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Geographic Differences in Use of Home Oxygen for Obstructive Lung Disease: A National Medicare Study

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ABOUT THE CENTER

The WWAMI Rural Health Research Center (RHRC) is one of six centers supported by the Federal Office of Rural Health Policy (FORHP), a component of the Health Resources and Services Administration (HRSA) of the U.S. Public Health Service. The major focus of the RHRC is to perform policy-oriented research on issues related to rural health care and the rural health professional workforce. Specific interests of the RHRC include the adequacy of the supply and education of rural health care professionals, and the availability and quality of health care for rural populations, with particular emphasis on access to high-quality care for vulnerable and minority rural populations.

The WWAMI Rural Health Research Center is based in the Department of Family Medicine at the University of Washington School of Medicine, and has close working relationships with the WWAMI Center for Health Workforce Studies, state offices of rural health, and the other health science schools at the University, as well as with other major universities in the five WWAMI states: Washington, Wyoming, Alaska, Montana, and Idaho. The University of Washington has over 30 years of experience as part of a decentralized educational research and service consortium involving the WWAMI states, and the activities of the RHRC are particularly focused on the needs and challenges in these states.

The Rural Health Final Report Series is a means of distributing prepublication articles and other working papers to colleagues in the field. Your comments on these papers are welcome, and should be addressed directly to the authors. Questions about the WWAMI Rural Health Research Center should be addressed to:

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EXECUTIVE SUMMARY

RATIONALE

Home oxygen is the most expensive equipment item that Medicare purchases ($1.7 billion/year). Identifying populations that are high or low users of supplemental oxygen is a first step in a quality-improvement process to investigate possible interventions.

OBJECTIVES

To assess geographic differences in the use of supplemental oxygen.

METHODS

Retrospective cohort analysis of Durable Medical Equipment claims for a 20% random sample of Medicare patients hospitalized for obstructive lung disease in 1999 and alive at the end of 2000.

MEASUREMENTS AND MAIN RESULTS

This study's outcome is evidence of supplemental oxygen use in the claims any time after hospitalization through 2000. 33.7% of the 34,916 patients used supplemental oxygen, with an over four-fold difference between states and an over six-fold difference between hospital referral regions with high/low utilization. Rocky Mountain states and Alaska had the highest utilization; the District of Columbia had the lowest utilization. After adjusting for patient characteristics and elevation, high utilization communities included low lying areas in California, Florida, Michigan, Missouri, and Washington. Living in rural areas was associated with higher unadjusted oxygen use rates than living in urban areas.

CONCLUSIONS

There is significant geographic variation in supplemental oxygen use, even after controlling for important patient and contextual factors. The Centers for Medicare & Medicaid Services (CMS) should examine these issues further and institute changes that will ensure both patient health and fiscal responsibility.

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INTRODUCTION

Supplemental oxygen has been shown to significantly improve survival and quality of life in patients with obstructive lung disease who cannot otherwise maintain sufficient levels of oxygen in their body.[1] Supplemental oxygen use in the home by Medicare beneficiaries has been a topic of increased interest over the past several years as it is the single most expensive equipment item that Medicare purchases, and costs the program $1.7 billion each year.[2] A 1997 study by the Government Accounting Office (GAO) (now called the Government Accountability Office) found that the Centers for Medicare & Medicaid Services' (CMS') payment rates for home oxygen supplies were significantly more than those of the Department of Veterans Affairs.[3] As a result of these findings, the GAO recommended that CMS should monitor trends in beneficiaries' use of and access to home oxygen systems.[4,5] Subsequently, CMS has taken several steps to reduce expenditures for home oxygen in response to the Medicare Modernization Act (MMA) of 2003, which mandated reductions in Medicare's monthly payment amounts for oxygen and oxygen equipment.[6]

As part of a continuing effort to understand and manage home oxygen use on the part of CMS, and as part of a more general desire to understand health care utilization behaviors of patients with obstructive lung disease, we used data from the Medicare Durable Medical Equipment (DME) files to assess geographic differences in the use of supplemental oxygen. This study is important because the identification of populations that are high or low users of supplemental oxygen is a first step in a quality improvement process and may identify communities or populations that require further investigation and ameliorative interventions.

METHODS

We performed a retrospective cohort analysis of Medicare patients who were continuously enrolled in Parts A and B fee-for-service Medicare throughout the study period and were hospitalized for obstructive lung disease (COPD) between January 1, 1999, and December 31, 1999, and alive at the end of 2000. Using a 20% random sample of the Medicare inpatient file, we identified patients admitted to acute care hospitals with the primary diagnosis of COPD or emphysema during 1999. This was performed by selecting those individuals whose primary diagnosis fell into the following categories: International Classification of Diseases 9th Revision (ICD-9) codes 490.0-492.8 and 494.0-496.0. ICD-9 codes 493.0-493.9 (asthma) were excluded. We chose to define our cohort using inpatients so that we could select individuals with relatively severe disease who were possible candidates for supplemental oxygen. We then searched the Medicare Durable Medical Equipment records (Statistical Analysis Durable Medical Equipment Regional Carrier Oxygen Supplies/Equipment, Nebulizers & Related Drugs, and Respiratory Assist Policy Groups) for information regarding the subsequent use of supplemental oxygen any time after their hospitalization through the end of 2000. This file contained information regarding patient age, gender, race, and home Zone Improvement Plan (ZIP) code.

We used the home ZIP code of the patient to define the rural/urban status of the beneficiary. This information is contained on each billing line. Rural status was determined by linking this ZIP code to its Rural-Urban Commuting Area Code (RUCA).[7,8] This rural-urban taxonomy was selected as RUCAs are now used in a wide range of federal programs and research studies. The ZIP code version of RUCAs (Version 1.11) describes more refined geographic units than county-based systems such as the Office of Management and Budget's Metropolitan, Non-Metropolitan taxonomy and includes a measure of functional relationships. RUCAs use Census Bureau information to differentiate areas based on their city/town size and work commuting patterns to larger cities and towns. The 30 RUCA designations were aggregated into four categories: Urban (RUCA = 1.0, 1.1, 2.0, 2.1, 2.2, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1), Large Rural City (in or associated with a large rural city of 10,000 to 49,999, RUCA = 4.0, 5.0, 6.0), Small Rural Town (in or associated with a rural town of 2,500 to 9,999, RUCA = 7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2), and Isolated Rural Town (in or associated with a rural town of fewer than 2,500, RUCA = 10.0, 10.2, 10.3, 10.4, 10.5). Non-city/town areas were aggregated with the city/town where they had a strong commuting relationship.

In addition, we linked the patient's home ZIP code to several other databases to estimate four other variables: median household income in the ZIP code, elevation above sea level, state, and hospital referral region.[9] Median household income in a patient's home ZIP code was obtained from the 1998 Claritas Demographic file which links ZIP code to income data through a previously described process.[9] Elevation above sea level was determined by linking each patient's home ZIP code to commercially available data.[10] When elevation was missing from this source, first the 2003 Area Resource File (ARF) (used for 2.5% of patients) and then the Web-based United States Geological Survey (USGS) National Map (used for 0.1% of patients) were used to obtain elevation.[11,12] The patient's hospital referral region (HRR) was one of 306 distinct medical care referral regions across the United States defined by the *Dartmouth Atlas of Health Care*.[9] We linked population estimates for 2004 to each ZIP code,[13] identified those ZIP codes classified as rural by the RUCA codes, and combined these data elements to calculate the proportion of the population in each HRR living in a rural area. Twelve of the 306 HRRs were missing population data for one ZIP code, and one HRR was missing population data for two ZIP codes. For these HRRs, we used the available population data in the other ZIP codes to calculate the rural population proportion. The number of ZIP codes in these 13 HRRs with population data ranged from 34 to 295. Patients' home ZIP codes were also used to identify their residence in different states or the District of Columbia, referred to as states only throughout the manuscript.

Finally, we controlled for patient severity of illness by determining the number of admissions the patient had while in the cohort as well as the length of stay in the hospital. In order to control for the influence of comorbid conditions, we applied Deyo's adaptation of Charlson's 17-condition Comorbidity Index for administrative data to each patient.[14]

DATA ANALYSIS

We first described patient sociodemographic characteristics (e.g., age, race), clinical characteristics (e.g., Charlson comorbidity index), environmental characteristics (e.g., ZIP code-based median household income, elevation), and oxygen use by individuals living in the four RUCA types. Standard statistical tests were employed (e.g., overall chi-square tests and analysis of variance). We then calculated oxygen use rates in both states and HRRs, and identified states and HRRs with unadjusted rates of oxygen use more or less than two standard deviations from the state and HRR mean rates of oxygen use. We also created a map displaying the distribution of states' unadjusted oxygen supplementation rates using logical breakpoints. Next we determined which states and HRRs had high or low utilization of supplemental oxygen after adjustment for patient sociodemographic, clinical, and environmental variables. In these multivariate patient-level logistic regression analyses, the dependent variable was occurrence or not (0/1) of any patient oxygen claim. We report those states and HRRs where the odds ratios were greater than two standard deviations above or below the overall mean odds ratio.

RESULTS

We identified 35,588 Medicare patients with a hospitalization for COPD or emphysema in 1999 who met our study criteria. The 672 (1.9%) patients who were missing at least one geographic identifier (598 without a hospital referral region code, 74 without a RUCA code) were excluded from the analyses, leaving 34,916 patients in our cohort. Patient characteristics by rural/urban categories are displayed in Table 1. Of the 34,916 study patients, 11,766 (33.7%) had a claim for home oxygen at some point between hospital discharge and December 31, 2000. Patients living in rural areas had higher rates of home oxygen use than those in urban areas; however, the elevations of these rural areas, on average, were nearly twice as high as for urban areas. Those living in rural areas were the most likely to be white or male and had the shortest lengths of stay and the lowest income in their ZIP codes. The rural-urban differences for the subset of the cohort that had an oxygen claim were similar, except sex. Within this subset, those living in urban areas were most likely to be male. Finally, the groups were more similar in terms of number of admissions and Charlson comorbidity scores.

Table 1: Patient Characteristics by Rural and Urban Residence Location†

	Urban	Large Rural	Small Rural	Isolated Small Rural	Total
All beneficiaries hospitalized with obstructive lung disease					
Number of patients	22,586	4,589	4,319	3,422	34,916
% with oxygen claim***	32.6%	36.8%	34.3%	35.9%	33.7%
Mean number of oxygen claims (SD)***	8.36 (16.8)	9.65 (17.3)	9.42 (17.7)	9.91 (17.7)	8.81 (17.1)
Mean age (SD)***	75.19 (10.9)	74.30 (10.6)	74.52 (10.4)	74.88 (10.6)	74.96 (10.8)
% male***	43.6%	47.9%	47.7%	51.8%	45.5%
% non-white***	14.3%	8.1%	7.3%	5.8%	11.8%
Mean number of admissions (SD)**	1.37 (0.9)	1.35 (0.8)	1.42 (1.0)	1.40 (1.0)	1.38 (0.9)
Mean hospital length of stay in days (SD)***	7.15 (7.9)	6.13 (5.7)	5.68 (4.8)	5.53 (4.9)	6.67 (7.1)
Mean Charlson comorbidity index (SD)**	1.06 (1.3)	1.04 (1.3)	0.99 (1.3)	1.00 (1.3)	1.04 (1.3)
Mean county elevation in feet (SD)***	581 (855)	988 (1,116)	938 (1,062)	1,069 (1,061)	726 (962)
Mean ZIP code-based median household income (SD)***	$40,970 ($16,274)	$30,446 ($6,827)	$27,175 ($6,102)	$25,824 ($6,335)	$36,396 ($15,021)
Beneficiaries hospitalized with obstructive lung disease and had an oxygen claim					
Number of patients	7,364	1,690	1,483	1,229	11,766
Mean number of oxygen claims (SD)***	25.64 (20.5)	26.21 (19.4)	27.43 (20.4)	27.60 (19.7)	26.15 (20.3)
Mean age (SD)**	74.11 (9.7)	73.29 (9.3)	73.65 (9.3)	74.00 (9.3)	73.92 (9.6)
% male***	50.1%	56.2%	57.5%	58.6%	52.8%
% non-white***	11.2%	6.5%	5.3%	4.5%	9.0%
Mean number of admissions (SD)**	1.60 (1.2)	1.54 (1.0)	1.69 (1.3)	1.63 (1.3)	1.61 (1.2)
Mean hospital length of stay in days (SD)***	7.25 (6.7)	6.31 (5.8)	5.83 (4.5)	5.90 (4.8)	6.80 (6.2)
Mean Charlson comorbidity index (SD)	1.14 (1.4)	1.10 (1.4)	1.08 (1.3)	1.10 (1.4)	1.13 (1.4)
Mean county elevation in feet (SD)***	693 (1,035)	1,129 (1,280)	1,031 (1,180)	1,200 (1,264)	851 (1,136)
Mean ZIP code-based median household income (SD)***	$40,917 ($15,544)	$30,941 ($6,800)	$27,395 ($6,131)	$26,489 ($6,517)	$36,272 ($14,301)

† Aggregations of Rural-Urban Commuting Areas.
Asterisks indicate statistically significant differences across the four geographic locations: $*P \le 0.05$, $**P \le 0.01$, $***P \le 0.001$.
SD = standard deviation.
Missing values: All beneficiaries: race: urban 100, large rural 20, small rural 18, isolated small rural 16; length of stay: urban 172, large rural 30, small rural 29, isolated small rural 23; ZIP code-based median household income: urban 1, large rural 0, small rural 0, isolated small rural 0. Beneficiaries who had an oxygen claim: race: urban 24, large rural 6, small rural 6, isolated small rural 5; length of stay: urban 43, large rural 10, small rural 6, isolated small rural 9.

Table 2 shows the unadjusted percent of study patients who used supplemental oxygen by state. There was an over four-fold difference between the highest and lowest utilization states. In general, the higher utilization areas were in the mountain states, while low utilization areas were in the East and South Census regions (see Figure 1).

Table 3 shows the unadjusted percent of study patients who used supplemental oxygen by HRR and the proportion of the HRR population living in rural areas. There was an over six-fold difference between the highest and lowest utilization HRRs. Overall, 18.3% (56/306) of the HRRs had over half of their population in rural areas (highlighted in red).

Table 4 identifies those HRRs that were at least two standard deviations above or below the HRR mean unadjusted utilization rates for supplemental oxygen. High utilization HRRs included Colorado Springs, Fort Collins, Greeley, and Pueblo, CO; Idaho Falls, ID; Traverse City, MI; Amarillo, TX; Salt Lake City and Ogden, UT; and Casper, WY. High utilization states (2 standard deviations above the state mean unadjusted utilization rate) included Colorado, Utah, and Wyoming (data not shown). Only the District of Columbia was classified as a low utilization state (2 standard deviations below the mean unadjusted utilization rate), while four HRRs—Lafayette, LA, New Brunswick, NY, Grand Forks, ND, and Harlingen, TX—fell into the low utilization rate category.

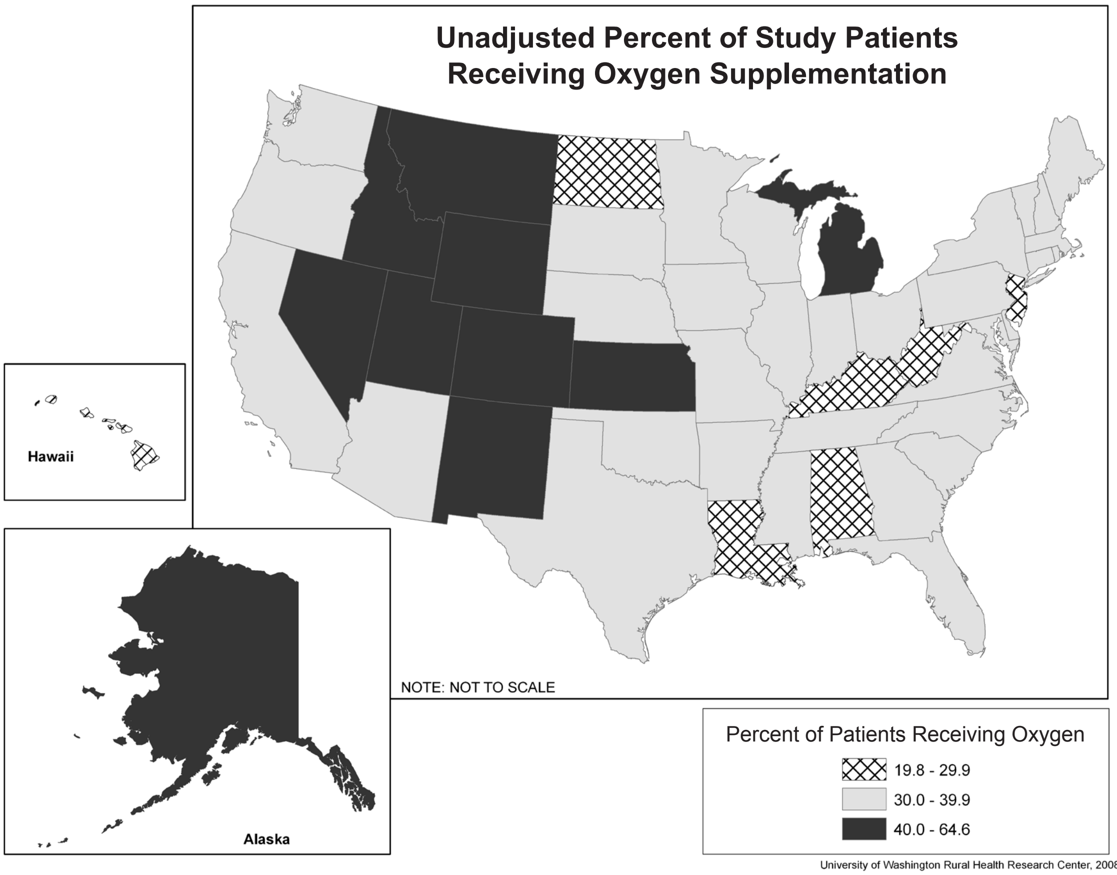
After adjusting for patient and contextual characteristics (including elevation above sea level), a somewhat different set of states (data not shown) and hospital referral regions were identified as high oxygen utilizers (2 standard deviations above the mean odds ratio) (Table 5). These included the state of Alaska, as well as the HRRs of Redding, CA, Pueblo, CO, Lakeland, FL, Idaho Falls, ID, South Bend, IN, Traverse City, Saginaw, Flint, and Grand Rapids, MI, Cape Girardeau, MO, Amarillo, TX, Ogden, UT, Olympia, WA, and La Crosse, WI. After this same adjustment, low oxygen utilization areas (2 standard deviations below the mean odds ratio) included the District of Columbia and Louisiana (data not shown), but no HRRs.

Table 2: Unadjusted Percent of Patients with an Oxygen Claim by State

State	% with Oxygen Claim (95% CI)	N
Wyoming	64.6 (53.8,75.3)	79
Utah	58.3 (49.8,66.9)	132
Colorado	53.8 (48.4,59.3)	338
New Mexico	52.9 (46.0,59.7)	210
Alaska	48.6 (32.2,65.1)	37
Idaho	47.9 (39.6,56.2)	144
Nevada	42.1 (34.4,49.8)	164
Montana	41.5 (33.8,49.2)	164
Kansas	41.4 (36.5,46.2)	411
Michigan	41.1 (38.4,43.8)	1,316
Vermont	39.2 (27.8,50.5)	74
Wisconsin	38.0 (34.1,42.0)	605
Washington	38.0 (33.5,42.5)	466
Arizona	38.0 (32.9,43.0)	374
Rhode Island	37.4 (27.6,47.1)	99
Oklahoma	37.1 (33.2,41.0)	601
Oregon	36.9 (31.0,42.8)	268
Nebraska	36.9 (30.5,43.3)	225
North Carolina	36.1 (33.4,38.9)	1,237
Tennessee	36.0 (33.0,39.0)	1,033
Indiana	35.6 (32.6,38.7)	988
Florida	35.6 (33.6,37.6)	2,271
Missouri	35.4 (32.3,38.6)	914
Maine	35.3 (28.6,42.1)	201
Delaware	35.1 (26.1,44.0)	114
New Hampshire	35.0 (26.9,43.2)	137
South Dakota	34.9 (27.1,42.7)	149
Massachusetts	34.1 (30.7,37.4)	801
South Carolina	33.9 (30.1,37.8)	598
Iowa	33.7 (29.6,37.9)	519
Arkansas	33.6 (29.6,37.6)	562
Ohio	33.2 (31.0,35.5)	1,736
Minnesota	33.2 (29.0,37.4)	506
Illinois	33.1 (30.8,35.5)	1,626
Georgia	33.1 (30.2,36.0)	1,039
Texas	33.0 (31.0,35.1)	2,134
Virginia	32.4 (29.4,35.5)	943
Connecticut	31.8 (26.8,36.9)	336
Mississippi	31.5 (27.4,35.5)	518
Pennsylvania	31.4 (29.2,33.7)	1,722
Maryland	31.3 (27.4,35.1)	579
California	31.1 (29.1,33.1)	2,139
New York	30.1 (28.0,32.3)	1,990
Alabama	28.8 (25.7,31.8)	869
Kentucky	28.3 (25.5,31.1)	1,032
West Virginia	27.6 (23.8,31.4)	558
Hawaii	26.3 (16.2,36.4)	76
North Dakota	26.2 (17.5,34.9)	103
New Jersey	24.2 (21.6,26.8)	1,088
Louisiana	19.8 (16.6,22.9)	637
District of Columbia	14.8 (5.1,24.5)	54

CI = confidence interval.

Figure 1



DISCUSSION

Our study reveals that over one-third of all Medicare patients admitted for obstructive lung disease utilized supplemental oxygen within one to two years of discharge. However, there is significant statewide variation in the use of supplemental oxygen after hospitalization, with the highest utilization occurring in the Rocky Mountain states. In addition, in-depth analysis of hospital referral regions suggests that after controlling for sociodemographic, clinical, and environmental factors (e.g., elevation above sea level), some low-lying communities such as Lakeland, FL, and Olympia, WA, have very high utilization rates.

Supplemental oxygen use was highest in large rural areas compared to urban areas and small rural areas. Previous studies have shown that the medical care received in large rural areas is similar in quality to that in urban areas. For example, Rosenblatt et al. found that patients who were living in large remote rural areas (as defined by the Washington State Department of Health and community hospital size) received the highest quality diabetes care,[15] while Stearns et al. found that those in rural counties that were adjacent to urban areas and that had their own city of at least 10,000 people reported the highest rates of satisfaction with care of all geographic areas.[16] Additional research has demonstrated that patients who received care from hospitals in RUCA-designated large rural areas (in or associated with a large rural city) generally had rates of guideline adherence for acute myocardial infarction close to that of urban areas.[17] The explanations for such findings need further investigation. Many of the large rural towns/cities are vital economic entities with growing populations, and are medical referral sites for their surrounding areas. These rural towns/cities of 10,000 to 49,000 often have an adequate supply of both primary care and specialty care physicians along with the associated medical infrastructure.

LIMITATIONS

There are several limitations to our findings. First, we defined our cohort through an initial hospitalization. If there were differential hospitalization rates between states, HRRs, or rural and urban locations, our findings regarding the comparative use of supplemental oxygen between those areas may not be accurate. We had limited data on patient severity of illness. Because we were dealing with administrative billing data, we had no access to specific measures of pulmonary

Table 3: Unadjusted Percent of Patients with an Oxygen Claim and by Hospital Referral Region

Hospital Referral Region*	State	N	% with Oxygen Claim (95% CI)	% Population Living in Rural Area†
Ogden	UT	25	76.0 (58.9,93.1)	10.3
Pueblo	CO	25	76.0 (58.9,93.1)	9.7
Idaho Falls	ID	21	71.4 (51.7,91.1)	43.4
Casper	WY	36	63.9 (47.9,79.9)	61.6
Fort Collins	CO	32	62.5 (45.4,79.6)	15.8
Greeley	CO	32	62.5 (45.4,79.6)	26.5
Colorado Springs	CO	66	62.1 (50.2,74.1)	23.7
Amarillo	TX	84	60.7 (50.1,71.4)	45.3
Traverse City	MI	28	60.7 (42.3,79.2)	100.0
Salt Lake City	UT	119	59.7 (50.7,68.7)	23.8
Lakeland	FL	62	53.2 (40.6,65.9)	11.7
La Crosse	WI	32	53.1 (35.5,70.8)	62.4
Reno	NV	65	52.3 (39.9,64.7)	32.5
Rapid City	SD	25	52.0 (32.0,72.0)	49.8
Saginaw	MI	104	51.9 (42.1,61.7)	54.4
Albuquerque	NM	151	51.7 (43.5,59.8)	37.6
Boulder	CO	12	50.0 (21.1,78.9)	0.9
Flint	MI	88	50.0 (39.3,60.7)	0.9
Grand Rapids	MI	114	50.0 (40.6,59.4)	20.2
Muskegon	MI	34	50.0 (32.9,67.1)	18.3
Olympia	WA	30	50.0 (31.7,68.3)	39.8
Asheville	NC	143	49.0 (40.6,57.3)	36.8
Anchorage	AK	37	48.6 (32.2,65.1)	36.1
Mason City	IA	25	48.0 (28.0,68.0)	100.0
Modesto	CA	65	47.7 (35.3,60.1)	24.7
South Bend	IN	99	47.5 (37.4,57.5)	18.0
Dubuque	IA	19	47.4 (24.5,70.3)	39.9
Redding	CA	49	46.9 (32.7,61.2)	48.5
Cape Girardeau	MO	45	46.7 (31.8,61.5)	100.0
Lubbock	TX	125	46.4 (37.5,55.3)	60.4
Denver	CO	171	46.2 (38.6,53.8)	10.3
Billings	MT	102	46.1 (36.2,55.9)	74.1
Spokane	WA	152	46.1 (38.0,54.1)	34.3
Wichita	KS	215	46.0 (39.2,52.8)	57.3
Terre Haute	IN	50	46.0 (31.9,60.1)	19.5
Muncie	IN	33	45.5 (28.1,62.8)	24.2
Neenah	WI	33	45.5 (28.1,62.8)	28.7
Salisbury	MD	75	45.3 (33.8,56.8)	72.4
Marquette	MI	38	44.7 (28.6,60.9)	100.0
Altoona	PA	47	44.7 (30.2,59.2)	49.3
Chattanooga	TN	108	44.4 (34.9,54.0)	13.3
Chico	CA	45	44.4 (29.6,59.3)	48.4
Medford	OR	54	44.4 (30.9,58.0)	55.7
Lafayette	IN	34	44.1 (27.1,61.1)	21.3
Syracuse	NY	169	43.8 (36.2,51.4)	45.5
Hattiesburg	MS	55	43.6 (30.3,57.0)	53.0
Green Bay	WI	62	43.5 (31.0,56.1)	48.0
Great Falls	MT	30	43.3 (25.2,61.4)	46.7
Ventura	CA	49	42.9 (28.7,57.0)	2.4
Buffalo	NY	173	42.8 (35.3,50.3)	15.5
Columbia	SC	144	42.4 (34.1,50.6)	37.7
Waterloo	IA	45	42.2 (27.5,56.9)	29.9
Burlington	VT	83	42.2 (31.3,53.0)	70.1
Johnson City	TN	38	42.1 (26.1,58.1)	31.1
Topeka	KS	62	41.9 (29.4,54.5)	52.4
Ann Arbor	MI	167	41.9 (34.3,49.6)	6.1
El Paso	TX	117	41.9 (32.8,51.0)	10.2
Worcester	MA	86	41.9 (31.2,52.5)	2.9
Kalamazoo	MI	110	41.8 (32.4,51.2)	37.1
Binghamton	NY	67	41.8 (29.7,53.8)	32.9
Hudson	FL	94	41.5 (31.3,51.7)	0.0

Table 3 (continued)

Hospital Referral Region*	State	N	% with Oxygen Claim (95% CI)	% Population Living in Rural Area†
Bangor	ME	87	41.4 (30.8,51.9)	67.1
Fresno	CA	63	41.3 (28.9,53.7)	24.8
Fort Wayne	IN	97	41.2 (31.2,51.2)	56.3
Ocala	FL	117	41.0 (31.9,50.1)	32.9
Missoula	MT	44	40.9 (26.1,55.7)	67.7
Springfield	MO	135	40.7 (32.3,49.2)	50.3
Charlottesville	VA	91	40.7 (30.4,51.0)	37.3
Sacramento	CA	187	40.6 (33.5,47.8)	15.0
Sarasota	FL	74	40.5 (29.1,52.0)	8.4
Phoenix	AZ	186	40.3 (33.1,47.5)	17.2
Albany	GA	30	40.0 (22.1,57.9)	30.7
Boise	ID	70	40.0 (28.3,51.7)	33.0
Madison	WI	118	39.8 (30.8,48.8)	36.2
Bakersfield	CA	88	39.8 (29.3,50.2)	26.3
Tulsa	OK	189	39.7 (32.6,46.8)	36.4
Springfield	IL	175	39.4 (32.0,46.8)	57.4
Minot	ND	28	39.3 (20.8,57.7)	100.0
Columbia	MO	153	39.2 (31.3,47.1)	61.1
Lebanon	NH	51	39.2 (25.5,52.9)	100.0
Gulfport	MS	23	39.1 (18.8,59.5)	0.0
Santa Barbara	CA	23	39.1 (18.8,59.5)	5.0
Springdale	AR	64	39.1 (26.9,51.3)	28.0
Fort Worth	TX	126	38.9 (30.2,47.6)	7.1
San Luis Obispo	CA	18	38.9 (15.9,61.9)	26.5
Orlando	FL	382	38.7 (33.8,43.7)	6.4
Marshfield	WI	44	38.6 (24.0,53.3)	86.3
Springfield	MA	101	38.6 (28.9,48.3)	14.8
Fort Smith	AR	65	38.5 (26.4,50.5)	38.3
Santa Rosa	CA	26	38.5 (19.4,57.5)	10.2
Wilmington	NC	65	38.5 (26.4,50.5)	34.9
Lincoln	NE	76	38.2 (27.0,49.3)	48.4
Portland	OR	153	37.9 (30.1,45.8)	14.6
Columbus	OH	412	37.9 (33.1,42.6)	37.5
Providence	RI	119	37.8 (28.9,46.7)	0.0
Pontiac	MI	45	37.8 (23.3,52.2)	0.0
Greenville	NC	143	37.8 (29.7,45.9)	60.9
Abilene	TX	64	37.5 (25.4,49.6)	49.2
Canton	OH	96	37.5 (27.6,47.4)	41.1
Petoskey	MI	32	37.5 (20.4,54.6)	100.0
Salem	OR	24	37.5 (17.7,57.3)	6.9
Salinas	CA	32	37.5 (20.4,54.6)	8.0
Slidell	LA	24	37.5 (17.7,57.3)	22.0
Rockford	IL	91	37.4 (27.2,47.5)	32.5
Des Moines	IA	168	36.9 (29.5,44.4)	43.1
Albany	NY	274	36.9 (31.0,42.7)	23.6
Allentown	PA	152	36.8 (29.0,44.7)	14.5
Huntsville	AL	87	36.8 (26.4,47.1)	25.8
Milwaukee	WI	259	36.7 (30.7,42.7)	5.8
Grand Junction	CO	30	36.7 (19.1,54.3)	57.8
Harrisburg	PA	129	36.4 (28.0,44.9)	30.5
Dallas	TX	338	36.4 (31.2,41.6)	9.5
Lansing	MI	66	36.4 (24.5,48.2)	28.5
Sun City	AZ	33	36.4 (19.6,53.1)	0.0
Louisville	KY	344	36.3 (31.2,41.5)	26.4
Joliet	IL	80	36.3 (25.5,47.0)	0.1
Urbana	IL	80	36.3 (25.5,47.0)	36.3
Little Rock	AR	329	36.2 (30.9,41.5)	49.8
Napa	CA	47	36.2 (22.2,50.2)	65.3
Seattle	WA	188	36.2 (29.2,43.2)	6.1
Peoria	IL	133	36.1 (27.8,44.4)	41.2
Kansas City	MO	327	36.1 (30.8,41.4)	14.2

Table 3 (continued)

Hospital Referral Region*	State	N	% with Oxygen Claim (95% CI)	% Population Living in Rural Area†
Bloomington	IL	25	36.0 (16.8,55.2)	15.6
Fort Myers	FL	170	35.9 (28.5,43.2)	4.2
Elmira	NY	81	35.8 (25.1,46.5)	19.5
Winston-Salem	NC	162	35.8 (28.3,43.3)	42.6
Pensacola	FL	109	35.8 (26.6,45.0)	16.4
Palm Spr/Rancho Mir	CA	28	35.7 (17.6,53.8)	21.1
New Haven	CT	152	35.5 (27.8,43.3)	0.4
Atlanta	GA	523	35.4 (31.2,39.6)	9.5
Bismarck	ND	34	35.3 (18.9,51.7)	54.3
Jacksonville	FL	153	35.3 (27.6,43.0)	14.0
Las Vegas	NV	119	35.3 (26.5,44.1)	6.9
Davenport	IA	108	35.2 (26.0,44.4)	32.3
Duluth	MN	54	35.2 (22.2,48.2)	49.4
Tampa	FL	128	35.2 (26.7,43.6)	0.0
Stockton	CA	37	35.1 (19.4,50.8)	9.2
Odessa	TX	57	35.1 (22.4,47.7)	23.5
Oklahoma City	OK	300	35.0 (29.5,40.5)	37.4
Tucson	AZ	80	35.0 (24.3,45.7)	19.4
Mesa	AZ	63	34.9 (22.9,46.9)	1.9
Omaha	NE	172	34.9 (27.6,42.2)	38.7
Spartanburg	SC	66	34.8 (23.1,46.6)	26.2
Ridgewood	NJ	46	34.8 (20.7,48.8)	0.0
Yakima	WA	23	34.8 (14.9,54.6)	41.7
St. Paul	MN	75	34.7 (23.7,45.7)	8.3
Melrose Park	IL	127	34.6 (26.2,43.1)	0.0
Nashville	TN	436	34.6 (30.1,39.2)	36.0
Ormond Beach	FL	55	34.5 (21.7,47.4)	0.0
Greensboro	NC	84	34.5 (24.1,44.9)	28.1
Cleveland	OH	299	34.4 (29.0,39.9)	6.6
Clearwater	FL	90	34.4 (24.4,44.5)	0.0
Detroit	MI	250	34.4 (28.4,40.4)	0.1
Knoxville	TN	330	34.2 (29.0,39.5)	43.7
Bridgeport	CT	41	34.1 (19.3,49.0)	0.0
Dearborn	MI	82	34.1 (23.7,44.6)	0.0
Gainesville	FL	85	34.1 (23.8,44.4)	46.0
Charlotte	NC	264	34.1 (28.3,39.9)	21.5
Joplin	MO	91	34.1 (24.1,44.0)	66.8
Tacoma	WA	47	34.0 (20.2,47.9)	0.1
York	PA	47	34.0 (20.2,47.9)	21.6
Fort Lauderdale	FL	288	34.0 (28.4,39.6)	0.0
Richmond	VA	206	34.0 (27.4,40.6)	13.1
San Bernardino	CA	130	33.8 (25.5,42.1)	4.3
Indianapolis	IN	399	33.8 (29.1,38.6)	25.3
Rochester	MN	68	33.8 (22.3,45.3)	54.1
Erie	PA	119	33.6 (25.0,42.3)	59.7
Portland	ME	131	33.6 (25.3,41.8)	39.3
Minneapolis	MN	289	33.6 (28.0,39.1)	28.9
Bradenton	FL	48	33.3 (19.7,46.9)	0.0
Greenville	SC	147	33.3 (25.6,41.1)	17.8
Longview	TX	42	33.3 (18.8,47.9)	30.3
St. Cloud	MN	30	33.3 (16.1,50.5)	25.8
St. Petersburg	FL	84	33.3 (23.0,43.6)	0.0
Tallahassee	FL	105	33.3 (24.1,42.5)	43.4
Wausau	WI	15	33.3 (9.0,57.7)	44.5
Winchester	VA	72	33.3 (22.2,44.4)	46.0
Tyler	TX	106	33.0 (23.9,42.2)	54.6
Durham	NC	203	33.0 (26.4,39.6)	45.6
Augusta	GA	97	33.0 (23.4,42.5)	26.0
Morgantown	WV	88	33.0 (22.9,43.0)	71.7
Pittsburgh	PA	591	32.8 (29.0,36.7)	14.2
Arlington	VA	116	32.8 (24.0,41.5)	0.1

Table 3 (continued)

Hospital Referral Region*	State	N	% with Oxygen Claim (95% CI)	% Population Living in Rural Area†
Kettering	OH	58	32.8 (20.4,45.1)	0.0
Newport News	VA	52	32.7 (19.7,45.7)	2.8
Elyria	OH	46	32.6 (18.8,46.4)	0.0
Mobile	AL	117	32.5 (23.8,41.1)	24.9
Baton Rouge	LA	68	32.4 (21.0,43.7)	20.1
Sayre	PA	34	32.4 (16.3,48.4)	88.6
Elgin	IL	65	32.3 (20.7,43.9)	0.0
Eugene	OR	65	32.3 (20.7,43.9)	41.6
Cincinnati	OH	243	32.1 (26.1,38.1)	10.6
Panama City	FL	53	32.1 (19.3,44.9)	19.0
Baltimore	MD	290	32.1 (26.6,37.6)	4.3
St. Joseph	MI	25	32.0 (13.3,50.7)	25.0
Houston	TX	416	32.0 (27.4,36.5)	11.2
Charleston	SC	97	32.0 (22.5,41.4)	14.3
Macon	GA	113	31.9 (23.1,40.6)	47.2
Wichita Falls	TX	44	31.8 (17.8,45.9)	29.2
Waco	TX	54	31.5 (18.8,44.1)	28.5
Boston	MA	592	31.4 (27.6,35.2)	0.6
Akron	OH	90	31.1 (21.4,40.9)	0.3
Norfolk	VA	113	31.0 (22.3,39.7)	13.2
Johnstown	PA	39	30.8 (16.0,45.6)	39.4
Rochester	NY	137	30.7 (22.8,38.5)	18.6
Jackson	MS	196	30.6 (24.0,37.2)	53.5
Beaumont	TX	69	30.4 (19.4,41.5)	27.1
Columbus	GA	33	30.3 (14.3,46.3)	8.5
Hinsdale	IL	33	30.3 (14.3,46.3)	0.0
Lancaster	PA	66	30.3 (19.0,41.6)	0.7
Hickory	NC	43	30.2 (16.2,44.2)	0.0
Manchester	NH	86	30.2 (20.3,40.1)	30.4
Evanston	IL	106	30.2 (21.3,39.1)	0.0
Corpus Christi	TX	80	30.0 (19.8,40.2)	34.4
St. Louis	MO	500	30.0 (25.9,34.1)	21.5
White Plains	NY	100	30.0 (20.8,39.2)	0.0
Savannah	GA	114	29.8 (21.3,38.4)	49.7
Morristown	NJ	104	29.8 (20.8,38.8)	3.1
Dayton	OH	151	29.8 (22.4,37.2)	25.9
Jackson	TN	81	29.6 (19.5,39.8)	64.2
Raleigh	NC	187	29.4 (22.7,36.1)	18.1
Roanoke	VA	154	29.2 (21.9,36.6)	46.0
Jonesboro	AR	55	29.1 (16.8,41.3)	58.4
Blue Island	IL	124	29.0 (20.9,37.2)	0.0
Memphis	TN	252	29.0 (23.3,34.7)	33.1
Gary	IN	97	28.9 (19.7,38.1)	4.4
Takoma Park	MD	59	28.8 (17.0,40.6)	0.0
Danville	PA	66	28.8 (17.6,39.9)	57.7
Birmingham	AL	445	28.8 (24.5,33.1)	31.1
Bend	OR	14	28.6 (4.4,52.7)	35.2
Hartford	CT	154	28.6 (21.3,35.9)	10.5
Meridian	MS	49	28.6 (15.7,41.5)	100.0
Hackensack	NJ	165	28.5 (21.5,35.5)	0.0
Sioux Falls	SD	158	28.5 (21.3,35.7)	74.5
Miami	FL	295	28.5 (23.2,33.7)	2.6
Wilmington	DE	88	28.4 (18.8,38.0)	0.0
Evansville	IN	134	28.4 (20.6,36.1)	52.3
Philadelphia	PA	443	28.2 (23.9,32.5)	0.0
Austin	TX	78	28.2 (18.0,38.4)	10.8
Kingsport	TN	149	28.2 (20.8,35.6)	51.3
Contra Costa Co.	CA	57	28.1 (16.2,40.0)	0.0
Orange Co.	CA	143	28.0 (20.5,35.5)	0.0
Lexington	KY	413	27.8 (23.4,32.3)	77.3
Alameda Co.	CA	87	27.6 (18.0,37.2)	0.0

Table 3 (continued)

Hospital Referral Region*	State	N	% with Oxygen Claim (95% CI)	% Population Living in Rural Area†
Victoria	TX	29	27.6 (11.0,44.2)	37.0
Chicago	IL	262	27.5 (22.0,33.0)	0.0
Owensboro	KY	33	27.3 (11.8,42.8)	29.4
Oxford	MS	22	27.3 (8.3,46.3)	100.0
San Angelo	TX	33	27.3 (11.8,42.8)	31.3
San Antonio	TX	170	27.1 (20.2,33.9)	18.9
Lawton	OK	26	26.9 (9.5,44.3)	38.3
Charleston	WV	313	26.8 (21.8,31.8)	51.4
Iowa City	IA	45	26.7 (13.5,39.9)	62.2
Temple	TX	30	26.7 (10.5,42.8)	14.4
Washington	DC	252	26.6 (21.0,32.2)	8.2
Youngstown	OH	143	26.6 (19.2,34.0)	21.7
Camden	NJ	405	26.4 (22.0,30.8)	4.3
Honolulu	HI	76	26.3 (16.2,36.4)	28.2
Royal Oak	MI	88	26.1 (16.8,35.5)	0.0
Montgomery	AL	77	26.0 (16.0,36.0)	19.1
San Diego	CA	154	26.0 (18.9,33.0)	2.4
Appleton	WI	27	25.9 (9.1,42.8)	34.5
Fargo Moorhead-Mn.	ND	62	25.8 (14.7,36.9)	62.9
Bryan	TX	39	25.6 (11.7,39.6)	24.2
Paducah	KY	106	25.5 (17.0,33.9)	99.4
Wilkes-Barre	PA	59	25.4 (14.1,36.8)	1.2
Aurora	IL	12	25.0 (0.0,50.0)	0.0
Provo	UT	16	25.0 (3.3,46.7)	14.3
Texarkana	AR	56	25.0 (13.4,36.6)	46.6
East Long Island	NY	383	24.5 (20.1,28.9)	0.6
Sioux City	IA	45	24.4 (11.6,37.3)	46.6
Rome	GA	54	24.1 (12.4,35.7)	54.1
Tupelo	MS	71	23.9 (13.8,34.1)	100.0
Los Angeles	CA	585	23.9 (20.4,27.5)	0.3
Dothan	AL	109	23.9 (15.7,32.0)	67.5
Scranton	PA	42	23.8 (10.7,37.0)	18.8
Toledo	OH	147	23.8 (16.8,30.8)	30.8
Lake Charles	LA	38	23.7 (9.9,37.5)	23.9
Reading	PA	68	23.5 (13.2,33.8)	23.5
Alexandria	LA	61	23.0 (12.2,33.7)	48.3
New Orleans	LA	88	22.7 (13.8,31.7)	1.4
San Jose	CA	66	22.7 (12.4,33.0)	3.3
McAllen	TX	49	22.4 (10.5,34.4)	10.4
Everett	WA	32	21.9 (7.3,36.5)	12.5
Lynchburg	VA	33	21.2 (7.0,35.4)	21.3
San Mateo Co.	CA	29	20.7 (5.6,35.7)	0.0
Huntington	WV	110	20.0 (12.4,27.6)	18.5
Munster	IN	47	19.1 (7.7,30.6)	0.0
Florence	SC	74	18.9 (9.8,28.0)	50.9
Bronx	NY	92	18.5 (10.4,26.6)	0.0
Tuscaloosa	AL	49	18.4 (7.3,29.4)	28.1
Manhattan	NY	404	18.3 (14.5,22.2)	0.0
Cedar Rapids	IA	44	18.2 (6.6,29.8)	20.4
Houma	LA	33	18.2 (4.8,31.6)	29.5
Metairie	LA	44	18.2 (6.6,29.8)	12.8
Santa Cruz	CA	11	18.2 (-5.1,41.4)	0.0
Shreveport	LA	116	18.1 (11.0,25.3)	42.3
Covington	KY	51	17.6 (7.0,28.3)	0.0
Newark	NJ	180	16.7 (11.1,22.2)	0.0
San Francisco	CA	93	16.1 (8.5,23.8)	0.3
Paterson	NJ	56	16.1 (6.3,25.9)	0.0
Monroe	LA	93	15.1 (7.6,22.5)	32.4
Harlingen	TX	54	14.8 (5.1,24.5)	6.3
New Brunswick	NJ	102	13.7 (6.9,20.5)	0.0
Lafayette	LA	92	12.0 (5.2,18.7)	53.3
Grand Forks	ND	35	11.4 (0.7,22.2)	59.2

* Hospital referral regions with over 50% of the population living in a rural ZIP code are highlighted in red.
† Percent of the population in that hospital referral region that lived in a rural ZIP code in 2004.
CI = confidence interval.

Table 4: Hospital Referral Regions (HRRs) Two Standard Deviations Above and Below the Unadjusted Mean Oxygen Utilization Rate

	Unadjusted % Using Oxygen	N
HRR unadjusted oxygen utilization rate > 2 standard deviations above the mean HRR oxygen utilization rate		
Ogden, UT	76.0	25
Pueblo, CO	76.0	25
Idaho Falls, ID	71.4	21
Casper, WY	63.9	36
Fort Collins, CO	62.5	32
Greeley, CO	62.5	32
Colorado Springs, CO	62.1	66
Amarillo, TX	60.7	84
Traverse City, MI	60.7	28
Salt Lake City, UT	59.7	119
HRR unadjusted oxygen utilization rate > 2 standard deviations below the mean HRR oxygen utilization rate		
Harlingen, TX	14.8	54
New Brunswick, NJ	13.7	102
Lafayette, LA	12.0	92
Grand Forks, ND	11.4	35

Table 5: Hospital Referral Regions (HRRs) Two Standard Deviations Above and Below the Adjusted* Mean Oxygen Utilization Odds Ratio

	Unadjusted % Using Oxygen	N
HRR adjusted* odds ratio for oxygen utilization > 2 standard deviations above the mean HRR odds ratio		
Ogden, UT	76.0	25
Pueblo, CO	76.0	25
Idaho Falls, ID	71.4	21
Amarillo, TX	60.7	84
Traverse City, MI	60.7	28
Lakeland, FL	53.2	62
La Crosse, WI	53.1	32
Saginaw, MI	51.9	104
Flint, MI	50.0	88
Grand Rapids, MI	50.0	114
Olympia, WA	50.0	30
South Bend, IN	47.5	99
Redding, CA	46.9	49
Cape Girardeau, MO	46.7	45
HRR adjusted* odds ratio for oxygen utilization > 2 standard deviations below the mean HRR odds ratio		
None		

* Multiple logistic regression analyses adjusted for age, sex, race, number of admissions, Charlson comorbidity index, elevation, and ZIP code-based median household income.

function. Thus, we were forced to infer patient severity of illness by controlling for the number of hospital admissions and patient length of stay. Another limitation is the small sample size in many of the HRRs, resulting in oxygen supplementation rates with very large confidence intervals. For this reason, we present results only for those HRRs above or below two standard deviations from the mean oxygen supplementation rates. Finally, since our project only examines billing data, we do not have any data on patient outcomes. Although we have documented that significant variation in supplemental oxygen utilization exists between geographic areas, it is unclear what the appropriate rate of supplemental oxygen utilization is after hospitalization for obstructive lung disease.[18,19]

IMPLICATIONS

To our knowledge, this is the first time geographic differences in the utilization of supplemental home oxygen have been examined in detail. We have identified significant variations between states, hospital referral regions, and types of rural/urban areas, and highlighted the rural population rates in hospital referral regions nationally. Given that there is an over four-fold difference between the high and low utilization states and an over six-fold difference between high and low utilization hospital referral regions, and that CMS pays nearly $2 billion per year for these services, further examination of why these variations exist is warranted. CMS, through their Quality Improvement Organizations and Durable Medical Equipment Regional Carriers (DMERCs), has the means to examine these issues in detail and institute changes that will ensure both patient health and fiscal responsibility.

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