

# Neighborhoods Matter

## Use of Hospitals With Worse Outcomes Following Total Knee Replacement by Patients From Vulnerable Populations

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**Background:** Neighborhood sociodemographic characteristics are associated with health care utilization across many conditions. There has been little study of whether total knee replacement (TKR) recipients from vulnerable populations, including racial and ethnic minorities, the poor, the elderly, and the less well educated, are more likely to use low-volume hospitals (LVHs).

**Methods:** We used Medicare claims and census data to identify a national cohort of Medicare beneficiaries who had elective TKR. We defined an LVH as a center performing fewer than 26 TKRs per year, and we used geocoding to identify “bypassers” (patients who had a high-volume hospital closer to their residence than the one where they had TKR). We used multivariate logistic regression to examine the association of patient and neighborhood characteristics with utilization of LVHs and bypassing. We derived a summative measure of neighborhood vulnerability that included 4 high-risk characteristics (factors were high proportions of residents who

are minority individuals, who have foreign-born status, with low income, and with low education).

**Results:** Of 113 015 TKR recipients, 13 120 (11.6%) used LVHs. Of all the TKR recipients, 9815 (8.7%) bypassed a center with a higher TKR volume than the one they used. Multivariate analyses showed that nonwhite (odds ratio [OR], 1.24; 95% confidence interval [CI], 1.16-1.33), poor (OR, 1.94; 95% CI, 1.83-2.08), and nonurban (OR, 1.94; 95% CI, 1.87-2.01) subjects were more likely to use LVHs. The TKR recipients from neighborhoods with 3 or 4 vulnerability factors were more likely than patients in neighborhoods with no vulnerability factors to use an LVH and bypass a high-volume hospital.

**Conclusion:** Efforts to inform patients about the association of volume with TKR outcomes should target rural areas and vulnerable populations in urban settings.

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**D**ISPARITIES PERSIST IN THE delivery and utilization of health care in the United States.<sup>1-6</sup> Even after adjustment for insurance status and income, racial and ethnic minorities receive lower-quality care.<sup>7</sup> White patients have higher rates of many operations than do African American patients,<sup>3</sup> with “referral-sensitive surgeries” showing the largest effects.<sup>8</sup> White patients more often receive renal transplantation,<sup>4</sup> cardiac surgical procedures,<sup>1,9</sup> total joint replacement,<sup>1,5,10</sup> and other procedures.<sup>11-13</sup>

Several studies have also shown differences across racial groups in the utilization of high- vs low-volume providers.<sup>9,12-16</sup> High procedure volume is associated with fewer perioperative deaths and complications.<sup>6,17,18</sup> Thus, procedure volume is frequently used as a proxy for quality of care.<sup>19-22</sup> In one study, white patients were more likely than Hispanic and

African American patients to receive invasive cardiac procedures in hospitals performing a high volume of such procedures, a factor strongly associated with the quality of cardiac care.<sup>16</sup>

Total knee replacement (TKR) is one of the most common elective surgical procedures performed in the United States, with an annual volume of more than 350 000,<sup>23</sup> two thirds of which are performed on Medicare beneficiaries.<sup>24</sup> While overall outcomes of TKR are favorable, vulnerable populations more than others tend to have lower utilization and worse perioperative and functional outcomes.<sup>10,25,26</sup> The higher volume of TKR performed by the hospital and the surgeon is inversely associated with risk of perioperative mortality and complications,<sup>24,27,28</sup> as well as with better functional status 2 years postoperatively.<sup>26</sup>

Since low volume is associated with worse outcomes, it is critical to understand who chooses low-volume hospitals (LVHs). Using a national sample of Medi-

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care beneficiaries, we sought to identify patients more likely to use an LVH for TKR. We then examined the patient- and neighborhood-based factors associated with the utilization of LVHs. We hypothesized that patients from vulnerable populations are more likely than others to use LVHs or to bypass high-volume hospitals.

## METHODS

### POPULATION

Our study used a national cohort of Medicare patients who underwent primary TKR in 2000. Using Medicare claims submitted by hospitals (Medicare Part A) and by surgeons (Part B), we identified Medicare beneficiaries who underwent TKR between January 1 and November 30, 2000. We excluded patients with *International Classification of Diseases, Ninth Revision* codes that indicated preexisting infection of the knee, metastatic cancer, or bone cancer. We also excluded patients enrolled in health maintenance organizations, those not enrolled in both parts of Medicare, those younger than 65 years, and patients not resident in the United States. Algorithms for identifying cases, diagnoses, and outcome events are available from the authors on request.

We used Medicare claims and the annual Medicare denominator files to determine hospital volume and patient demographic factors such as age, sex, race, and ZIP code of residence. On the basis of patients' ZIP codes and information from the 2000 census, we classified each patient's residence as urban, suburban, or rural. Using the hospital identification number available in Medicare claims data, we augmented claims with data from the American Hospital Association 2000 Annual Survey to elicit the addresses of all hospitals at which patients in our sample received TKR.

The patient ZIP code and the hospital address were analyzed using standard geocoding procedures to determine latitude and longitude. We then calculated the distance between the patient's residence and the hospital in which the patient had his or her operation. We also identified all hospitals performing TKR in proximity to the patient's residence.

The geocoding results also enabled us to use US census data to obtain demographic information regarding the patient's neighborhood. Census tracts are subdivisions of counties as defined by the census, designed to include 2500 to 8000 persons.<sup>29</sup> They are typically more accurate than geocoding at the ZIP code level.<sup>30,31</sup> We used census tract statistics to characterize patient neighborhoods. We sought out neighborhood characteristics that would be most relevant to an elderly population. We focused on 4 domains: poverty, education level, proportion of minorities, and foreign birth. *Poverty level* was defined as the proportion of the total population living below 100% of the federal poverty level in 1999, which was classified by means of the federal Office of Management and Budget's official poverty definition.<sup>32</sup> On the basis of distributional traits of each factor, we defined the following cutoff levels: low education level was set at 20% or more receiving less than a high school-level education; high rate of foreign birth was defined as 20% or higher; high degree of poverty area was defined as having 25% or more of the residents living below the poverty level; and high concentration of minority population was defined as having 50% or more minorities.

### OUTCOMES DEFINITIONS

We defined *close hospital(s)* for each TKR recipient as the hospital closest to the patient's residence, as well as any hospitals within 3.2 km (2 miles) of that hospital. *Bypassers* of high-volume hospitals were defined as patients who had a high-volume hospital closer to their home than the one in which they had their TKR.

*Low-volume hospital users* refers to all patients, including bypassers, who had TKR at a hospital that performed fewer than 26 TKRs per year in the Medicare population. In determining hospital volume, we used all TKR procedures including primary, revision, and simultaneous bilateral TKRs.

Our principal outcomes were (1) use of an LVH for TKR and (2) bypassing a high-volume hospital (having a high-volume hospital closer to the residence than the hospital at which the TKR was actually performed).

### STATISTICAL ANALYSIS

We undertook both crude and adjusted analyses to identify the patient and neighborhood factors that were associated with either use of LVHs or bypassing a high-volume hospital. Factors exhibiting odds ratios greater than 1.5 or less than 0.6, those with crude analysis-based  $P < .1$ , and factors that we suspected a priori were associated with the outcome of interest were advanced into multivariate logistic regression to examine the independent associations of patient and neighborhood factors with the principal outcomes. Because relevant sociodemographic characteristics of neighborhoods are intercorrelated, we combined them into a single measure. This was calculated as the sum of the following characteristics: a high proportion of racial and ethnic minorities (>50%), a high proportion of persons with low education (>20%), a high proportion of persons living below the poverty level (>25%), and a high proportion of foreign-born citizens (>20%). For the purposes of this article, we will use the foregoing characteristics to define a vulnerable population. We used this measure of neighborhood vulnerability in multivariate analyses, assigning the vulnerability index to each subject according to the characteristics of the neighborhood for his or her residence address.

We also performed a subgroup analysis that focused on urban patients to examine the associations of patient and neighborhood factors with LVH use and the bypassing of high-volume hospitals among patients living in urban areas.

## RESULTS

### COHORT COMPOSITION

We identified 132 824 patients 65 years and older who were residents of the United States and had codes for TKR in January through November 2000. We excluded 2128 (1.6%) who were not enrolled in Medicare Parts A and B at the time of TKR, 3099 (2.3%) who were enrolled in health maintenance organizations, and 5638 (4.2%) who did not have both hospital and surgeon codes for TKR. We further excluded 151 who had codes for bone or metastatic cancer and 376 who had codes indicating a preexisting infection. This left 121 432 Medicare beneficiaries who received primary TKR in 2000, in a total of 3196 hospitals. Of this sample, 8417 (6.9%) were excluded from the analysis as geocoding data were not available. Our analysis cohort thus was composed of 113 015 Medicare beneficiaries who underwent primary TKR in 2000 in the United States. Of these patients, 75 100 (66.5%) were female and 53 042 (46.9%) were at least 75 years of age; 98.0% (110 727) had knee osteoarthritis. Nonwhite patients composed 7.7% of the sample, and 9938 subjects (8.3%) were eligible for Medicaid. Altogether, 29.4% lived in urban areas, 28.1% in rural areas, and the remaining 42.6% of the cohort resided in suburban areas. Overall, 6297 people lived in areas in which the proportion of residents below the poverty level exceeded 25% (**Table 1**).

**Table 1. Patient- and Neighborhood-Based Demographic Factors Associated With LVH Use and Bypassing an HVH: Crude Analysis**

Factor	No. (%)	LVH Use		Bypassing an HVH	
		No. (%)	Crude OR (95% CI)	No. (%)	Crude OR (95% CI)
<b>Patient-Based Factors</b>					
Race	112 894				
White	104 204 (92.3)	11 544 (11.1)	1.00	8410 (8.1)	1.00
Nonwhite	8690 (7.7)	1561 (18.0)	1.76 (1.66-1.86)	1396 (16.1)	2.18 (2.05-2.32)
Medicaid status	113 015				
Noneligible	103 677 (91.7)	11 061 (10.7)	1.00	8640 (8.3)	1.00
Eligible	9338 (8.3)	2059 (22.0)	2.37 (2.25-2.50)	1175 (12.6)	1.58 (1.48-1.69)
Residence	112 472				
Rural	47 893 (42.6)	7182 (15.0)	1.00	2304 (4.8)	1.00
Suburban	31 561 (28.1)	2908 (9.2)	0.58 (0.55-0.60)	2611 (8.3)	1.79 (1.68-1.89)
Urban	33 018 (29.4)	2934 (8.9)	0.55 (0.52-0.58)	4868 (14.7)	3.42 (3.24-3.60)
<b>Neighborhood-Based Factors</b>					
Poverty status, % below poverty line	112 472				
≤25	106 175 (94.4)	12 057 (11.4)	1.00	8790 (8.3)	1.00
>25	6297 (5.6)	967 (15.4)	1.42 (1.32-1.52)	993 (15.8)	2.07 (1.93-2.23)
Distribution of minority residents, %	112 472				
≤50	104 367 (92.8)	11 703 (11.2)	1.00	8348 (8.0)	1.00
>50	8105 (7.2)	1321 (16.3)	1.54 (1.45-1.64)	1435 (17.7)	2.47 (2.33-2.63)
Distribution of foreign-born residents, %	112 472				
≤20	103 663 (92.2)	11 511 (11.1)	1.00	8583 (8.3)	1.00
>20	8809 (7.8)	1513 (17.2)	1.66 (1.57-1.76)	1200 (13.6)	1.75 (1.64-1.86)
Low education (<high school), %	112 472				
≤20	106 018 (94.3)	11 779 (11.1)	1.00	9092 (8.6)	1.00
>20	6454 (5.7)	1245 (19.3)	1.91 (1.79-2.04)	691 (10.7)	1.28 (1.18-1.39)

Abbreviations: CI, confidence interval; HVH, high-volume hospital; LVH, low-volume hospital; OR, odds ratio.

A total of 64 793 TKR recipients (57.3%) went to the closest hospital to their home for their TKR, traveling a median distance of 5.8 km (3.6 miles). Of these patients, 14.9% (n=9636) went to an LVH, which carried out 25 or fewer TKRs annually in the Medicare population. Of the 48 222 patients who went to a more distant hospital, 4143 (8.6%) bypassed a high-volume hospital to have their TKR, and an additional 1717 (3.6%) used a more distant but still LVH, traveling a median distance of more than 30.5 km (18.9 miles). More than 40% of the bypassers who did not go to a close hospital went to an LVH, traveling a median distance of 21.0 km (13.0 miles) (**Figure 1**). Overall, 13 120 (11.6%) primary TKRs were performed in LVHs. Among the LVH users, 73.4% went to the closest hospital to their home, with a median distance of 5.1 km (3.2 miles). The remaining patients using LVHs went to a distant hospital; half of them bypassed a high-volume hospital to have their TKR, traveling a median distance of 21.0 km. Of the entire sample, 9815 (8.7%) bypassed a high-volume hospital and traveled an average of 21.0 km to reach the hospital of their choice.

#### FACTORS ASSOCIATED WITH LVH USE

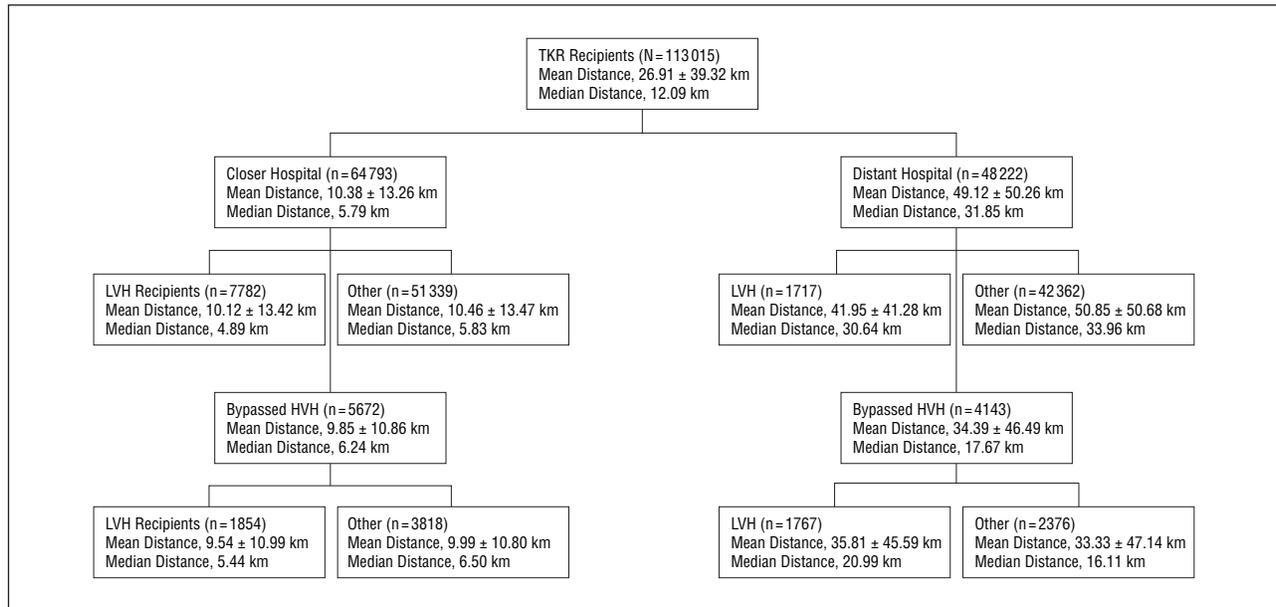
Several individual patient factors were associated with LVH use: nonwhite race, eligibility for Medicaid, and residence in a rural area (Table 1 and **Table 2**). In multivariate analyses, nonwhite patients were about 24% more likely to use LVHs; poor patients and those living in non-urban areas were almost twice as likely to use LVHs. A similar pattern emerged for neighborhood-level factors:

patients from neighborhoods with high concentrations of foreign-born citizens or of minorities (>20% and >50%, respectively) were more than 50% more likely than patients from neighborhoods with lower concentrations to use LVHs (Table 1). Patients from neighborhoods with low education levels were about 94% more likely to have TKR in LVHs (Table 1).

In multivariate analysis using the summative measure of neighborhood vulnerability, TKR recipients from neighborhoods with 3 or 4 vulnerability factors were about twice as likely to use an LVH as patients living in neighborhoods with no vulnerability factors. Patients from neighborhoods with 1 or 2 vulnerability factors were 34% and 55% more likely to use LVHs (Table 2).

#### FACTORS ASSOCIATED WITH GREATER LIKELIHOOD OF BYPASSING HIGH-VOLUME HOSPITALS

Patients bypassing high-volume hospitals were more likely to be nonwhite, have Medicaid eligibility, and live in urban areas (Table 1 and Table 2). These results were confirmed in multivariate analyses (Table 2). Nonwhite patients had 53% greater likelihood of bypassing a high-volume hospital, and those living in urban areas were 2.4 times more likely to be a bypasser. After adjusting for patient race, poverty status, and residence, patients from neighborhoods with at least 2 factors from the summative measure of neighborhood vulnerability were 33% more likely than patients from neighborhoods with no vulnerability factors to bypass a high-volume hospital (Table 2).



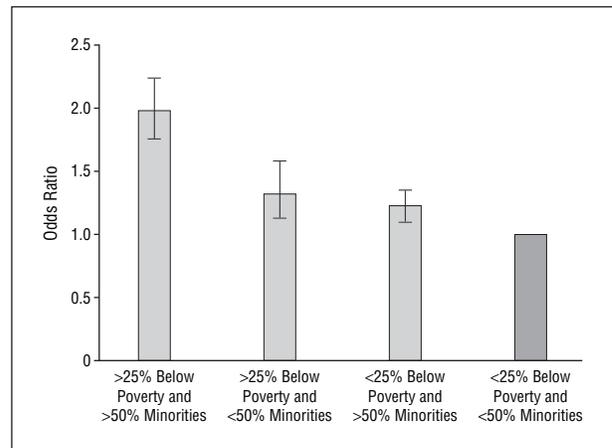
**Figure 1.** Flow of total knee replacement (TKR) recipients according to hospital choice, showing distance traveled in kilometers. HVH indicates high-volume hospital; LVH, low-volume hospital. To convert kilometers to miles, divide by 1.6.

**Table 2. Adjusted Odds Ratios of Patient and Neighborhood Factors Associated With LVH Use or Bypassing an HVH**

Factor	Odds Ratio (95% CI)*	
	LVH Use	Bypassing an HVH
<b>Patient-Based Factors</b>		
Race		
White	1.00	1.00
Nonwhite	1.24 (1.16-1.33)	1.53 (1.42-1.65)
Medicaid status		
Noneligible	1.00	1.00
Eligible	1.94 (1.83-2.06)	1.23 (1.15-1.33)
Residence		
Urban	1.00	1.00
Nonurban	1.94 (1.87-2.01)	0.41 (0.39-0.43)
<b>Summative Measure of Neighborhood Vulnerability</b>		
0	1.00	1.00
1	1.34 (1.26-1.42)	1.14 (1.07-1.22)
2	1.55 (1.42-1.69)	1.33 (1.21-1.45)
3 or 4	2.04 (1.84-2.25)	1.29 (1.15-1.44)

Abbreviations: CI, confidence interval; HVH, high-volume hospital; LVH, low-volume hospital.

\*Adjusted for patient race, poverty status, and residence.



**Figure 2.** Results of multivariate analysis for urban patients, showing adjusted odds ratios for bypassers of high-volume hospitals (adjusted for patient characteristics: race, Medicaid eligibility). Limit lines indicate the 95% confidence interval. The bar to the far right (<25% below poverty and <50% minorities) represents the referent group.

concentrations of poor citizens and minorities to bypass a high-volume hospital. Patients from neighborhoods with high concentrations of either minorities or poor citizens were 20% to 30% more likely to bypass a high-volume hospital.

### SUBGROUP ANALYSIS: URBAN PATIENTS

We examined whether patients from urban neighborhoods with high concentrations of minorities and poor citizens would be more likely than patients from other neighborhoods to bypass a high-volume hospital. These analyses were adjusted for patient race and poverty status (Medicaid eligibility). The results of our analysis, illustrated in **Figure 2**, showed that TKR recipients from urban neighborhoods with high concentrations of both minorities and poor citizens were twice as likely as patients from neighborhoods with lower

### COMMENT

We assembled a national cohort of Medicare beneficiaries who underwent TKR in 2000. Using Medicare claims, census data, and American Hospital Association survey data, we performed a series of analyses of patient and neighborhood factors associated with having TKR in LVHs. These analyses are particularly salient given the well-documented patterns of worse outcomes in LVHs.<sup>6,15,18,24,33-35</sup> We found that patients using LVHs were more likely to be nonwhite, be eligible for Medicaid, and live in rural areas.

They were also more likely to come from neighborhoods with higher concentration of poor citizens, lower educational attainment, and higher concentration of foreign-born citizens and racial and ethnic minorities.

Patients bypassing high-volume hospitals were also more likely to be nonwhite and eligible for Medicaid. As distinct from LVH users in general, bypassers were more likely to live in urban areas. This finding may simply reflect the larger number of hospitals available in urban areas. Patients from neighborhoods with higher concentrations of minorities, foreign-born persons, and poor or low-educated citizens were also significantly more likely to bypass a high-volume hospital. In our sample, poor, less educated, rural patients and patients from urban areas with high concentration of poor, foreign-born citizens or minorities were more likely to both bypass a high-volume hospital and to have TKR in an LVH.

Several studies have shown an inverse association between hospital volume and perioperative<sup>17,36,37</sup> and longer-term<sup>26</sup> outcomes after TKR. These volume-outcome associations have prompted calls to shift TKR from low- to high-volume hospitals.<sup>37,38</sup> However, evidence suggests that some patients would refuse to have surgery in unfamiliar and possibly distant high-volume hospitals.<sup>39</sup> Patients who defer undergoing TKR until later in the course of functional decline experience worse functional outcomes.<sup>40,41</sup> Furthermore, as the results of this study suggest, because poor, less educated, and elderly patients, as well as ethnic and racial minorities, are most likely to have TKR in LVHs,<sup>42</sup> shifting TKR from low- to high-volume hospitals could exacerbate existing racial, ethnic, and socioeconomic disparities in utilization of TKR.

Our results are consistent with several studies of utilization of high- and low-volume hospitals. Heslin et al<sup>14</sup> found that African American patients infected with the human immunodeficiency virus (HIV) were 40% less likely to receive HIV care from (high-volume) infectious disease specialists than were white patients with HIV infection. Rothenberg et al<sup>16</sup> reported that African American recipients of coronary artery bypass graft surgery tend to be treated by surgeons with higher risk-adjusted mortality rates more often than are white patients, and this association persisted after careful case-mix adjustment. Nelson et al<sup>13</sup> found that Hispanic newborns were less likely to be transferred to receive high-quality care for management of bladder exstrophy. Although most of these studies focused on indirect measures of procedure volume, our study, to the best of our knowledge, provides the first detailed comprehensive analysis of both patient and neighborhood factors associated with the use of LVHs and with bypassing high-volume hospitals.

About three quarters of LVH users went to the closest hospital for their TKR, which suggests that proximity influenced their decision. However, our previous work with total hip replacement has shown that low education attainment and low income were associated with high rates of LVH use even after adjusting for the distance patients had to travel and their preferences.<sup>42</sup> The association of LVH use and importance of convenient location shown in our previous study<sup>25</sup> was most prominent among urban patients despite the fact that these patients had to travel very little to reach either an LVH or a high-volume hospital, which indicates that the concept of convenience is much broader than simply geographic proximity. Previous research<sup>43</sup> has shown that convenience, de-

defined as a multidimensional concept that includes convenient location and general familiarity with the structure and personnel of the referring facility, is one of the primary factors affecting the general practitioner's choice of hospital when referring patients for elective surgery. Further studies are needed to better understand the role of patient preferences in hospital choice. In particular, do patients bypass a high-volume hospital because they wish to go to the hospital that tends to treat "patients like me"? How do they end up in LVHs? What role, if any, do physician referrals to specific surgeons play in the choice of hospital? Although analysis of large administrative data sets can provide good information about the existence and prevalence of LVH use, it is critical to realize that the question of how patients choose hospitals is just as important and needs to be studied before interventions can be developed.

The strengths of our study include the population-based national sample, the use of geocoding techniques, and the use of characteristics of the patients, neighborhoods, and hospitals. However, our study also has several limitations. Census data reflect the demographics of the entire population, not just the elderly population covered by Medicare data. In addition, estimated distances were based on geographic coordinates and do not necessarily reflect the actual travel distance or time between 2 locations. Finally, Medicare claims are subject to error, which creates the possibility of miscoding of procedure and other factors. By using a hospital claim and a surgeon claim, both of which specified TKR, to define our patient cohort, we made procedure miscoding unlikely.

Our research suggests that providing better information to physicians and disadvantaged patients about the association of procedure volume with outcomes could motivate them to consider care at high-volume hospitals, thus potentially averting important adverse clinical outcomes. These discussions may be the most productive in a shared decision-making process in which patients and physicians take into consideration patient preferences and the best available data on outcomes and factors associated with outcome. Our research suggests that efforts should focus on open discussion about all possible options and preferences to patients in rural areas, who are especially likely to use LVHs, and to vulnerable populations in urban settings, who are particularly likely to bypass high-volume hospitals. This information could be integrated into shared decision-making strategies and tools. These patterns of utilization should also be examined in other procedures and diseases.

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