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The Rural Inpatient Mortality Study: Does Urban-Rural County Classification Predict Hospital Mortality in California?

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ABSTRACT

Context: Evidence suggests an association between rurality and decreased life expectancy.

Objective: To determine whether rural hospitals have higher hospital mortality, given that very sick patients may be transferred to regional hospitals.

Design: In this ecologic study, we combined Medicare hospital mortality ratings (N = 1267) with US census data, critical access hospital classification, and National Center for Health Statistics urban-rural county classifications. Ratings included mortality for coronary artery bypass grafting, stroke, chronic obstructive pulmonary disease, heart attack, heart failure, and pneumonia across 277 California hospitals between July 2011 and June 2014. We used generalized estimating equations to evaluate the association of urban-rural county classifications on mortality ratings.

Main Outcome Measures: Unfavorable Medicare hospital mortality rating "worse than the national rate" compared with "better" or "same."

Results: Compared with large central "metro" (metropolitan) counties, hospitals in medium-sized metro counties had 6.4 times the odds of rating "worse than the national rate" for hospital mortality (95% confidence interval = 2.8-14.8, $p < 0.001$). For hospitals in small metro counties, the odds of having such a rating were 3.7 times greater (95% confidence interval = 0.7-23.4, $p = 0.12$), although not statistically significant. Few ratings were provided for rural counties, and analysis of rural counties was underpowered.

Conclusion: Hospitals in medium-sized metro counties are associated with unfavorable Medicare mortality ratings, but current methods to assign mortality ratings may hinder fair comparisons. Patient transfers from rural locations to regional medical centers may contribute to these results, a potential factor that future research should examine.

INTRODUCTION

The health of rural populations is challenged by lower access to health care services and a wider geographic dispersion of health services compared with urban and suburban settings.[1] The association between rurality and worse-than-average hospital mortality has been found in prior research.[1-4] The US National Advisory Committee on Rural Health and Human Services also noted that rural mortality rates in the US were, on average, 13% higher compared with metropolitan areas and that the gap between the 2 regions is widening.[4] Evidence suggests that rural patients have access to fewer hospitals and clinicians, and are exposed to long transfer times via ambulance or helicopter.[5-9] Rural hospitals serving small communities have lower occupancy rates and are at increased risk of closure.[10] Medicaid expansions under the Affordable Care Act[11] have increased hospital profitability in some rural locations.[7] However, many critical access hospitals (CAHs) must cope with substantial resource shortages, including limited access to clinicians and capital.[12] Consequently, if rural hospitals lack the resources to care for very sick patients,[6] transferring or diverting these patients to regional hospitals would reduce observable mortality in rural hospitals and increase it in the receiving hospitals. Hospital mortality ratings from Centers for Medicare and Medicaid Services (CMS) do not account for rurality and/or patient transfer patterns.[13]

It is difficult to define rurality in unambiguous terms. In some US states, rural communities may be situated next to small or medium-sized cities, which may facilitate more between-hospital transfers or direct admissions to adjacent regional hospitals. In other states, the entire population may be relatively isolated, and hospitals operate relatively independently. California, for example, has a highly developed agricultural sector, and many of its inland counties have an urbanized center. Consequently, there may be fewer isolated rural hospitals in this state than in other parts of the US. It is unclear whether the increased level of hospital mortality in rural areas seen throughout the US is evident in states such as California.

The aim of this study was to evaluate whether, and which, urban-rural county classifications are associated with hospital mortality in California. We hypothesized that CMS risk-adjusted hospital mortality ratings (worse, same, better than the national average) would be associated with counties' urban-rural classification as defined using the National Center for Health Statistics (NCHS) 6-level classification scheme (from Class 1 to 6: Large central metro [metropolitan], large fringe metro, medium metro, small metro, micropolitan, noncore).[14]

METHODS

The institutional review board of the University of California, San Francisco determined that this study was exempt according to its human subjects protection guidelines. Data were publicly available, and we did not use patient data.

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Study Design and Population

In this ecologic study, we evaluated the association of NCHS urban-rural county classifications with hospital mortality ratings, adjusting for mean county population age, county sex distributions, and CAH classification. We built the research dataset by joining CMS mortality ratings data with 2010 US Census Bureau data for median age, sex, county population size, and NCHS urban-rural county classifications.

The study population included 320 California hospitals that were given mortality ratings by CMS between July 2011 and June 2014. After excluding 43 hospitals that CMS coded as "not available" or "number of cases too small to report," 277 hospitals remained in the study. CMS did not rate federal facilities, long-term care facilities, skilled nursing facilities, psychiatric institutions, or rehabilitation facilities in this dataset. California has 34 hospitals with CMS CAH designation, defined as "hospitals with a maximum of 25 beds that are in a rural area over 35 miles from another hospital."[15] We did not identify patients for this study because this study did not require any patient-level data.

Measurements

Outcome Variable

The outcome variable was a CMS hospital mortality rating, coded as "worse" vs "the same or better" than the national rate. CMS analyzes and reports hospital-level, risk-adjusted 30-day mortality ratings for Medicare and Medicaid fee-for-service beneficiaries who received hospital care as inpatients using risk-standardized mortality rates (RSMRs).[16] These RSMRs account for patient characteristics, including age, comorbidities, and frailty, using a complex algorithm.[17] Then CMS classifies each hospital's RSMR as better, the same as, or worse than the national rate.[13] These ratings do not describe individual patients; rather, they summarize mortality for the following 6 patient populations: Coronary artery bypass graft, stroke, chronic obstructive pulmonary disease, acute myocardial infarction (heart attack), heart failure, and pneumonia. Throughout the study period, CMS rated each hospital only once per diagnosis. Thus, we obtained as many as 6 mortality ratings for each hospital.

Table 1. Definition of National Center for Health Statistics urban-rural county classes[14]

Class	Class name	Description
1	Large central metro	Central counties with at least 1 million residents
2	Large fringe metro	Counties adjacent to central counties
3	Medium metro	Counties with 250,000-999,999 residents
4	Small metro	Counties with 50,000-249,999 residents
5	Micropolitan[a]	Nonmetropolitan counties with 10,000-49,999 residents
6	Noncore[a]	Nonmetropolitan counties outside micropolitan areas

[a] National Center for Health Statistics Classes 5 and 6 are defined as rural by the Federal Office of Budget Management (available from: www.hrsa.gov/ruralhealth/aboutus/definition.html).
metro = metropolitan.

Predictor Variables

The primary predictor was NCHS urban-rural classification[14] measured at the county level (Table 1). We obtained county data on age and sex from the 2010 US Census and CAH designation data from a California Hospital Association 2016 public listing,[15] coded as present or not present. The initial set of predictor variables included NCHS urban-rural county classification, median age and female-male ratio at the county level, and CAH classification at the hospital level.

Statistical Analysis

We performed data transformations and statistical modeling and testing in Stata 14 (StataCorp LLC, College Station, TX) as well as data joins, visual graphs, and maps in Tableau Desktop 9.1 (Tableau Software, Seattle, WA). We fit the initial model using stepwise forward addition of predictor variables. Variables were included if they met a statistical significance threshold of $p < 0.05$, and the predictor with the lowest p value was added first. This approach removed median age, female-male ratio, and CAH classification in the interest of parsimony, and retained the NCHS urban-rural county classifications. Hospital clustering accounted for possible

Table 2. Descriptive characteristics of NCHS urban-rural county classes in California (July 2011 to June 2014)[a,14]

	Metropolitan statistical areas				Rural areas		
Characteristic	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total
Hospitals, no. (%)	147 (53.1)	35 (12.6)	54 (19.5)	14 (5.1)	14 (5.1)	13 (4.7)	277 (100)
CMS ratings, no. (%)[b]	701 (55.3)	152 (12.0)	250 (19.7)	72 (5.7)	58 (4.6)	34 (2.7)	1267 (100)
Counties with critical access hospitals, no. (%)[c]	1 (4.2)	1 (4.2)	3 (12.5)	3 (12.5)	6 (25.0)	10 (41.7)	24 (100)
Mean population density[d,e]	9534	2848	2215	665	557	45	—
Mean median age, years[d]	35.6	35.7	35.4	39.2	39.3	45.2	—
Mean female-male ratio[d]	1.01	1.04	0.99	1.03	0.97	1.02	—

[a] Percentages are calculated across each variable and were rounded to the first decimal.
[b] Up to 6 hospital mortality ratings per hospital for 6 diagnoses: Coronary artery bypass graft, stroke, chronic obstructive pulmonary disease, acute myocardial infarction (heart attack), heart failure, and pneumonia. Ratings "not available" or "too small to report" were excluded. Each hospital was rated once per medical diagnosis for the entire timeframe.
[c] Hospitals must be rurally located to receive CMS Critical Access Hospital designation.
[d] US Census Bureau data. 2010. Data are at the county level, not the patient level. Available from: www2.census.gov/census_2010/04-Summary_File_1/National/.
[e] Population per square mile by county.
CMS = Centers for Medicare and Medicaid Services; NCHS = National Center for Health Statistics.

Table 3. Tabulation of NCHS urban-rural county classes[14] by CMS risk-standardized hospital 30-day mortality ratings (N = 1267) for 6 medical diagnoses in California (July 2011 to June 2014)[a]

	Metropolitan statistical areas				Rural areas		
Characteristic	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Total
CABG							
Better	—	—	—	—	—	—	—
No different	55 (60.4)	10 (11.0)	21 (23.1)	6 (6.6)	—	—	92 (100)
Worse	—	—	—	—	—	—	—
Stroke							
Better	6 (100)	—	—	—	—	—	6 (100)
No different	115 (56.4)	28 (13.7)	37 (18.1)	11 (5.4)	11 (5.4)	4 (3.2)	206 (100)
Worse	2 (33.3)	—	3 (50.0)	1 (16.7)			6 (100)
COPD							
Better	4 (80.0)	1 (20.0)	—	—	—	—	5 (100)
No different	119 (54.1)	29 (13.2)	41 (18.6)	14 (6.4)	12 (5.5)	7 (3.2)	222 (100)
Worse	4 (30.8)	1 (7.7)	7 (53.9)	—	1 (7.7)	—	13 (100)
AMI							
Better	3 (100)	—	—	—	—	—	3 (100)
No different	117 (60.3)	22 (11.3)	38 (19.6)	12 (6.2)	6 (3.1)	1 (0.5)	196 (100)
Worse	—	—	—	—	—	—	—
Heart failure							
Better	19 (90.5)	1 (4.8)	—	1 (4.8)	—	—	21 (100)
No different	116 (51.8)	30 (13.4)	46 (20.5)	12 (5.4)	14 (6.3)	9 (4.0)	227 (100)
Worse	1 (14.3)	—	5 (71.4)	1 (14.3)	—	—	7 (100)
Pneumonia							
Better	21 (91.3)	2 (8.7)	—	—	—	—	23 (100)
No different	117 (52.0)	27 (12.0)	44 (19.6)	12 (5.3)	14 (6.2)	13 (5.8)	227 (100)
Worse	4 (26.7)	1 (6.7)	8 (53.3)	2 (13.3)	—	—	15 (100)

[a] Data are number (%). Centers for Medicare and Medicaid Services ratings numbers "not available" and "too small to report" were excluded. Each hospital was rated once per medical diagnosis for the entire timeframe. Percentages are calculated across each measure and were rounded to the first decimal.

— = CMS data not reported; AMI = acute myocardial infarction; CABG = coronary artery bypass graft; CMS = Centers for Medicare and Medicaid Services; COPD = chronic obstructive pulmonary disease; NCHS = National Center for Health Statistics.

dependence of ratings within hospitals. Inferences were based on robust standard errors incorporating hospital-level clustering using generalized estimating equation methods.[18]

On model fitting, a test for homogeneity confirmed within-group differences for the urban-rural county classifications ($p < 0.001$). Likelihood ratio testing between 2 models with and without the urban-rural county classification confirmed a significantly better model fit in the model with this predictor ($\chi^2 = 30.1$, $p < 0.001$). Standardized Pearson residual plotting confirmed constant variance and the absence of influential points (data not shown). The Hosmer-Lemeshow statistic did not demonstrate a statistically significant lack of fit ($p = 0.02$).

RESULTS

Descriptive Statistics and Geographic Mapping

Among all mortality ratings, CMS reported 19% as "number of cases too small to report" and 16% as "not available." These ratings were excluded. Table 2 summarizes characteristics of hospitals and counties in California by urban-rural county classification (n = 277). A total of 27 hospitals (9.8%) were in rural counties (NCHS Classes 5 and 6), compared with 250 hospitals (90.2%) in counties with at least one large/medium/small metro area (NCHS Classes 1 through 4). Of the 1267 CMS mortality ratings, 92 (7.3%) occurred in rural counties and 1175 ratings (92.7%) occurred in urban counties. The female-male ratio was approximately 1.0 across all counties. The counties' mean population age ranged from 35.6 years in large metro counties to 45.2 years in the most rural settings. Of the 24 counties with CAHs, 16 (66.7%) were rurally classified (NCHS Class 5 or 6).

We compared mortality rating frequencies by medical diagnosis across NCHS urban-rural county classes (Table 3). Hospitals in large central metro counties and counties adjacent to large metro counties (NCHS Classes 1 and 2) accounted for all better-than-average mortality performance for stroke, chronic obstructive pulmonary disease, acute myocardial infarction, heart failure, and pneumonia. A large share of "worse than the national rate" ratings (58%) occurred in hospitals in medium-sized metro counties. None of the "worse than the national rate" ratings occurred in rural counties (Figure 1). The geographic map of CMS ratings (Figure 2) confirmed favorable hospital mortality ratings in the state's 2 metropolitan hubs and a greater number of "worse than the national rate" mortality ratings in

inland territory such as the San Joaquin Valley, the state's largest agricultural area.

Modeling Results

Table 4 shows the results for the unadjusted and adjusted models. Compared with large central metros, the odds of a mortality rating "worse than the national rate" were 6.4 times greater for hospitals in medium-sized metro areas. (95% confidence interval [CI] = 2.8-14.8, p < 0.001). For hospitals in small metros, the odds of a "worse than the national rate" rating were 3.7 times greater compared with large central metros (95% CI = 0.7-23.4, p = 0.12). For hospitals in rural counties, outcome odds were essentially equal (odds ratio = 1.1), and CIs were wide (95% CI = 0.1-8.7, p = 0.92).

DISCUSSION

We sought to evaluate whether urban-rural county classifications are associated with hospital mortality in California. Before discussing the results, we wish to point out the study limitations. First, because of the ecologic design, we cannot establish causality for the observed association of "worse than the national rate" mortality ratings and medium-sized and small metro counties. Similarly, the ecologic design further limits our analysis to the macro level of counties in the state, not individual care encounters or hospitals. Second, CMS and other public databases do not report characteristics of hospitals with NCHS Classes 3 and 4 (hospital occupancy rates, services, clinician certifications), their patient characteristics (comorbidities, severity of illness, health behaviors, medication adherence), or process measures (transport from rural location, transport time, time from door to treatment). Our model does not adjust for these potential factors; however the CMS ratings do risk-adjust for patient characteristics, and the association between NCHS medium-sized metro counties and unfavorable hospital mortality ratings was quite strong. A third limitation is that power for rural counties was not adequate to detect an effect for rural hospitals because the number of "worse than the national rate" mortality ratings was small. To address this, we combined the 6 diagnosis-based mortality ratings into 1 outcome variable. An additional limitation is that NCHS urban-rural classes are measured at the county level. We observed one-third of CAHs in nonrural counties even though CAHs are defined as rural.[15] This incongruence suggests that urbanized counties may still contain a substantial proportion of rural communities. A more granular measure of rurality may add more precision in future studies. Finally, generalizability is limited to US states and countries that are similar to California in size, economy, and urban-rural hospital distributions.

Policymakers appear to agree that rurality is associated with unfavorable hospital mortality. Our results, however, suggest that patients receiving hospital care in California's small to medium-sized metro counties fare worse than those in rural counties and the main metropolitan regions of the state. The NCHS medium-sized metro counties had a very strong association with "worse than the national rate" mortality even after applying robust standard errors, which are the most resistant to incorrect modeling assumptions. Figure 2 shows two distinct regions of better-than-average mortality outcomes in the resource-rich metropolitan hubs of the state.

For urban metro counties, our findings agree with prior evidence regarding the impact of closer proximity to care, better clinician-to-population ratios, and overall better mortality trends

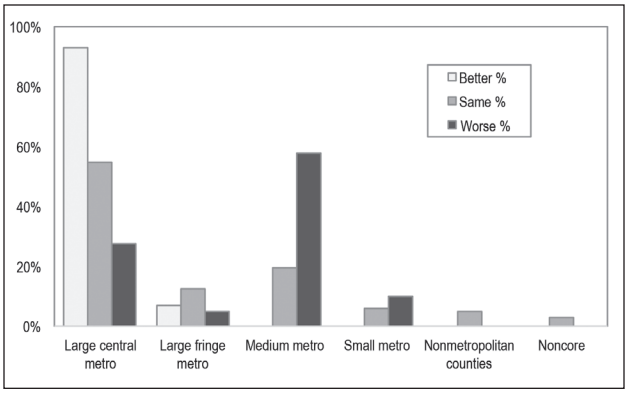

Figure 1. Proportions of CMS mortality ratings (better, same, worse) across NCHS county categories.

CMS = Centers for Medicare and Medicaid Services; NCHS = National Center for Health Statistics.

Table 4. Model results for association of NCHS urban-rural county classes[14] with CMS "worse than national rate" hospital mortality ratings across California hospitals (July 2011 to June 2014, N = 277)[a]

Factor	Odds ratio	95% confidence interval	p value
Age	1.0	0.9-1.1	0.58
Female-male ratio	3.4	0.03-386.1	0.62
CAH classification	0.6	0.07-5.7	0.69
NCHS class in unadjusted univariate model[b]			
1 (reference)	—	—	—
2	0.8	0.2-3.8	0.83
3	6.4	2.8-14.8	< 0.001
4	3.7	0.7-19.8	0.12
5	1.1	0.1-8.7	0.92
6[c]	—	—	—
NCHS class in adjusted multivariate model[b]			
1 (reference)	—	—	—
2	0.8	0.2-3.7	0.81
3	6.4	2.8-14.2	< 0.001
4	4.0	0.7-23.4	0.12
5	1.5	0.2-9.5	0.68
6[c]	—	—	—

[a] Outcome was Centers for Medicare and Medicaid Services hospital mortality ratings "worse than the national rate."

[b] Generalized estimating equations. Model was clustered by hospital with robust standard errors.

[c] Class 6 had no "worse than the national rate" ratings.

CAH = critical access hospital; CMS = Centers for Medicare and Medicaid Services; NCHS = National Center for Health Statistics.

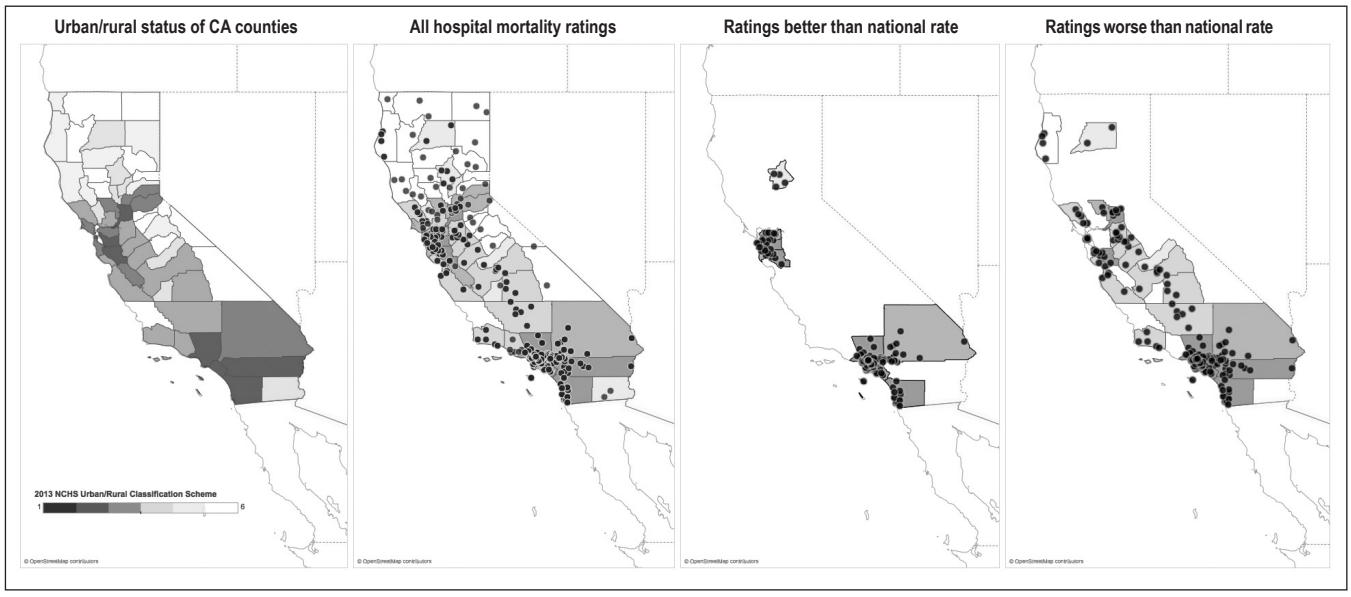

Figure 2. Geographic distribution of CMS hospital mortality ratings across California.[a]

[a] See Table 1 for an explanation of National Center for Health Statistics (NCHS) county classes.
CMS = Centers for Medicare and Medicaid Services.

in metropolitan settings described previously. Contrary to prior studies using national datasets, we did not detect increased hospital mortality in rural counties (or hospitals with critical access designation). The seemingly favorable mortality ratings for rural hospitals may be caused by their limited scope of services.[19,20] These hospitals may not be equipped to handle critically ill patients[3] and may transfer critically ill patients to the nearest regional medical centers.[6] Accordingly, these transfer patterns may increase the pool of very ill patients in the receiving hospitals, which is then reflected in their unfavorable CMS mortality ratings. This explanation agrees with prior research that has found that patients in CAHs are generally healthier than those transferred to regional medical centers.[19]

The way rural hospitals are used in California seems to be working well, in that their hospital mortality rates are not keenly elevated. For medium-sized metropolitan counties, hospital mortality rates were strikingly elevated (although our study could not disentangle the many potential explanations for the elevated rates). Because rural hospitals may send acutely ill patients to larger hospitals (if they admit them in the first place), rating challenges may obscure federal quality ratings of hospital mortality. Results from this study suggest that CMS should account for patient transfer rates[6] because overlooking contextual risk factors introduces unexplained variation in measurement.[21] For example, "primary rural residence with transfer to a regional medical center" may be an important variable to quantify. Without this context, CMS may potentially penalize receiving hospitals in medium-sized metro counties in certain states for patient mortality outside their control. A second explanation for the higher risk of mortality in medium-sized metro counties is poorer population health. For example, California's San Joaquin Valley is a large agricultural region within NCHS Classes 3 and 4. A 2016 population health report[22] discussed the valley's unique health challenges, including poor health of undocumented immigrants, drug abuse, asthma, obesity, poor dental health, and psychiatric illness. Exacerbating factors include social determinants of health, such as poverty and low educational attainment. CMS may not capture such population health disparities in medium-sized metro counties as root causes of mortality and, again, may inadvertently penalize hospitals in such communities.

CONCLUSION

Policymakers should continue to advocate for rural health initiatives, particularly those increasing access and services, but they should also consider whether the transferring of rural patients to nonrural or semirural regional hubs has an impact on these hospitals' mortality performance. Future research should assess whether transfers skew hospital mortality data and should investigate what processes contribute to these patterns. Patient transfer time, time-to-treatment, patient-level health predictors, median income and other socioeconomic data, and utilization of outpatient services, such as hospice and home health, may be important explanatory variables for the observed increased hospital mortality in counties with medium-sized metros. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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