Rural-Urban Differences in Access to Specialist Providers of Colorectal Cancer Care in the United States
A Physician Workforce Issue

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IMPORTANCE Although early detection and treatment of colorectal cancer has been shown to improve outcomes, geographic proximity may influence access to these services.

OBJECTIVE To examine the disparities that may exist in colorectal cancer screening and treatment by comparing the distribution of providers of these services in rural and urban counties in the United States.

DESIGN, SETTING, AND PARTICIPANTS A retrospective population-based study using data obtained from the 2009 Area Resource File for the entire US population within each county.

MAIN OUTCOMES AND MEASURES Counties in the United States were categorized as rural or urban using rural-urban continuum codes as our primary exposure. The proportion of gastroenterologists, general surgeons, and radiation oncologists per 100 000 people in each county was estimated as primary outcomes. Multivariate linear regression analysis adjusted for county-level socioeconomic variables, such as percentages of females, blacks, population without insurance, those with a high school diploma, and median household income, to estimate the relative density of each category of these providers between urban and rural counties.

RESULTS In total, 3220 counties were identified, comprising 1807 rural and 1413 urban counties. An unadjusted analysis showed an increased density of gastroenterologists, general surgeons, and radiation oncologists per 100 000 people in urban vs rural counties. A multivariable analysis revealed a significantly higher density of gastroenterologists (1.63; 95% CI, 1.40-1.85; P < .001), general surgeons (2.01; 95% CI, 1.28-2.73; P < .001), and radiation oncologists (0.68; 95% CI, 0.59-0.77; P < .001) per 100 000 people living in urban vs rural counties.

CONCLUSIONS AND RELEVANCE A rural-urban disparity exists in the density of gastroenterologists, general surgeons, and radiation oncologists who traditionally provide colorectal cancer screening services and treatment. This might affect access to these services and may negatively influence outcomes for colorectal cancer in rural areas.
Colorectal cancer is the second leading cause of cancer mortality in the United States.1 This ranking persists despite overwhelming evidence in support of screening measures such as colonoscopy, which provide early diagnosis and treatment of the disease and thus improve outcomes for patients.2 Colonoscopy screening has been shown to lower colorectal cancer mortality, and it has become a quality of care measure.3 The US Preventive Services Task Force and other interest groups thus recommend colonoscopy screening for patients older than 50 years every 10 years until age 75.4,5

Several factors have been implicated as barriers to cancer screening and treatment, including insurance status, income, and race or ethnicity.6-8 Geographic proximity, which has been defined by travel time or physical distance to a health facility (or service supply) in a region, has been identified as a possible barrier to cancer screening and a cause of poorer outcomes for patients.9-11 There is increasing evidence of a disparity in outcomes for colorectal cancer between residents in urban and rural counties in the United States.12 In this study, we sought to examine disparities that may exist in colorectal cancer screening and treatment by comparing the distribution of providers for these services within rural and urban counties across the United States. We hypothesized that the density of providers of colonoscopy screening and colorectal cancer treatment would be equivalent, regardless of the type of population. We specifically examined the shortage of gastroenterologists, general surgeons, and radiation oncologists in rural counties across the United States.

Methods

A retrospective population-based study was performed using the Health Resources and Services Administration’s Area Resource File 2009 data file (Department of Health and Human Services, Bureau of Health Professions, Rockville, Maryland). The Area Resource File is a nationwide database with demographic, economic, and health care information across different geographic regions in the United States. Sources of data include the US Census Bureau, Bureau of Labor Services, National Center for Health Statistics, Centers for Medicare & Medicaid Services, American Hospital Association, Veterans Association, and professional organizations such as the American Medical Association, American Academy of Nurse Practitioners, American Academy of Physician Assistants, and American Osteopathic Association.13 Primary outcome measures included the density of gastroenterologists, general surgeons, and radiation oncologists in each US county, estimated from the number of these specialists per capita in each county per 100 000 people. The primary exposure was type of county, which was categorized as urban or rural using the 2003 rural-urban continuum codes that were developed by the Economic Research Services of the Department of Agriculture in collaboration with the Rural Health Research Center at the University of Washington.14 Counties with codes 1 to 5 were deemed urban and those with codes 6 to 9 were classified as rural.

Other covariates of interest in the model included county-level demographic characteristics such as the percentage of females, blacks, and residents with a high school diploma and health insurance, as well as median household income. The 2008 population estimates for each of these demographic variables at the county level when present were used. However, for health insurance and percentage of residents with high school diploma data, 2006 population estimates and 2000 census data were used, respectively. County-level demographic variables were compared across rural and urban counties, using the t test for continuous variables and the χ² test for categorical variables. A linear regression model was fitted separately to estimate the absolute difference in the density of gastroenterologists, general surgeons, and radiation oncologists between urban and rural counties. An initial unadjusted analysis was conducted, followed by a multivariable analysis. In the multivariable analysis, county-level variables, including median household income and percentage of females, blacks, those with a high school diploma, and persons younger than 65 years without health insurance, were accounted for in the model.

Results

A total of 3220 counties were identified, comprising 1413 urban and 1807 rural counties. The mean percentage of females was 50.5% across urban counties and 50.0% across rural counties (P < .001). Moreover, the mean percentage of blacks was higher in urban than in rural counties (10.7% vs 7.5%, P < .001). The median income was also higher for residents living in urban than in rural counties ($49 975 vs $37 678, P < .001). The percentage of persons younger than 65 years without private health insurance was higher in rural compared with urban counties (18.5% vs 16.9%, P < .001). Also, residents in urban counties were more likely to have a high school diploma than their rural county counterparts (79.8% vs 74.3%, P < .001) (Table 1). Figure 1 shows the distribution of gastroenterologists, general surgeons, and radiation oncologists across counties in the United States.

The mean density of gastroenterologists per 100 000 people was 2.55 in urban counties compared with 0.39 in rural counties (P < .001). Similarly, the mean density of general surgeons per 100 000 people was 8.48 in urban counties compared with 4.82 in rural counties (P < .001). Moreover, the mean density of radiation oncologists per 100 000 people was 1.01 in urban counties compared with 0.13 in rural counties (Figure 2).

An unadjusted analysis demonstrated a decrease in gastroenterologists, general surgeons, and radiation oncologists across rural counties compared with urban counties. A multivariable analysis confirmed that the density of gastroenterologists in urban counties was higher than that in rural counties (1.63; 95% CI, 1.40-1.85). Also, the absolute difference in density of general surgeons in urban counties compared with rural counties was 2.01 (95% CI, 1.28-2.73). Similarly, per 100 000 people, there were 0.68 (95% CI, 0.59-0.77) more radiation oncologists in urban vs rural counties (Table 2). A unit
increase in the densities of gastroenterologists, general surgeons, and radiation oncologists in a county was associated with a percentage increase in the proportion of residents with a high school diploma ($P < .001$) and females ($P < .001$). We, however, observed no association between the median household income per county and the densities of radiation oncologists ($P = .41$) and general surgeons ($P = .98$) per 100,000 people. In contrast, the density of gastroenterologists in counties with a median household income in the upper tertile ($> $42,923) was greater than that in the lowest tertile ($\leq $36,026) (0.34; 95% CI, 0.01 to 0.67; $P = .04$). There was, however, no difference in the density of gastroenterologists per 100,000 people for counties in the middle tertile of median household income (between $36,027$ and $42,023$) compared with those in the lowest tertile (0.05; 95% CI, -0.22 to 0.32; $P = .73$). Also, we observed that a percentage increase of people younger than 65 years without health insurance in a county was associated with a decrease in the densities of gastroenterologists (-0.02; 95% CI, -0.04 to -0.01; $P = .006$) and general surgeons (-0.15; 95% CI, -0.19 to -0.10; $P < .001$) per 100,000 people. We failed to see any association between the percentage of residents younger than 65 years without health insurance and the density of radiation oncologists per 100,000 people (-0.01; 95% CI, -0.01 to 0.00; $P = .08$).

**Discussion**

Rural residents who commonly seek treatment for advanced stages of colorectal cancer have been thought to lack access to cancer screening and adjuvant therapy.\textsuperscript{15,16} Some studies suggest that patients with colorectal cancer who live in rural communities have a reduced survival.\textsuperscript{22} Moreover, in our own currently unpublished data using the Surveillance, Epidemiology, and End Results registry, we identified a statistically significant increased risk of death for patients with colorectal cancer in rural counties compared with their urban counterparts. Several theories have been postulated to explain these findings, some of which include low socioeconomic status, lower educational attainment, lack of insurance coverage, underinsurance, and travel distance to health care facilities.\textsuperscript{17-19} Colonoscopy is the most sensitive and specific test to screen for colorectal cancer in individuals older than 50 years.\textsuperscript{3} Unlike the fecal occult blood test, however, colonoscopy requires the expertise of gastroenterologists, general surgeons, or colorectal surgeons.\textsuperscript{3} Specialist physicians—specifically, general surgeons and radiation oncologists—are necessary to render treatment to those patients with a diagnosis of colorectal cancer. One way of measuring the physician workforce available for colorectal cancer screening and treatment is by calculating the density of gastroenterologists, general surgeons, and radiation oncologists in a geographic area.

This study identified that rural residency is associated with a decrease in the density of gastroenterologists, general surgeons, and radiation oncologists. Therefore, significantly fewer providers of screening and adjuvant therapy services for colorectal cancer are geographically available in rural compared with urban counties. A smaller number of gastroenterologists, general surgeons, and radiation oncologists in rural areas may affect the availability of their services, plausibly resulting in worse outcomes for patients who seek treatment with advanced disease. A smaller provider density implies longer wait times and increased travel distances, which may severely affect immobile and poorly resourced patients. Odisho et al\textsuperscript{20} showed that an increase in the density of urologists in a county was associated with a decrease in prostate cancers. A similar study also revealed that an increased density of radiation oncologists was associated with reduced prostate cancer mortality.\textsuperscript{21}

The shortage of the physician workforce in rural America, which has been reported in a couple studies,\textsuperscript{22,23} clearly includes not only primary care physicians but also specialists such as general surgeons and radiation oncologists. The demand for the services of these specialists has been projected to increase in the decades ahead. The American Society for Radiation Oncology postulates an increased demand for radiotherapy that would outstrip the current supply of radiation oncologists.\textsuperscript{24} Similarly, Smith et al\textsuperscript{25} and Elkin and Bach\textsuperscript{26} project that the supply gap from a marginal increase in the number of radiation oncologists, against the backdrop of greater demand, will worsen the workforce deficit of radiation oncologists in the next decade. In the face of this looming workforce shortage in radiation oncologists, there already exists a rural-urban disparity in the distribution of radiation oncologists. Our finding of fewer radiation oncologists in counties designated as rural is corroborated by previous studies.\textsuperscript{24,27} These studies suggested an aggregation of radiation oncologists in academic centers that are more likely to be in metropolitan (urban) communities. Apart from the attractiveness of living in a larger city, the preponderance of the density of these providers in urban relative to rural counties could also be due to the hefty fiscal investment prerequisite to setting up these services. The relatively smaller patient population size may serve to dissuade the establishment of radiation oncology services in rural counties.

**Table 1. Comparing County-Level Demographic Variables Across Rural and Urban Counties\textsuperscript{a}**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Urban (n = 1413)</th>
<th>Rural (n = 1007)</th>
</tr>
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<tbody>
<tr>
<td>% Female sex</td>
<td>50.5 (1.7)</td>
<td>50.0 (2.4)</td>
</tr>
<tr>
<td>% Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>84.9 (14.4)</td>
<td>83.7 (25.4)</td>
</tr>
<tr>
<td>Black</td>
<td>10.7 (0.4)</td>
<td>7.5 (3.3)</td>
</tr>
<tr>
<td>Median household income, $</td>
<td>49,975.23 (12,474.74)</td>
<td>37,678.42 (11,152.98)</td>
</tr>
<tr>
<td>Median household income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile ($\leq $36,026)</td>
<td>180 (12.7)</td>
<td>895 (49.5)</td>
</tr>
<tr>
<td>Middle tertile ($36,027 to $42,023)</td>
<td>458 (32.4)</td>
<td>615 (34.0)</td>
</tr>
<tr>
<td>Upper tertile ($&gt; $42,023)</td>
<td>775 (54.8)</td>
<td>297 (16.5)</td>
</tr>
<tr>
<td>% Persons aged &lt;65 y without health insurance</td>
<td>16.9 (5.5)</td>
<td>18.5 (7.4)</td>
</tr>
<tr>
<td>% Persons with high school diploma</td>
<td>79.8 (7.9)</td>
<td>74.3 (10.6)</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Values are given as mean (SD) unless otherwise indicated. $P < .001$ for all.
Figure 1. Specialty Provider Density per 100 000 People Across Counties

Distribution of general surgeons per 100 000 people by US counties

Distribution of gastroenterologists per 100 000 people by US counties

Distribution of radiation oncologists per 100 000 people by US counties

Distribution of (A) general surgeons, (B) gastroenterologists, and (C) radiation oncologists per 100 000 people by US counties.
policy intervention occurs to mitigate the trend. The benefit of colonoscopy screening for colorectal cancer makes it imperative to bridge the gap in the rural-urban disparity in the density of gastroenterologists, general surgeons, and radiation oncologists in the United States. Allowing access to early screening may decrease the rural-urban disparity in colorectal cancer outcomes. Other options include training primary care physicians, who are more likely to be in rural communities, to perform colonoscopy.31-32 Another alternative is the use of itinerant endoscopists in rural areas, as in the Alaska Tribal Health system, in which care is provided to Alaskan Natives who may lack access to colorectal cancer screening as a result of geographic barriers.33 Although it could be argued that increasing the total number of the workforce may not necessarily correct this maldistribution, some of these disparities. This would involve increasing funding for residency programs in these specialties might help mitigate some of these disparities. This would involve increasing funding for residency programs with an emphasis on training rural surgeons. This may become necessary with a projected 18% decline in the number of surgeons by 2028, which could worsen this disparity.34 Alternatively, other policy interventions may focus on attracting and retaining these much-needed physicians to and in these underserved communities. Relieving student loan debt for physicians who accept work in rural and other underserved areas could also serve as an incentive to attract and retain young surgeons and other specialists in these areas. In addition, extending the National Health Service Corps scholarship and providing other scholarships to medical students who decide to pursue surgery or other specialties and agree to serve a period in rural communities might also reduce the disparity.35 Intentionally encouraging and incentivizing medical students to pursue rotations in rural surgery practices and providing general surgery residents exposure to practice in rural settings could also improve the density of general surgeons returning to these areas after residency. Addressing payer structures in rural settings would be key to correct low reimbursement algorithms. As has been observed, rural dwellers are more likely to be poor and uninsured; therefore, practitioners depend more on Medicare reimbursement and only a smaller fraction on private insurance.36 Improving Medicare reimbursement for rural surgeons and other physicians may attract and retain them.

In addition to radiation oncologists, the relatively smaller density of general surgeons in rural compared with urban counties may serve as a target point for policy formulation in creating incentives to attract providers. The 4.82 general surgeons per 100,000 people living in rural counties from our study is below the mean national density reported in previous studies (7.1 per 100,000) and the standard held by health maintenance organizations (5.1 per 100,000).28,29 Previously, Thompson et al categorized urban, large rural, and small rural counties and identified a comparatively smaller density of general surgeons in small rural counties (4.67 per 100,000 people). Our finding confirms many of these results from earlier studies in the distribution of the surgical workforce across rural and urban counties in the United States. One unique finding from our study is that, even after adjusting for county-level socioeconomic factors that might confound the relationship between the type of county and the density of general surgeons, the disparity still persisted. To our knowledge, previously published studies have not accounted for these factors. While we found a positive linear association between the density of general surgeons per 100,000 people and the county-level proportion of people with high school diplomas and females, no such association was observed between the density of general surgeons per 100,000 people and median household income. Counties with a higher proportion of people younger than 65 years without insurance were more likely to have a lower density of general surgeons. This suggests that insurance penetration might dictate the distribution of general surgeons as well as other specialist physicians, thereby impeding access to colonoscopy screening or treatment. The positive association between the density of gastroenterologists per 100,000 people and median household income is also noteworthy. This indicates that higher-income earners might have greater access to colonoscopy screening than those who earn less.

It is plausible that health care careers in rural communities simply may be unattractive to specialist providers. The disparity identified here is likely to worsen unless focused on addressing incentives to attract providers. The 4.82 general surgeons per 100,000 people living in rural counties from our study is below the mean national density reported in previous studies (7.1 per 100,000) and the standard held by health maintenance organizations (5.1 per 100,000).28,29 Previously, Thompson et al categorized urban, large rural, and small rural counties and identified a comparatively smaller density of general surgeons in small rural counties (4.67 per 100,000 people). Our finding confirms many of these results from earlier studies in the distribution of the surgical workforce across rural and urban counties in the United States. One unique finding from our study is that, even after adjusting for county-level socioeconomic factors that might confound the relationship between the type of county and the density of general surgeons, the disparity still persisted. To our knowledge, previously published studies have not accounted for these factors. While we found a positive linear association between the density of general surgeons per 100,000 people and the county-level proportion of people with high school diplomas and females, no such association was observed between the density of general surgeons per 100,000 people and median household income. Counties with a higher proportion of people younger than 65 years without insurance were more likely to have a lower density of general surgeons. This suggests that insurance penetration might dictate the distribution of general surgeons as well as other specialist physicians, thereby impeding access to colonoscopy screening or treatment. The positive association between the density of gastroenterologists per 100,000 people and median household income is also noteworthy. This indicates that higher-income earners might have greater access to colonoscopy screening than those who earn less.

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Table 2. Adjusted and Unadjusted Absolute Difference in Densities of Gastroenterologists, General Surgeons, and Radiation Oncologists per 100,000 Residents in Urban vs Rural US Counties

<table>
<thead>
<tr>
<th>Specialist</th>
<th>Difference in Density of Physicians (95% CI)</th>
<th>Adjusted Difference in Density of Physicians, Adjusted (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastroenterologists</td>
<td>2.16 (1.96-2.35)</td>
<td>1.63 (1.40-1.85)</td>
</tr>
<tr>
<td>General surgeons</td>
<td>3.66 (3.02-4.30)</td>
<td>2.01 (1.28-2.73)</td>
</tr>
<tr>
<td>Radiation oncologists</td>
<td>0.88 (0.80-0.96)</td>
<td>0.68 (0.59-0.77)</td>
</tr>
</tbody>
</table>

* Adjusted for median household income and percentage of blacks, females, those with a high school diploma, and those younger than 65 years without health insurance. P < .001 for all.
in rural areas.30 Inasmuch as improving the numbers of these providers in rural areas could improve access to their services, technologic advances geared toward developing efficient, less skill-demanding screening tests and advances in treatment could be another way to improve access to screening and care.

The interpretation of our findings should be guided by study limitations. Our study does not account for service providers with multiple locations of practice, which might overestimate the provider density in some areas while underestimating the disparity in others. In addition, the cross-sectional nature of our study and the use of ecologic data preclude any causal inference to be made.

Conclusions
This study shows that the density of physicians who are more likely to offer screening and/or treatment services for colorectal cancer is significantly higher in urban than in rural counties. This is yet more evidence of the disparity in access to health care between residents in rural and urban counties in the United States. This disparity may serve to adversely affect outcomes of patients with colorectal cancer in rural areas. By quantifying the variation in geographic density of these providers, we can best begin the process of addressing geographic disparities in outcomes for colorectal cancer.


CORRECTION

Incorrectly Classified Article: The article titled "Fifty-three Years' Experience With Randomized Clinical Trials of Emergency Portacaval Shunt for Bleeding Esophageal Varices in Cirrhosis: 1958-2011" was published online January 8, 2014, and in the February print issue of JAMA Surgery (2014;149[2]:155-169, doi:10.1001/jamasurg.2013.4045) as an Original Investigation but has been reclassified as a Special Communication. Wording has been added to the Objectives portion of the Abstract (page 155) and to the opening paragraph of the text (page 156) to indicate that the article is a summary of two previously published randomized clinical trials (RCTs) by Orloff et al (J Am Coll Surg. 2009;209[1]:25-40; J Gastrointest Surg. 2011;15:38-47; and J Gastrointest Surg. 2012;16[11]:2094-2111). In addition, references to the two previously published RCTs (J Am Coll Surg. 2009;209[1]:25-40 and J Gastrointest Surg. 2012;16[11]:2094-2111) have been added to Tables 1, 2, 3, and 4 and Figure 1; a reference (J Am Coll Surg. 2009;209[1]:25-40) has been added to Figure 2; and a reference (J Gastrointest Surg. 2012;16[11]:2094-2111) has been added to Figure 3. This article was corrected online.

Error in Funding/Support: In the Original Investigation entitled "Factors Associated With the Disposition of Severely Injured Patients Initially Seen at Non-Trauma Center Emergency Departments: Disparities by Insurance Status," published online February 19, 2014, in JAMA Surgery (doi:10.1001/jamasurg.2013.4398), one of the funding sources was inadvertently omitted from the Funding/Support section. The Disclaimer section was also corrected to reflect the funding source. This article was corrected online.