TJA.

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Submitted for publication March 10, 2006; accepted in revised form June 30, 2006.

Osteoarthritis (OA) is a major cause of disability worldwide (1). Total joint arthroplasty (TJA) is a highly cost-effective procedure for the management of hip and knee OA (2,3). Despite this, variations in the rates of TJA by region, sex, race, and socioeconomic status (SES) have been shown (4–9). These studies, however, have been based largely on cross-sectional analyses of administrative data that tell us about who is undergoing surgery, but provide little information about determinants of access to care. No studies have prospectively examined predictors of receipt of TJA in community cohorts or considered the impact of subjects' preferences in determining access to care.

The Andersen behavioral model (10) posits that health services use is influenced by 3 groups of factors: 1) predisposing factors, including sociodemographics and health beliefs (11–13); 2) enabling factors, including health insurance, living circumstances, and social support (14–17); and 3) need factors, including the health condition that warrants treatment. Determining whether and how these factors predict use of TJA is essential as a first step toward guiding the development of interven-

tions designed to reduce modifiable barriers to appropriate care.

Our prior work suggests that another important predisposing factor affecting TJA rates is the individual's willingness to consider TJA as a treatment option (18). In a cross-sectional population-based study in 2 regions of Ontario, Canada, 1 with high TJA rates and 1 with low rates, we examined the appropriateness of current TJA rates, taking into consideration both arthritis severity and preferences for care, or "willingness" (18). Among appropriate TJA candidates, <15% reported willingness to consider TJA. Unwillingness was largely explained by misperceptions regarding the indications for TJA, e.g., participants overestimated the degree of pain and disability at which TJA is indicated (19). Lower SES was associated with greater perceived risks of TJA, and both female sex and lower SES were associated with being less likely to have received a recommendation from family or friends to pursue TJA. These findings suggest that systematic differences in willingness by sex and SES may partly explain documented disparities in TJA use, and that strategies to improve subjects' understanding of the indications for and outcomes of TJA will increase willingness more in women and in those with lower SES, effectively reducing disparity.

The objective of the current study was to prospectively examine the predictors of time to receipt of a first TJA over a defined followup period in a population-based cohort with disabling hip/knee arthritis, with a particular focus on the effect of individuals' preferences for care (willingness). We have previously shown that even among appropriate candidates for TJA who report willingness to consider TJA as a treatment option there is significant unmet need for this procedure. We hypothesized that willingness would be a major predictor of time to TJA.

SUBJECTS AND METHODS

Details of this study have been published previously (7,8,18). This was a 3-phase study of 100% of the population 55 years and older residing in 2 regions of Ontario, Canada, 1 rural with high TJA rates and 1 urban with low rates. Ontario has a publicly funded health care system with access to orthopedic care via referral from another physician.

Study design. The institutional research ethics review board of the University of Toronto approved this study. In phase I, conducted between 1995 and 1997, a brief mail/telephone questionnaire was used to assess the presence of symptomatic joints and specific functional disabilities. Of 28,451 phase I respondents, 3,307 were selected for phase II based on self-reported difficulty in the last 3 months with stair

climbing, arising from a chair, standing, and walking; swelling, pain, or stiffness in any joint lasting at least 6 weeks; and indication on a diagram that a hip and/or knee had been "troublesome."

In phase II, a second mail/telephone questionnaire was used to assess the severity of the respondents' hip/knee complaints (using the Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC] subscale and total scores) (20), self-reported health status (using the Short Form 36 general health subscale) (21), comorbidity (on a list of 18 concurrent health problems, respondents indicated those for which they were receiving treatment or had seen a physician in the past year, plus body mass index [BMI], calculated from height and weight), whether they were currently under the care of a physician for their arthritis (yes/no), highest level of education (elementary, high school, post–high school), gross annual household income (≤$20,000, $21,000–$40,000, $41,000–$60,000, >$60,000), race (white, nonwhite), employment status (currently employed for pay [yes/no], farming [yes/no]), and living circumstances (nursing home, independent with others, independent alone). A subset of phase II respondents who had severe hip or knee arthritis (WOMAC summary score ≥39 based on phase II responses [maximum possible score 100]) and who had neither undergone prior TJA nor were on a TJA waiting list then completed a standardized in-person interview to determine their willingness to consider TJA. Willingness was assessed on a 5-point scale ranging from "definitely not willing" to "definitely willing."

Followup study. In 1999, phase II cohort members were invited to participate in a 5-year followup study: 2,103 were alive and agreed. There were no substantial (>5%) differences in sociodemographic characteristics between the original phase II cohort and the 2,103 who agreed to participate in the followup study. Annual followup was by telephone interview. In addition to those variables collected at baseline (phase II), at each followup visit all respondents were asked to indicate their willingness to consider TJA (5-point scale from "definitely not willing" to "definitely willing") and about their use of arthritis therapies. Annual survey response rates, adjusted for deaths and inability to complete, ranged from 78% to 85%.

Respondents' survey information was linked with administrative databases to determine receipt of TJA. Consent for linkage was obtained from all living phase II participants, regardless of their participation in the prospective study. Probabilistic matching (Automatch 4.0; MatchWare Technologies, Silver Spring, MD) was used to match the name, address, month/year of birth, and sex of all phase II participants with records in Ontario's health care registry, the Registered Persons Database, to obtain their unique health care numbers (HCNs). An encryption of the HCN was used to link the survey data with inpatient Discharge Abstract Data from the Canadian Institute for Health Information (CIHI) using a previously defined, valid methodology (22–24) to determine provision of TJA. The discharge data were searched retrospectively back to April 1, 1988, to ensure that there were no records of prior TJAs, and forward from the baseline assessment (date of completion of phase II) to March 31, 2003, to establish the date of the first TJA.

CIHI records were searched for the presence of a procedure field containing a Canadian Classification of Ther-

Table 1. Baseline characteristics of the Ontario hip/knee arthritis cohort (excluding those with a prior TJA)*

Characteristic	Overall	Urban region	Rural region
No. of patients	2,128	970	1,158
Age, mean ± SD years	71.5 ± 9.5	72.3 ± 9.8	70.9 ± 9.2†
Women, no. (%)	1,561 (73.4)	725 (74.7)	836 (72.2)
White, no. (%)	1,967/2,047 (96.1)	868/940 (92.3)	1,099/1,107 (99.3)†
Living alone, independently, no. (%)	644/2,076 (31.0)	370/949 (39.0)	274/1,127 (24.3)†
Education less than high school, no. (%)	658/2,051 (32.1)	267/933 (28.6)	391/1,118 (35.0)†
Income ≤$20,000/year, no. (%)	1,131/1,752 (64.6)	512/790 (64.8)	619/962 (64.3)
WOMAC score, mean ± SD (maximum 100)‡			
Total	41.1 ± 19.7	41.6 ± 20.5	40.6 ± 19.0
Pain	41.4 ± 21.7	41.7 ± 22.4	41.1 ± 21.1
Physical function	40.6 ± 20.7	41.4 ± 21.6	40.0 ± 20.0
Stiffness	43.5 ± 23.1	42.8 ± 23.6	44.2 ± 22.6
Body mass index, mean ± SD kg/m² (n = 1,905)	27.7 ± 5.4	27.5 ± 5.4	27.9 ± 5.5
Comorbid conditions, no. (%)			
0	589 (27.7)	269 (27.7)	320 (27.6)
1	636 (29.9)	296 (30.5)	340 (29.4)
≥2	903 (42.4)	405 (41.8)	498 (43.0)
Short Form 36 general health subscale score, mean ± SD (n = 2,058)§	47.8 (22.1)	47.9 (22.6)	47.7 (21.7)
Employed, no. (%)	54/1,308 (4.1)	22/570 (3.9)	32/738 (4.3)
Seen a physician in the past year for hip/knee problems, no. (%)	1,024 (48.1)	505 (52.1)	519 (44.8)
Definitely or probably willing to consider TJA, no. (%)	313/1,564 (20.0)	135/699 (19.3)	178/865 (20.6)

* TJA = total joint arthroplasty; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.
† $P < 0.001$ versus urban.
‡ Higher scores indicate greater arthritis symptoms and disability.
§ Higher scores indicate better general health status; scores have been rescaled to lie between 0 and 100.

apeutic, Diagnostic and Surgical Procedure (CCP) code of 93.51 or 93.59, indicating hip replacement, or a CCP code of 93.41, indicating knee replacement. The International Statistical Classification of Diseases and Related Health Problems, Tenth Revision/CCI classification (ICD–10CCI was implemented in Ontario in 2002–03. Hip replacements were identified using the rubric of 1.VA.53; knee replacements were identified using the rubric of 1.VG.53. TJAs for fractures and cancers were excluded. In 2000, new CCP codes for revisions were added: 93.40 (for knees) and 93.52, 93.53, 93.65, 93.66, 93.67, and 93.68 (for hips). These were used to further identify and exclude revisions.

The outcome of interest was the length of time from completion of the phase II survey (January 20, 1996, to August 17, 1998) to the first TJA. Using the Andersen model (10) as a framework, predictor variables were categorized as predisposing factors, such as sex, age (quintiles), education (less than high school, high school, post–high school), BMI, race, farming status (yes/no), employment status (currently employed for pay [yes/no]), and willingness to consider TJA (definitely or probably willing versus unsure or probably or definitely unwilling); enabling factors, such as region (urban/rural), income (≤$20,000, $20,001–$40,000, >$40,000), living circumstances (alone versus with others), consulted a physician for arthritis in prior year (yes/no); and need factors, such as WOMAC pain, stiffness, physical function, and total scores, comorbidity (0, 1, or >2 conditions), and type of arthritis (OA versus non-OA).

With the exception of arthritis type, willingness, farming, and current employment status, all predictor variables were derived from baseline (phase II) responses. Willingness

to consider TJA as a treatment option was based on responses at baseline (for those in the phase II subset noted above) and yearly followup assessments (for those who agreed to participate in longitudinal followup), with those who were either definitely or probably willing defined as "willing" and those who were unsure or definitely or probably unwilling defined as "unwilling."

Statistical analysis. Categorical variables were compared using chi-square tests or the Cochran-Armitage test for trend; continuous variables were compared using 2-sample t-tests. The effect of each predictor on time to TJA was evaluated using the Kaplan-Meier curve (for categorical predictors) or the Cox proportional hazards model (for continuous predictors). Cox proportional hazards modeling was used to obtain a multivariate regression model for the independent predictors of time to first TJA. Farming and employment status were treated as time-dependent variables using participants' responses at all available assessments. Using the definitions outlined above, willingness was categorized at each time point as willing, unwilling, or data missing. Willingness was also treated as a time-varying covariate to incorporate the fact that willingness changed over time.

Since the primary care physician might be expected to influence decision-making regarding TJA, we examined the effect of clustering of participants by primary care physician. The physician was determined for each participant using information available from the Ontario Health Insurance Plan physician billing database for the year prior to the participant's phase II completion date. Of the 2,128 participants, 137 did not see a primary care physician in the year prior to phase II

completion. The remaining 1,991 participants visited 589 physicians. Of the 589 physicians, 349 (59.3%) saw only 1 participant, 82 (13.9%) saw 2 participants, 43 (7.3%) saw 3 participants, and the remaining 115 (19.5%) saw 4 or more participants, giving a median cluster size of 1. (Removing highly and moderately clustered participants from the analyses did not change the results.)

Interactions between sex and other variables (WOMAC scores, income, education level, and age) and between income and education level were also investigated. The assumption of proportional hazards was checked for all models. All analyses were performed using SAS software, version 8.2 (SAS Institute, Cary, NC). *P* values less than 0.05 were considered significant.

RESULTS

Cohort characteristics at baseline (phase II). Of the 3,307 individuals selected for phase II, 2,411 completed the phase II questionnaire (response rate, adjusted for deceased and ineligible, of 82%). All 2,411 phase II respondents were successfully matched to HCNs in the Registered Persons Database. Of these, 2,128 (88.3%) had no history of a prior TJA and were included in this analysis; their baseline (phase II) characteristics are shown in Table 1. Individuals in the urban region were slightly older and more likely to be nonwhite, to have received post–high school education, and to be living alone. Of the 2,128 participants, 971 (45.6%) were unsure or unwilling to consider TJA at all followup interviews, 43 individuals (2.0%) were willing at all followup interviews, and 550 (25.8%) were willing at some but not all followup interviews, and 564 (26.5%) had a missing value for willingness at all assessments (i.e., phase II respondents who were neither in the baseline subset for whom willingness was assessed nor had participated in the followup study).

Correlates of receipt of a postbaseline TJA. The average followup time was 5.2 years (median 6.1 years; range 2 days–7.2 years). Two hundred fifty-four individuals (11.9%) underwent 1 or more TJA procedures during followup; 89 (35.0%) of the first TJA procedures were hip replacements, and the remainder were knee replacements. Figure 1 shows the Kaplan-Meier curve of time to TJA and the percentage of individuals ever versus never willing to consider TJA. The overall rate of TJA within the study population was similar in the 2 regions (urban region 12.1%, rural region 11.8%). When the predictors were examined individually, the predisposing factors baseline age in the middle range, higher BMI, higher education level, and willingness to consider having TJA; the enabling factors having consulted a physician about arthritis in the prior year and lower
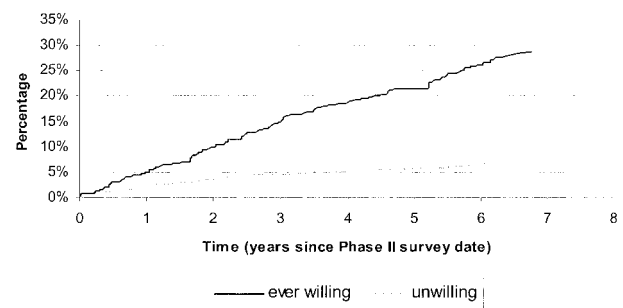

Figure 1. Kaplan-Meier curve of cumulative percentage of subjects who underwent a total joint arthroplasty.

income; and the need factors better health status and higher WOMAC score were associated with receipt of a TJA. No effects were seen for living circumstances, region, sex, employment or farming, race, or arthritis type. The unadjusted association between each variable and receipt of TJA is shown in Table 2.

Predictors of time to first TJA (multivariate analysis). The likelihood of undergoing a TJA was significantly greater among individuals in the mid-age quintiles, those with higher WOMAC total scores, those with better general health, and those willing to consider TJA (Table 3). A nonlinear relationship was found between age and time to TJA. Compared with individuals in the lowest quintile for age (≤62 years), those in the middle 3 quintiles (ages 63–81 years) were more likely and those in the highest quintile for age (≥82 years) were less likely to undergo a TJA during the followup period. After adjustment for age, arthritis severity, general health status, and willingness, neither education, sex, income, nor a sex–income interaction was observed to affect time to TJA. The predictors of time to hip replacement versus time to knee replacement did not differ (data not shown).

Since our prior work suggested that several key correlates of willingness vary systematically by sex and SES, we also modeled time to TJA excluding willingness, but including sex, education level, and income. When willingness was excluded from the model, education level was significantly associated with receipt of TJA (*P* = 0.020) and showed a clear trend of increasing likelihood of having a TJA with more education. Compared with the reference group of people with less than a high school education, the risk ratio for high school education was 1.18 (*P* = 0.28) and for those with post–high school education it was 1.63 (*P* = 0.008). However, when willingness was included in the model, education level was no longer significant (*P* = 0.059).

Table 2. Correlates of receipt of postbaseline TJA, by univariate analysis (n = 2,128)

Variable (n)	Percentage with postbaseline TJA	Hazard ratio (95% CI)	P*
Predisposing factors			
Sex			0.570
Female (1,561)	12.4	1.00 (reference)	
Male (567)	10.8	0.92 (0.69–1.23)	
Age quintile, years			<0.001
≤62 (449)	12.3	1.00 (reference)	
63–68 (408)	16.9	1.47 (1.03–2.10)	
69–74 (455)	14.3	1.28 (0.89–1.83)	
75–81 (450)	12.2	1.15 (0.79–1.67)	
≥82 (366)	2.7	0.28 (0.14–0.55)	
Education			0.020
Less than high school (658)	9.7	1.00 (reference)	
High school (1,019)	11.8	1.19 (0.88–1.61)	
Post–high school (374)	15.2	1.54 (1.08–2.20)	
Body mass index, kg/m^2			0.004
<24 (468)	9.4	1.00 (reference)	
24–27 (442)	10.6	1.02 (0.67–1.53)	
28–30 (428)	12.4	1.17 (0.79–1.75)	
>30 (567)	15.5	1.48 (1.03–2.12)	
Race			0.910
White (1,967)	11.8	1.00 (reference)	
Nonwhite (80)	11.2	0.96 (0.50–1.88)	
Employment status			0.810
Not employed for pay (1,254)	16.1	1.00 (reference)	
Employed for pay (54)	16.7	1.09 (0.56–2.12)	
Farming status			0.480
Nonfarmer (1,954)	11.7	1.00 (reference)	
Current farmer (174)	14.4	1.16 (0.77–1.75)	
Willingness to consider TJA as a treatment option			<0.001
Unsure/unwilling (1,251)	10.4	1.00 (reference)	
Willing (313)	31.0	3.20 (2.46–4.16)	
Missing information (564)	4.8	0.62 (0.41–0.94)	
Enabling factors			
Region			0.910
Rural (1,158)	11.8	1.00 (reference)	
Urban (970)	12.1	0.99 (0.77–1.27)	
Annual household income			0.021
≤$20,000 (1,131)	11.9	1.00 (reference)	
$20,000–$40,000 (477)	12.4	1.00 (0.74–1.36)	
>$40,000 (144)	8.3	0.61 (0.34–1.10)	

Sex and income were not significant predictors of time to TJA, regardless of whether we adjusted for education level or willingness (data not shown). However, both sex and income were significantly correlated with education level. Of those with less than a high school education, 29.6% were male, of those with a high school education, 25.2% were male, and of those with post–high school education, 24.6% were male (P = 0.047 by Cochran-Armitage trend test). Similarly, 81.6% of those with an annual income <$20,000 were women, compared with only 58.7% of those reporting an income of between $20,000 and $40,000, and 54.2% of those reporting an income >$40,000.

DISCUSSION

Equity in health care use is demonstrated when care is primarily determined by health-related need factors, and inequity is demonstrated when care is largely explained by enabling and predisposing factors (25). In our study, among individuals willing to consider TJA, need (more severe arthritis) was associated with greater likelihood of undergoing a TJA. However, while need factors were significant predictors of time to TJA, by far the strongest determinant was the individual's preference for surgery (willingness). Among individuals with similar arthritis severity and health status, the

Table 2. *(Cont'd)*

Variable (n)	Percentage with postbaseline TJA	Hazard ratio (95% CI)	P*
Living circumstances			0.079
Lives with others, independently (1,391)	12.8	1.00 (reference)	
Lives alone, independently (644)	10.4	0.56 (0.28–1.12)	
Institutionalized (41)	0	†	
Saw a physician for arthritis in the prior year			<0.001
No (1,104)	9.6	1.00 (reference)	
Yes (1,024)	14.4	1.60 (1.25–2.05)	
Need factors			
WOMAC pain score, quartile (maximum 100)‡			<0.001
<25 (431)	7.7	1.00 (reference)	
25–40 (616)	11.5	1.50 (0.99–2.26)	
41–55 (581)	13.9	1.92 (1.28–2.87)	
>55 (466)	13.9	2.03 (1.33–3.08)	
WOMAC physical function score, quartile (maximum 100)			<0.001
<25 (474)	8.2	1.00 (reference)	
25–41 (586)	12.1	1.50 (1.02–2.22)	
42–54 (530)	13.4	1.82 (1.23–2.68)	
>54 (498)	13.9	1.93 (1.30–2.86)	
WOMAC total score, quartile (maximum 100)			<0.001
<27 (507)	8.1	1.00 (reference)	
27–43 (576)	11.5	1.45 (0.98–2.14)	
44–54 (492)	13.0	1.80 (1.22–2.66)	
>54 (507)	15.4	2.17 (1.49–3.16)	
Short Form 36 general health subscale score, quartile (maximum 100)			0.004
0–25 (417)	9.8	1.00 (reference)	
26–46.5 (583)	8.7	0.84 (0.56–1.27)	
47–66.5 (536)	13.6	1.30 (0.88–1.90)	
67–100 (522)	15.5	1.44 (0.99–2.10)	
No. of comorbidities			0.010
0 (589)	14.9	1.00 (reference)	
1 (636)	12.4	0.82 (0.61–1.11)	
≥2 (903)	9.6	0.68 (0.50–0.91)	
Arthritis type			0.530
Noninflammatory (1,968)	12.0	1.00 (reference)	
Inflammatory (160)	11.2	0.86 (0.53–1.39)	

* *P* values for the categorical variables were obtained using Kaplan-Meier tests. The continuous variables were compared using Cox proportional hazards regression. Ordinal variables (education level, income, comorbidities) were also tested using Cox proportional hazards regression in order to capture the ordinal nature of these variables. For the purpose of this table, the continuous variables, with the exception of age, have been collapsed into quartiles in order to illustrate their effects on the proportion of subjects who received a total joint arthroplasty (TJA). Age, which had a significant quadratic term in the Cox proportional hazards regression, has been collapsed into quintiles, chosen to best capture the trend revealed by the Cox proportional hazards regression.
† The hazard ratio and 95% confidence interval (95% CI) for individuals living in an institution could not be estimated because there were no TJA procedures performed in this group.
‡ WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

probability of undergoing a TJA was almost 4 times greater among those willing to consider TJA than for those who were unsure or unwilling. This finding suggests that unwillingness to consider TJA, which our prior work has linked mainly to misperceptions about the indications for and risks associated with TJA (19), poses a significant, potentially modifiable barrier to the use of TJA. Of note, even among those who consistently re-

ported willingness to consider TJA, only 26% underwent a hip or knee replacement during the period of observation, again suggesting that there is a significant unmet need for TJA among those who might benefit.

Although the majority of participants were consistent over time in their willingness to consider TJA as a treatment option (most were unwilling or unsure when first surveyed and retained that opinion for all subse-

Table 3. Predictors of time to TJA in individuals with no prior TJA, by multivariate analysis*

Predictor variable	Hazard ratio (95% CI)	P
Age quintile, years		
≤62	1.00 (reference)	–
63–68	1.57 (1.10–2.25)	0.014
69–74	1.46 (1.01–2.10)	0.043
75–81	1.51 (1.03–2.20)	0.035
≥82	0.44 (0.22–0.88)	0.020
WOMAC total score (per 10-point increase in score)	1.22 (1.13, 1.31)	<0.001
Short Form 36 general health subscale (per 10-point increase in score)	1.14 (1.07–1.21)	<0.001
Willingness to consider TJA as a treatment option		
Unsure/unwilling	1.00 (reference)	
Willing	4.92 (3.73–6.44)	<0.001
Missing information	0.88 (0.57–1.34)	0.54

* TJA = total joint arthroplasty; 95% CI = 95% confidence interval; WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

quent surveys), a small proportion (11%) of the respondents had a "stable" change of mind, that is, they changed their opinion and then stayed with the new opinion (another 6% changed their mind between the fourth and the fifth surveys, so there is no way to tell whether the new opinion persisted over time). The remainder of the respondents changed their minds more than once. Because we did not ask why participants changed their minds, we can only speculate, based on our prior research, that their willingness changed in response to factors such as increased pain, new information (e.g., knowing someone else who underwent a TJA and had a good or bad outcome), and/or changes in circumstances (illness of a spouse). Further research is warranted to better understand the factors that impact willingness.

Of the predisposing and enabling factors posited by the Andersen model to affect health care use (10), only age was associated with time to TJA. Adjusting for general health status, arthritis severity, and willingness, participants in both the youngest and the oldest cohorts were less likely to undergo a TJA during the followup period than those in the mid-age groups (63–81 years). These findings are consistent with those of a previous survey of Ontario orthopedic surgeons (26), in which 86.8% of surgeons reported lower likelihood of performing a total knee replacement (TKR) if the patient was younger (<55 years) and 20.8% reported lower likelihood of performing a TKR if the patient was elderly (>80 years). Physicians' reluctance to perform TJA in

younger individuals may be due to perceptions about the projected lifespan of the replaced joint, while reluctance to operate in older patients may reflect lower perceived benefit. Our results indicate a need for knowledge dissemination about the success of TJA in the "well elderly" and current projections for prosthesis survival following surgery in younger individuals in order to ensure appropriate access to TJA in these age groups.

Sex and SES were not found to be independent predictors of time to TJA. However, this should not be considered evidence that disparity in access to TJA does not exist. Instead, we would propose that our results indicate that the influence of sex and SES on TJA rates is mediated by willingness, which, in turn, is directly related to the probability of undergoing a TJA. We have previously shown that social network factors that are related to willingness, including encouragement by family or friends to seek a doctor's advice about TJA and knowledge of someone who has successfully undergone TJA, differ systematically by sex and SES. Furthermore, when willingness was removed from our final model, greater level of education in individuals with similar arthritis severity and health status was associated with greater likelihood of undergoing a TJA. Together, these results suggest that level of education is the prime factor among sex, education level, and income that determines willingness to consider TJA.

Our findings are inconsistent with those of cross-sectional studies that suggest that region of residence is an independent determinant of the likelihood of having undergone TJA (4,9). Among members of our community cohort with similar need and willingness, the rates of TJA were comparable regardless of region of residence. This is despite the fact that, over the same time period, the underlying population rate of TJA was ~2-fold higher in the high-rate versus the low-rate region. This finding confirms our prior assertion that regional variations in TJA rates are explained, in part, by regional differences in prevalence of severe arthritis and preferences for care.

Only one prior study has prospectively examined factors predicting receipt of TJA in a population sample. Birrell et al prospectively examined the determinants of being slated for total hip replacement (THR) among new patients presenting to primary care for hip pain in the UK (27). Of 195 new patients who presented with hip pain between 1994 and 1997, 7% were put on a THR waiting list within 1 year, and 23% within 4 years. Consistent with our findings, worse pain and physical disability were associated with a higher likelihood of being put on a waiting list, as was reduced hip range of

motion and greater radiographic severity. Unfortunately, in that study, the effect of nonclinical factors, such as age, sex, and SES, was not assessed.

Strengths of our study include its large sample size and prospective design. Unlike prior studies, our cohort was recruited from the community rather than at the level of the health care provider, thus it included both those who chose to seek care for their arthritis as well as those who did not or could not. Preferences for care were determined and factored into our analyses.

However, our study also has potential limitations. First, access to an elective surgery such as TJA is highly complex, and we have likely considered only a subset of the factors that determine access to this procedure. Second, we used willingness as a proxy for individuals' preferences for TJA and cannot comment on the impact of individual components of willingness (e.g., risk perceptions) on access to TJA. Third, the study was conducted in 2 Ontario regions; the results may not be generalizable to other Ontario regions, other Canadian provinces, or other countries where health care system factors are different. Fourth, we did not collect information on, and thus could not examine the impact of, the duration of severe arthritis symptoms on receipt of TJA. Finally, we did not examine time to a second or a revision TJA among individuals with a prior TJA. We anticipate the factors that predict time to subsequent surgery will differ from those for primary TJA for many reasons, including greater urgency, prior relationship with an orthopedic surgeon, and less variability in willingness to undergo the procedure.

In conclusion, in a population-based cohort with disabling hip or knee arthritis, willingness to consider TJA was the primary determinant of time to receipt of a first TJA. Adjusting for willingness, we found no effect on time to TJA for sex, education level, income, race, or region of residence. However, when willingness was dropped from the model, education level became a prime determinant of receipt of TJA. These results provide further evidence that education is strongly related to key determinants of one's willingness to consider TJA. As such, willingness mediates the effect of sex and SES on receipt of this procedure. These findings highlight once again (16) the need for the development and implementation of strategies directed at the level of health care delivery, possibly through population education programs about arthritis and its treatment, and in particular about the indications for and expected outcomes of specific interventions such as TJA.

REFERENCES

1. Murray CJ, Lopez AD, editors. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Boston: Harvard University Press; 1996.
2. Chang RW, Pellisier JM, Hazen GB. A cost-effectiveness analysis of total hip arthroplasty for osteoarthritis of the hip. JAMA 1996;275:858–65.
3. Liang MH, Larson M, Thompson M, Eaton H, McNamara E, Katz R. Costs and outcomes in rheumatoid arthritis and osteoarthritis. Arthritis Rheum 1984;27:522–9.
4. Katz BP, Freund DA, Heck DA, Dittus RS, Paul JE, Wright J, et al. Demographic variation in the rate of knee replacement: a multi-year analysis. Health Serv Res 1996;31:125–40.
5. Hoaglund FT, Oishi CS, Gialamas GG. Extreme variations in racial rates of total hip arthroplasty for primary coxarthrosis: a population-based study in San Francisco. Ann Rheum Dis 1995;54:107–10.
6. Escalante A, Barrett J, del Rincon I, Cornell JE, Phillips CB, Katz JN. Disparity in total hip replacement affecting Hispanic Medicare beneficiaries. Med Care 2002;40:451–60.
7. Hawker GA, Wright JG, Coyte PC, Williams JI, Harvey B, Glazier R, et al. Differences between men and women in the rate of use of hip and knee arthroplasty. N Engl J Med 2000;342:1016–22.
8. Hawker GA, Wright JG, Glazier RH, Coyte PC, Harvey B, Williams JI, et al. The effect of education and income on need and willingness to undergo total joint arthroplasty. Arthritis Rheum 2002;46:3331–9.
9. Skinner J, Weinstein JN, Sporer SM, Wennberg JE. Racial, ethnic, and geographic disparities in rates of knee arthroplasty among Medicare patients. N Engl J Med 2003;349:1350–9.
10. Andersen RM. Revisiting the behavioral model and access to medical care: does it matter? J Health Soc Behav 1995;36:1–10.
11. Nease RF Jr, Kneeland T, O'Connor GT, Sumner W, Lumpkins C, Shaw L, et al, and the Ischemic Heart Disease Patient Outcomes Research Team. Variation in patient utilities for outcomes of the management of chronic stable angina: implications for clinical practice guidelines [published erratum appears in JAMA 1995;274:612]. JAMA 1995;273:1185–90.
12. Llewellyn-Thomas HA, Williams JI, Levy L, Naylor CD. Using a trade-off technique to assess patients' treatment preferences for benign prostatic hyperplasia. Med Decis Making 1996;16:262–82.
13. Cher DJ, Miyamoto J, Lenert LA. Incorporating risk attitude into Markov-process decision models: importance for individual decision making. Med Decis Making 1997;17:340–50.
14. Schulman KA, Berlin JA, Harless W, Kerner JF, Sistrunk S, Gersh BJ, et al. The effect of race and sex on physicians' recommendations for cardiac catheterization [published erratum appears in N Engl J Med 1999;340:1130]. N Engl J Med 1999;340:618–26.
15. Epstein AM, Taylor WC, Seage GR III. Effects of patients' socioeconomic status and physicians' training and practice on patient-doctor communication. Am J Med 1985;78:101–6.
16. Van Ryn M, Burke J. The effect of patient race and socio-

economic status on physicians' perceptions of patients. Soc Sci Med 2000;50:813–28.

17. Ayanian JZ. Race, class, and the quality of medical care. JAMA 1994;271:1207–8.

18. Hawker GA, Wright JG, Coyte PC, Williams JI, Harvey B, Glazier R, et al. Determining the need for hip and knee arthroplasty: the role of clinical severity and patients' preferences. Med Care 2001;39:206-16.

19. Hawker GA, Wright JG, Badley EM, Coyte PC, for the Toronto Arthroplasty Health Services Research Consortium. Perceptions of, and willingness to consider, total joint arthroplasty in a population-based cohort of individuals with disabling hip and knee arthritis. Arthritis Rheum 2004;51:635–41.

20. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to anti-rheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15:1833–40.

21. Ware JE, Snow KK, Kosinski M, Gandek B. SF-36 health survey: manual and interpretation guide. Boston: The Health Institute, New England Medical Center; 1993.

22. Newcombe HB. Handbook of record linkage: methods for health and statistical studies, administration and business. New York: Oxford University Press; 1988.

23. Tu JV, Naylor CD, and the Steering Committee of the Provincial Adult Cardiac Care Network of Ontario. Coronary artery bypass mortality rates in Ontario: a Canadian approach to quality assurance in cardiac surgery. Circulation 1996;94:2429–33.

24. Badley EM, Glazier RH, editors. Arthritis and related conditions in Ontario: ICES research atlas. 2nd ed. Toronto: Institute for Clinical Evaluative Sciences; 2004.

25. Jacobi CE, Triemstra M, Rupp I, Dinant HJ, van den Bos GA. Health care utilization among rheumatoid arthritis patients referred to a rheumatology center: unequal needs, unequal care? Arthritis Rheum 2001;45:324–30.

26. Wright JG, Coyte P, Hawker G, Bombardier C, Cooke D, Heck D, et al. Variation in orthopedic surgeons' perceptions of the indicators for outcomes of knee replacement. CMAJ 1995;152: 687–97.

27. Birrell F, Afzal C, Nahit E, Lunt M, Macfarlane GJ, Cooper C, et al. Predictors of hip joint replacement in new attenders in primary care with hip pain. Br J Gen Pract 2003;53:26–30.