Rural-Urban Differences in Surgical Procedures for Medicare Beneficiaries

Mark L. Francis, MD; Steven L. Scaife, MS; Whitney E. Zahnd, MS

Objective: To determine whether Medicare beneficiaries in rural areas were less likely to undergo a variety of surgical procedures compared with their urban counterparts.

Design, Setting, and Patients: Cross-sectional study of Medicare beneficiaries.

Main Outcome Measure: Any incidence of the surgical procedures studied.

Results: Compared with urban Medicare beneficiaries, rural Medicare beneficiaries were more likely to undergo a broad array of surgical procedures: 35% more likely for carotid endarterectomy (odds ratio [OR] = 1.35; 95% confidence interval [CI], 1.33-1.38), 32% for lumbar spine fusion (OR = 1.32; 95% CI, 1.29-1.35), 30% for knee replacement surgery (OR = 1.30; 95% CI, 1.28-1.31), 28% for abdominal aortic aneurysm repair (OR = 1.28; 95% CI, 1.24-1.31), 22% for prostatectomy (OR = 1.22; 95% CI, 1.19-1.24), 19% for hip replacement surgery (OR = 1.19; 95% CI, 1.17-1.21), 18% for aortic valve replacement (OR = 1.18; 95% CI, 1.14-1.21), 16% for open reduction and internal fixation of the femur (OR = 1.16; 95% CI, 1.14-1.18), and 15% for appendectomy (OR = 1.15; 95% CI, 1.11-1.19). To determine whether these differences could be explained by known confounding variables, we then used logistic regression to adjust for age, sex, race/ethnicity, median household income, average house value, mean poverty ratio, and state of residence. Rural beneficiaries were still more likely to undergo all of these surgical procedures.

Conclusions: Medicare beneficiaries living in rural areas were more likely to undergo a broad array of surgical procedures compared with those living in urban areas. While allaying some concern about rural access to surgical procedures, the uniformity of these results raises concern that people living in rural areas may have an overall poorer quality of health.


There are well-documented disparities in who receives surgical procedures based on sex, race, and ethnicity. There are also concerns about whether there is a disparity in health care services provided to rural residents. Removing disparities is a health care priority, and good health care should not depend on where people live. Moreover, a disparity in the provision of care to rural residents would also have significant implications for the allocation of health care resources. It is becoming increasingly clear, for instance, that patient outcomes are better with hospitals and surgeons performing a higher volume of a given procedure, this approach must be balanced against the risk that rural patients may not receive a needed procedure if there are no nearby hospitals and surgeons.

Consistent with a potential disparity in health care delivery to rural residents, a recent study demonstrated that rural residents were less likely to be placed on a wait list for solid organ transplantation. Paradoxically, we recently found that rural Medicare beneficiaries were more rather than less likely to undergo total knee or hip replacement surgery. These results ran counter to our research hypothesis that rural residents would be less likely to undergo elective surgical procedures. We therefore evaluated our hypothesis of a rural disparity by evaluating surgical procedures more broadly and by including surgical procedures that are generally more discretionary and more likely to be done electively (such as lumbar spine fusion and total hip and knee replacement surgery) as well as those that are generally less dis-
surgical procedures that were considered both the dichotomous rural-urban designations as well as the 10-point RUCA designations. In our analysis of the effect of rural or urban residency on undergoing each surgical procedure, we used logistic regression to adjust for age, sex, race/ethnicity, and state of residence. Because health policies can be established on a state level, we used state of residence as an indicator variable in our regression analysis to control for geographic variation. Based on the zip code census tabulation area for each subject, we also assessed for confounding by median household income, median household income index, average house value, average house value index, mean poverty ratio, and mean poverty ratio index. We used the methods of Hosmer and Lemeshow to build our regression model. No adjustments were made for missing data. The final model included age, age squared, sex, race/ethnicity, median household income, average house value, mean poverty ratio, and state of residence.

Statistical analysis was performed with SAS version 9.1 statistical software (SAS Institute, Inc, Cary, North Carolina). We used 2-sided P < .05 to indicate statistical significance for baseline characteristics of the study population, and we used 95% confidence intervals (CIs) for all other analyses.

METHODS

STUDY POPULATION

We obtained a deidentified Medicare Provider Analysis and Review File for 2006 from Centers for Medicare and Medicaid Services. We also obtained the entire 2006 Medicare denominator file that constitutes the study cohort.

STUDY END POINTS

We identified each surgical procedure by hospital discharges using International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic and procedure codes: AAA surgery (38.44, 39.25, 39.32, 39.71), aortic valve replacement (35.21, 35.22), nonincidental appendectomy (47.01, 47.09, 47.20, 47.91, 47.92, 47.99), carotid endarterectomy (CEA) (38.1x), lumbar spine fusion (81.04-81.08), total hip replacement surgery (81.51), total knee replacement surgery (81.54), open reduction and internal fixation of the femur (79.35), and prostatectomy (60.21, 60.29, 60.30, 60.40, 60.50, 60.62, 60.69). For our primary end point, we included all incidences of these surgical procedures. As a secondary end point, we included only those surgical procedures designated as the primary procedure, which is the designation used if that procedure is the reason for admission to the hospital.

STUDY EXPOSURE

Because there is a continuum of change from rural to urban environments and because we anticipate that commuting patterns will best reflect health-seeking behavior, we evaluated each surgical procedure with a well-established rural-urban definition based on Rural-Urban Commuting Area (RUCA) codes, version 2.15 There are 33 RUCA codes, and the RUCA designations are on a 10-point scale that ranges from 1 as a large urban core area to 10 as an isolated rural area. This 10-point scale reflects the primary flow of commuting and has subscales to address secondary flow. Areas were assigned based on the zip code of Medicare beneficiaries. When reporting dichotomous rural-urban differences, we chose the established RUCA designations for small towns and rural areas, essentially designations 7 to 10, to indicate rural.15

BENEFICIARY CHARACTERISTICS

The Medicare denominator file records the age, sex, and race/ethnicity of the beneficiaries. While use of the Medicare database ensures homogeneity for insurance status and affordability of health care, socioeconomic background of beneficiaries may nevertheless influence whether they obtain each surgical procedure. To help control for socioeconomic status in our analysis, we merged data from the US Census Bureau based on zip code region with data from our Medicare cohort. Data included median household income, median household income index (the median household income as a percentage of the national average), average house value, average house value index (the average house value as a percentage of the national average), mean poverty ratio (the individual’s or family’s income divided by the poverty threshold), and mean poverty ratio index (the mean poverty ratio as a percentage of the national average).16

STATISTICAL ANALYSIS

Age, sex, race/ethnicity, and economic measures for Medicare beneficiaries were compared by both the dichotomous rural-urban designations as well as the 10-point RUCA designations. In our analysis of the effect of rural or urban residency on undergoing each surgical procedure, we used logistic regression to adjust for age, sex, race/ethnicity, and state of residence. Because health policies can be established on a state level, we used state of residence as an indicator variable in our regression analysis to control for geographic variation. Based on the zip code census tabulation area for each subject, we also assessed for confounding by median household income, median household income index, average house value, average house value index, mean poverty ratio, and mean poverty ratio index. We used the methods of Hosmer and Lemeshow to build our regression model. No adjustments were made for missing data. The final model included age, age squared, sex, race/ethnicity, median household income, average house value, mean poverty ratio, and state of residence.

Statistical analysis was performed with SAS version 9.1 statistical software (SAS Institute, Inc, Cary, North Carolina). We used 2-sided P < .05 to indicate statistical significance for baseline characteristics of the study population, and we used 95% confidence intervals (CIs) for all other analyses.

RESULTS

CHARACTERISTICS OF THE STUDY POPULATION

There were 45,447,043 Medicare beneficiaries in 2006. Characteristics among rural and urban beneficiaries are shown in Table 1, with a RUCA designation of 1 indicating the most urban area and a RUCA designation of 10 indicating the most rural area. Rural Medicare beneficiaries were slightly younger. They had a higher percentage of white individuals compared with individuals of minority race/ethnicity. They also had a lower median household income, average house value, and mean poverty ratio.

MULTIVARIABLE ANALYSIS

Compared with urban Medicare beneficiaries, rural beneficiaries were significantly more likely to have undergone all of the surgical procedures we examined (Table 2), listed here in order of their odds ratio (OR): CEA (OR = 1.35; 95% CI, 1.33-1.38), lumbar spine fusion (OR = 1.32; 95% CI, 1.29-1.35), total hip replacement surgery (OR = 1.30; 95% CI, 1.28-1.31), AAA repair (OR = 1.28; 95% CI, 1.24-1.31), prostatectomy (OR = 1.22; 95% CI, 1.19-1.24), total hip replacement surgery (OR = 1.19; 95% CI, 1.17-1.21), aortic valve replacement (OR = 1.18; 95% CI, 1.14-1.21), open reduction and internal fixation of the femur (OR = 1.16; 95% CI, 1.14-1.18), and appendectomy (OR = 1.15; 95% CI, 1.11-1.19). This pattern of a higher use of all of the tested surgical procedures in rural Medicare beneficiaries remained the same after adjusting for confounding variables, although the order based on the OR changed in some instances (Table 2). We obtained similar results when we analyzed those surgical procedures that were consid-
these confounding variables to determine whether they explain these results. After adjusting for these variables as well as age and state of residence, rural Medicare beneficiaries remained significantly more likely to undergo the following, in order of their adjusted OR: aortic valve replacement, total hip replacement surgery, total knee replacement surgery, lumbar spine fusion, open reduction and internal fixation of the femur, CEA, prostatectomy, nonincidental appendectomy, and AAA repair. Thus, rurality, or an unmeasured variable associated with rurality, is associated with the increased likelihood of rural Medicare beneficiaries undergoing a wide variety of surgical procedures.

These results are consistent with our previous report that rural Medicare beneficiaries in 2005 were more likely to undergo elective total hip and knee replacement surgery.14 More importantly, we extend these findings by demonstrating that rural Medicare residents were more likely to undergo a wide variety of surgical procedures, including not only highly discretionary but also largely nondiscretionary procedures. Indeed, the top 4 surgical procedures that were more likely to be performed in rural residents included 2 that are largely discretionary (lumbar

Table 1. Characteristics of the Study Population by Rural-Urban Commuting Area Designation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>RUCA Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Beneficiaries, No.</td>
<td>31 023 130</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>71.1 (12.2)</td>
</tr>
<tr>
<td>Women, No. (%)</td>
<td>17 508 694 (56.4)</td>
</tr>
<tr>
<td>Race/Ethnicity, No. (%)</td>
<td>24 872 808 (80.2)</td>
</tr>
<tr>
<td></td>
<td>669 510 (2.2)</td>
</tr>
<tr>
<td>Missing data</td>
<td>669 510 (2.2)</td>
</tr>
<tr>
<td>Median household income, mean (SD), $</td>
<td>47 953 (19 974)</td>
</tr>
<tr>
<td>Mean poverty ratio, mean (SD)</td>
<td>102.04 (12.84)</td>
</tr>
<tr>
<td>Average house value index, mean (SD)</td>
<td>114.62 (83.41)</td>
</tr>
<tr>
<td>Mean poverty ratio index, mean (SD)</td>
<td>2.48 (0.31)</td>
</tr>
</tbody>
</table>

Abbreviation: RUCA, Rural-Urban Commuting Area (where 1 designates the most urban area and 10 the most rural).

*P < .001 for trend (Mantel-Haenszel test) for each beneficiary characteristic.

**Table 2. Procedures Undergoing by Rural-Urban Commuting Area Designation**

- Compared with their urban counterparts, we found that rural Medicare beneficiaries were significantly more likely to undergo a wide variety of surgical procedures that range from those that are generally more discretionary, such as total joint replacement surgery and lumbar spine fusion, to those that are generally less discretionary, such as CEA and appendectomy. The magnitude of this difference is also noteworthy, with rural patients being at least 20% more likely to undergo 5 of the 9 procedures studied. Rural beneficiaries were more likely to be white and male and were more likely to have a lower median household income, average house value, and mean poverty ratio. Other. Because these factors can significantly influence whether patients undergo surgery, we controlled for these confounding variables to determine whether they explain the observed primary procedures (Table 2). All of the findings remained significant when we used the 10-point RUCA designations instead of the dichotomous rural-urban designations (data not shown).

**COMMENT**

- These results are consistent with our previous report that rural Medicare beneficiaries in 2005 were more likely to undergo elective total hip and knee replacement surgery. More importantly, we extend these findings by demonstrating that rural Medicare residents were more likely to undergo a wide variety of surgical procedures, including not only highly discretionary but also largely nondiscretionary procedures. Indeed, the top 4 surgical procedures that were more likely to be performed in rural residents included 2 that are largely discretionary (lumbar

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bar spine fusion and total knee replacement surgery) and 2 that are largely nondiscretionary (CEA and AAA repair).

These results differ from another study demonstrating that rural patients were less likely to be placed on a wait list for solid organ transplantation than urban patients, although it is important to emphasize that there was no rural-urban difference in the proportion who ultimately underwent transplantation. Both studies adjusted for essentially the same confounding variables (age, race/ethnicity, sex, and median household income for the transplantation study), so it is unlikely that the different results are explained by the confounding variables used in each analysis. The differences may be explained by the fact that compared with the more general availability of surgical procedures in our study, there are only 11 Organ Procurement and Transplantation Network centers in the United States, which may in turn limit rural access more substantially than urban access. Moreover, these differing results also caution us to be careful about generalizing our results in surgical procedures to pre-surgical and nonsurgical medical care.

Because this is an observational study, its major limitation is the inability to adjust for unmeasured variables. From this data set, for instance, we cannot assess whether urban patients had greater access to alternative therapies or whether there was pent-up demand while rural patients awaited Medicare coverage. Moreover, we cannot assess comorbidities in all beneficiaries in the Medicare denominator file, so we cannot control for this confounding variable. In a previous sensitivity analysis of the effect of comorbidities, however, we found that such an adjustment would likely alter the point estimate of the OR by only 0.02 to 0.03. The prime strength of this study is that it assesses the actual use of health care resources, regardless of the explanation, for a large portion of the US population—essentially all Medicare beneficiaries.

While the results of our study suggest that rural residents have good access to more discretionary as well as less discretionary surgical procedures, it is important to emphasize that these data cannot address the question of either overuse or underuse among rural or urban beneficiaires because this study does not measure the frequency or severity of the underlying diseases prompting these procedures. What are striking, however, are the consistency and magnitude of the higher prevalence of surgical procedures for rural compared with urban beneficiaries among all of the procedures examined. Similar findings among a broad array of procedures argue that a more general difference in rural areas is driving their increased use of surgical procedures rather than individual risk factors for each of the various diseases that lead to these procedures.

If the frequency of the underlying diseases is indeed equal between these 2 populations, then these findings could suggest that cultural and other differences among these populations drive their decision of whether to undergo surgery, or they could suggest that access problems are more severe in urban rather than rural areas. Alternatively, these results could suggest that rural beneficiaries have a higher burden of the underlying diseases. Thus, our finding that rural residents are more likely to undergo a wide variety of surgical procedures could suggest that rural residents may have overall poorer health that then leads to their increased need to undergo these procedures. There is an additional possibility that rural beneficiaries could paradoxically have a greater access problem despite their higher use of these procedures. This situation would be analogous to the assessment that there is a disparity for women to undergo total joint replacement surgery despite a higher frequency of total joint replacement surgery in women, in part because there is an even greater prevalence of arthritis among women compared with men.

Although there are legitimate concerns about the availability of surgical procedures for rural residents, this study demonstrates that rural residents are actually more likely to undergo a wide variety of both more discretionary as well as less discretionary surgical procedures. While the distance to a surgeon may have posed a significant barrier in the past, rural and urban environments have been changing, so patterns of health care delivery have likely changed as well. Commuting from rural to urban areas has increased, and there is evidence that a significant number of rural residents bypass more rural health care facilities to seek care in more urban environments. Taken as a whole, the results of this study do not demonstrate a general need to reallocate resources to enhance the avail-

### Table 2. Rural vs Urban Differences in Surgical Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Rural vs Urban, OR (95% CI)</th>
<th>Unadjusted</th>
<th>Adjusted a</th>
<th>Rural vs Urban, OR (95% CI)</th>
<th>Unadjusted</th>
<th>Adjusted a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carotid endarterectomy</td>
<td>68 969</td>
<td>1.35</td>
<td>1.07</td>
<td>65 861</td>
<td>1.35</td>
<td>1.07</td>
</tr>
<tr>
<td>Lumbar spine fusion</td>
<td>57 084</td>
<td>1.32</td>
<td>1.14</td>
<td>54 499</td>
<td>1.31</td>
<td>1.14</td>
</tr>
<tr>
<td>Knee replacement surgery</td>
<td>257 892</td>
<td>1.30</td>
<td>1.15</td>
<td>257 245</td>
<td>1.30</td>
<td>1.15</td>
</tr>
<tr>
<td>Abdominal aortic aneurysm repair</td>
<td>41 087</td>
<td>1.28</td>
<td>1.04</td>
<td>38 602</td>
<td>1.29</td>
<td>1.04</td>
</tr>
<tr>
<td>Prostatectomy</td>
<td>55 548</td>
<td>1.22</td>
<td>1.06</td>
<td>53 513</td>
<td>1.21</td>
<td>1.06</td>
</tr>
<tr>
<td>Hl replacement surgery</td>
<td>108 616</td>
<td>1.19</td>
<td>1.15</td>
<td>109 221</td>
<td>1.19</td>
<td>1.15</td>
</tr>
<tr>
<td>Aortic valve replacement</td>
<td>35 393</td>
<td>1.18</td>
<td>1.18</td>
<td>33 225</td>
<td>1.18</td>
<td>1.18</td>
</tr>
<tr>
<td>Open reduction and internal fixation of the femur</td>
<td>97 178</td>
<td>1.16</td>
<td>1.15</td>
<td>92 071</td>
<td>1.16</td>
<td>1.15</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>25 621</td>
<td>1.15</td>
<td>1.06</td>
<td>19 965</td>
<td>1.16</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio.

a Adjusted for age, sex, race/ethnicity, median household income, average house value, mean poverty ratio, and state of residence.
ability of these surgical procedures in rural areas, although further studies are needed to determine whether there are problems with overuse or relative underuse in rural environments and to what extent the performance of these surgical procedures is driven by supply-sensitive care in either environment. It is also important to emphasize that rural environments are not homogeneous. Thus, some rural areas such as the more isolated rural areas and persistently poor rural areas may have significant access problems where surgical outreach or enhanced referrals may indeed be needed. Moreover, it is particularly important to emphasize that these studies may not generalize to nonsurgical care.

Rural Medicare beneficiaries were more likely to receive all of the surgical procedures examined, including both those that are more discretionary as well as those that are less discretionary. Thus, the most important question raised by the results of this study is whether rural residents have significantly poorer health than urban residents, even after adjusting for confounding variables. This would be consistent with surveys in which rural residents report poorer health than urban residents. Moreover, from a public health perspective, it is critical to determine whether the disproportionately higher frequency of surgical procedures for rural residents reflects poorer health among rural residents and therefore whether enhanced attention to primary care for rural residents would help reduce their surgical burden and improve their health.

Accepted for Publication: October 26, 2010. Published Online: January 17, 2011. doi:10.1001/archsurg.2010.306

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Author Contributions: Dr Francis had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Francis. Acquisition of data: Francis and Scaife. Analysis and interpretation of data: Francis, Scaife, and Zahnd. Drafting of the manuscript: Francis. Critical revision of the manuscript for important intellectual content: Scaife and Zahnd. Statistical analysis: Francis. Obtained funding: Francis. Administrative, technical, and material support: Scaife and Zahnd. Study supervision: Francis.

Financial Disclosure: None reported.

Funding Support: This study was supported by the Eskridge Translational Research Award.

REFERENCES