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Original Article

Rural–urban differences in acute myocardial infarction mortality: Evidence from Nebraska

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ABSTRACT

Aims: Acute myocardial infarction (AMI) remains a major cause of death and disability in the United States and worldwide. Despite the importance of surveillance and secondary prevention, the incidence of and mortality from AMI are not continuously monitored, and little is known about survival outcomes after 30 days of AMI hospitalization or associated risk factors, especially in the rural areas. The current study examines rural–urban differences in both in- and out-hospital survival outcomes for AMI patients.

Methods: We performed a retrospective analysis using hospital discharge data in Nebraska for January 2005 to December 2009 and Nebraska death certificate records through October 2011. Multivariate logistic regression was used to estimate the rural–urban difference in 30-day mortality. A Cox proportional hazard model was used to predict out-of-hospital and overall survival rate.

Results: In the 30-day mortality model, after controlling for age, comorbidities, and rehabilitation, patients in urban areas were less likely to die than patients in rural areas (odds ratio: 0.709, 95% confidence interval: 0.626–0.802). In the overall survival model, patients in urban areas had a lower hazard of AMI death (hazard ratio: 0.86, 95% confidence interval: 0.806–0.931) than patients in rural areas. Patients with a previous history of heart failure had a significantly higher likelihood of 30-day mortality, while atrial fibrillation, heart failure, and chronic kidney disease were associated with lower overall survival. Patients who attended at least 1 cardiac rehabilitation session had significantly lower 30-day and overall mortality ($p < 0.0001$).

Conclusions: This study confirms previous findings on rural–urban disparities in 30-day mortality following AMI hospitalization, and reports new findings on overall rural–urban mortality disparity. The study also found an association between cardiac rehabilitation and reduced mortality, a finding never before reported at the population level. Further efforts are needed to develop systems in rural hospitals and communities to ensure that AMI patients receive recommended care.

1. Introduction

Acute myocardial infarction (AMI) or heart attack is a major cause of death in the United States. The American Heart Association estimates around 7.6 million people have had at least 1 episode of AMI in 2013. It is also estimated that in 2013, about 635,000 Americans will have a first-time AMI and another 280,000 will have a recurrent AMI.[1]

About 134,000 people in the United States died from AMI in 2008.[2] AMI mortality and re-hospitalization rates, measured at the provider or the hospital level, are used as an indicator of inpatient quality of care.[3–5] To improve the process of care for AMI patients, the American Heart Association, the Centers for Medicare and Medicaid Services, and the American College of Cardiology have introduced quality improvement guidelines.[6–8] Despite these efforts, there is a wide difference in practice between optimal and actual care for AMI patients in the United States.[9,10] Consequently, disparities in health outcomes exist among different population groups and over different geographic areas.[11,12] In this study, we examine rural–urban differences in health outcomes among AMI patients in Nebraska.

Rural–urban disparities in treatment and outcomes of cardiovascular diseases including AMI remain an enormous public health concern.[13] Previous studies, both pre and post introduction of the quality improvement guidelines, have found a significant difference in process measures for AMI care between hospitals in rural and urban areas.[14–16] Evidence from the mid-1990s showed that rural hospitals provided a poorer quality of inpatient care for AMI patients than urban hospitals. Sheikh and Bullock, using 1994–1995 data, found that patients admitted to

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rural hospitals were less likely to receive lifesaving treatments such as aspirin at discharge, beta-blockers, and thrombolytic therapy.[15] Despite overall improvement in adhering to recommended treatments for AMI patients, and despite closing the gap in treatment quality between large rural and urban hospitals,[9] disparities in delivery of recommended treatment persist.[14,16–18] Rural hospitals have also been found to perform worse than urban hospitals in 30-day mortality rate. Two previous studies, using Medicare inpatient data, found that patients admitted to rural hospitals had a higher 30-day risk-adjusted mortality rate than patients admitted to urban hospitals.[9,19] However, one study from Iowa found no difference in the AMI in-hospital mortality rate between rural and urban hospitals.[20] Almost all of the studies cited above used 30-day or in-hospital mortality as the outcome; the current study exceeds this measure by reporting overall mortality.

Nebraska is a rural state, and compared to Nebraska's urban residents, those in rural areas tend to be older, and to have a lower socioeconomic status, a higher burden of chronic diseases, and poorer access to preventive health care services such as cholesterol screening and cardiac rehabilitation.[21–24] In 2005, about 45% of Nebraska's population resided in non-metropolitan and frontier counties (population density < 6 per square mile). Metropolitan counties (Douglas, Sarpy, and Lancaster) accounted for about 55% of the population.[25] From 2005 to 2009, rural residents aged 19 years or older were significantly ($p < 0.01$) more likely than urban residents to be obese (28.12% vs. 25.12%), use chewing tobacco, (10.34% vs. 4.77%), consider their health either fair or poor (13.1% vs. 11.36%), and do no exercise outside of work (25.03% vs. 20.66%). In addition, rural residents were less likely than urban residents to have had their cholesterol checked in the last 5 years (25.27% vs. 32.64%) and to have had a routine physical checkup in the past year (35.86% vs. 40.98%).[26]

In addition, rural residents face a number of barriers to receiving optimal care after an AMI.[27,28] First, the overwhelming majority of cardiology care services and facilities are in the state's two largest cities, Omaha and Lincoln. In 2012, the Health Professions Tracking Service at the University of Nebraska Medical Center reported that there were a total of 130 cardiologists in the state, 102 of whom had their primary practice locations in Omaha or Lincoln or in Douglas or Lancaster county.[29] Second, rural residents experiencing an AMI need care in the first 30–40 min and some patients may not have sufficient time to travel to an urban hospital. Furthermore, only 7 of Nebraska's 90 rural counties have a cardiologist with a primary practice location. As a result, some rural patients might seek care from a generalist rather than a cardiologist. Third, although a rural AMI patient may ultimately receive care at an urban hospital, Emergency Medical Services (EMS) travel time and treatment during transport may not be optimal.[18]

While most of the previous studies have focused on rural–urban disparities in 30-day AMI mortality, a gap remains in understanding rural–urban differences or associated risk factors in AMI morality beyond the initial 30 days following hospitalization. Despite the importance of surveillance and secondary prevention, mortality from AMI is not continuously monitored, especially in rural areas.[30] Variation in medical treatment, access to health services, and types of comorbidities can result in differences in mortality outcome. Therefore, this study used a linked dataset connecting hospital and community data from Nebraska to evaluate rural–urban differences in survival outcome in patients with AMI. We compared mortality outcomes between patients with AMI admitted to rural vs. urban hospitals, using observed in-hospital mortality, and survival outcome after discharge.

2. Methods

2.1. Study population

We conducted a county-based population study of AMI mortality for a period of 5 years (2005–2009) using 2 data sources. First, hospital discharge data for patients discharged for AMI between January 2005 and December 2009 were obtained from the Nebraska Hospital Association. The hospital discharge data include patient demographic information, diagnosis codes, procedure codes, and information on inpatient and outpatient visits, including in the emergency department and for rehabilitation treatment, from all hospitals in Nebraska. Second, Nebraska death records were obtained from the Nebraska Health and Human Services' Office of Vital Records. Using a probabilistic linkage strategy, the Nebraska Hospital Association linked hospitalization data to Nebraska death records from January 2005 to October 2011. The variables used for the linkage included patient name, date of birth, sex, and residence ZIP code. The data was later de-identified by removing patient name and address information. If the data included information on multiple hospitalizations and readmissions for a single patient, we selected the first hospitalization for AMI. The data analysis is, therefore, person based, not AMI-event based. International Classification of Diseases, Ninth Revision, codes were used to identify diagnosis and death from AMI. Rural–urban status for each county was based on the United States Department of Agriculture's Business and Industry Loan Program definition, which defines Douglas, Lancaster, and Sarpy counties as urban counties. Finally, population data from the US Census Bureau was used to calculate age-sex specific AMI incidence by rural and urban areas.[25]

2.2. Study design

The 2005–2009 Nebraska Hospital Discharge data served as a cross-sectional observational dataset for the study, with a passive longitudinal follow up for mortality status through data linkage. The study protocol was approved by the Institutional Review Board of University of Nebraska Medical Center.

2.3. Inclusion/exclusion criteria

The study includes Nebraska residents who were hospitalized in a Nebraska hospital. Out-of-state patients who were admitted to a Nebraska hospital during 2005–2009 and Nebraska residents who sought care in another state were excluded. A total of 12,783 unique patient records were used.

2.4. Study variables

Control variables included patient age, sex, and comorbidities. As presence of comorbidities can alter the effectiveness of a treatment, based on prior literature, a number of important comorbidity conditions, such as diabetes mellitus, anemia, atrial fibrillation, chronic kidney disease, and previous incidence of heart failure, were included as controls. If a diagnosis included one of these health conditions, we coded it as 1; otherwise, it was coded as 0. Cardiac rehabilitation, also known as secondary prevention of heart disease, has been shown to prolong survival and reduce disability in patients with coronary heart disease, including AMI.[31] However, the literature on access to cardiac rehabilitation programs for specific patients groups, including patients from rural areas, is scarce. Long travel distances and guilt over neglecting family obligations are important predictors of participating in cardiac rehabilitation.[31,32] We also included the use of outpatient rehabilitation in our analysis. If a patient received rehabilitation, we coded it as 1; otherwise, it was coded as 0.

2.5. Statistical analysis

The primary outcome variable was out-of-hospital survival. However, since 30-day mortality is often reported in other studies, we included it to provide a reference point. In the descriptive statistics, all the variables are in proportion, and Pearson chi-squared tests are used for analysis of rural–urban differences. In unadjusted descriptive analysis, AMI mortality rates were compared by rural status, age, and comorbidity. The adjusted analysis (multivariate regression) was used to understand AMI mortality and survival patterns among rural–urban populations, after adjusting for sex, age, and comorbidity status. Logistic regression was used to predict 30-day mortality, and the Cox proportional hazard model was used to predict survival rates. Odds ratios (OR) and hazard ratios (HR) were calculated to estimate AMI death and survival rates, respectively, with 95% confidence intervals (CIs). All statistical analysis was performed with SAS software version 9.3 (SAS Institute Inc., Cary, NC). A significance level of $p < 0.05$ was used for all data analysis.

3. Results

Table 1 shows that between 2005 and 2009, there were 12,764 patients hospitalized with AMI in Nebraska, of which 60.8% (7773) were male and 39.2% (4991) were female. More than half of the patients (58.5%) resided in rural areas. More patients in rural areas were aged 60 years or older than in urban areas, 74.2% and 66.0%, respectively. Based on age-sex specific incidence by rural and urban areas, we also calculated crude and age-standardized AMI incidence rates using 10-year age groups from 15 to 85 + years from the US Census Bureau's 2010 census. The crude 5-year incidence rates for males were 135.1 and 85.9 per 10,000 population for rural and urban counties, respectively; the corresponding rates for females were 67.1 and 55.7, respectively. After adjusting age using the 2000 standard population, the rates were 114.6 and 100.5 and 114.6 for males in rural and urban counties, respectively, and 54.6 and 55.6 for females, respectively. For males, both crude and standardized AMI incident rates were higher in rural areas, while the rural–urban rates were comparable for females after standardization.

For comorbidity, except atrial fibrillation, the percentage of patients with anemia, diabetes mellitus, and chronic kidney disease was lower in rural areas than in urban areas. A previous incident of heart failure was not significantly different between rural and urban patients. Significantly, a higher percentage of rural patients (30.8%) than urban patients (16.3%) received at least one episode of cardiac rehabilitation. In the 30-day in-hospital mortality model, rural patients were more likely to die than urban patients (11.5% vs. 9.3%, $p < 0.001$).

Table 2 lists the results from logistic regression models assessing factors associated with 30-day mortality for AMI. There was an obvious rising trend in OR for each age group (ranging from 1.368 to 8.994), although the trend was not significant in the 40–59 year age group, indicating that age was a critical predictor of mortality and that older patients were much more likely to die than younger patients. With regard to comorbidity, anemia and diabetes mellitus were negatively associated with 30-day AMI mortality, while a previous incident of heart failure increased the risk of death approximately twofold within 30 days. The odds of 30-day mortality (OR: 0.010; 95% CI: 0.003–0.032) were significantly reduced for patients with at least one episode of cardiac rehabilitation. The odds of 30-day mortality were significantly lower for patients living in an urban area (OR: 0.709; 95% CI: 0.626–0.802). Additionally, patient sex was not significantly associated with AMI mortality based on our data.

To assess survival outcome, we ran out-of-hospital and overall survival models using the same set of variables as in Table 2. The results of both models were quite similar in terms of sex, age, and rehabilitation (Table 3). Sex was not an independent predictor of mortality. The age impact also followed the same gradient as seen in the logistic regression: older patients tended to have a greater HR. For example, compared to out-of-hospital patients aged 39 years or younger, those aged 91 years and older had an HR of 21.413. Rehabilitation significantly lowered the risk of AMI mortality (out-of-hospital survival: HR: 0.748; 95% CI: 0.700–0.801; overall survival: HR: 0.554; 95% CI: 0.516–0.595). For both the out-of-hospital and overall survival model, atrial fibrillation, chronic kidney disease, and heart failure increased the risk of AMI mortality, with heart failure having the largest HR (out-of-hospital survival 2.190; overall survival 2.002). But anemia and diabetes mellitus were positively associated with mortality only in the out-of-hospital survival model. After controlling for sex, age, comorbidity, and rehabilitation after discharge, urban patients with AMI were still less likely to die (HR: 0.866; 95% CI 0.806–0.931) than rural

Table 1
Descriptive statistics of hospitalized MI patients by location.

	Urban (%) ($N = 5295$)	Rural (%) ($N = 7469$)	p-Value
Sex			
Male	3177 (59.8)	4596 (61.5)	<0.001
Female	2118 (40.2)	2873 (38.5)	
Age (yrs.)			
<40	126 (2.4)	102 (1.4)	<0.001
40–59	1681 (31.6)	1827 (24.5)	
60–75	1807 (34.0)	2574 (34.5)	
76–90	1452 (27.3)	2523 (33.8)	
>90	247 (4.7)	444 (5.9)	
Comorbidity			
Atrial fibrillation	714 (13.4)	1085 (14.5)	0.081
Anemia	619 (11.7)	689 (9.2)	<0.001
Diabetes mellitus	1240 (23.3)	1589 (21.3)	0.005
Chronic kidney disease	556 (10.5)	690 (9.2)	0.021
Heart failure	1046 (19.7)	1444 (19.3)	0.615
Rehabilitation			
Yes	852 (16.3)	2304 (30.8)	<0.001
No	4461 (83.7)	5166 (69.2)	
Expired status			
Less than 30 days	494 (9.3)	861 (11.5)	0.0001
30 days and more	4819 (90.1)	6589 (88.5)	

Note: urban and rural percentages are in parentheses.

Table 2
Logistic regression 30-day AMI mortality.

	30-Days mortality	
	OR	95% CI
Female (ref: male)	1.050	0.926–1.189
Age (yrs) (ref: <40)		
40–59	1.368	0.593–3.155
60–75	2.799	1.226–6.388
76–90	6.028	2.646–13.735
>90	8.994	3.889–20.799
Comorbidity		
Atrial fibrillation	1.013	0.867–1.183
Anemia	0.621	0.507–0.762
Diabetes mellitus	0.748	0.642–0.871
Chronic kidney disease	1.067	0.892–1.275
Heart failure	1.947	1.703–2.225
Rehab (ref: no)	0.010	0.003–0.032
Live in urban area	0.709	0.626–0.802

Abbreviation: CI, confidence interval; OR, odds ratio.
If a CI does not contain 1, then the OR is significant.

Table 3
Cox survival model for out-of-hospital survival and overall survival.

	Out-of-hospital survival		Overall survival	
	HR	95% CI	HR	95% CI
Female (ref: male)	1.059	0.964–1.164	1.046	0.974–1.124
Age (yrs) (ref: <40)				
40–59	1.886	0.774–4.596	1.613	0.883–2.948
60–75	4.720	1.955–11.395	3.697	2.038–6.706
76–90	11.068	4.589–26.694	8.249	4.552–14.950
>90	21.413	8.812–52.030	13.552	7.431–24.716
Comorbidity				
Atrial fibrillation	1.204	1.077–1.345	1.115	1.023–1.215
Anemia	1.165	1.026–1.322	0.948	0.855–1.052
Diabetes mellitus	1.201	1.082–1.333	1.011	0.931–1.098
Chronic kidney disease	1.393	1.230–1.576	1.228	1.115–1.353
Heart failure	2.190	1.984–2.418	2.002	1.856–2.160
Rehab (ref: no)	0.748	0.700–0.801	0.554	0.516–0.595
Live in urban area	0.966	0.879–1.061	0.866	0.806–0.931

Abbreviation: CI, confidence interval; HR, hazard ratio.
If a CI does not contain 1, then the HR is significant.

patients in the overall survival model, but there was no urban-rural difference in out-of-hospital AMI survival.

4. Discussion

By integrating hospital discharge data with community-based vital statistics records, our study found rural–urban disparities in AMI mortality in Nebraska between 2005 and 2009. Consistent with the previous literature, we found that patients in urban areas have lower odds of 30-day in-hospital mortality than patients in rural areas. Patients in urban areas also have a better overall survival chance than patients in rural areas.

A higher 30-day in-hospital mortality rate for rural AMI patients may be attributed to the difference in quality of care between rural and urban hospitals or it may arise from systematic differences between rural and urban communities. Assuming that most rural AMI patients are treated in rural hospitals, while most urban AMI patients are treated in urban hospitals, differences in quality of AMI patient care is likely to play a role. First, the lack of cardiologists and emergency services in rural areas may mean that rural AMI patients are more likely to see generalist physicians. Two prior studies examining the difference in prescribing behavior between generalist physicians and cardiologists found that cardiologists were more likely than generalist physicians to prescribe recommended AMI medications.[33,34] As the demand for cardiologists in the United States far exceeds the supply, this shortage will likely continue to get worse.[30] Second, patient- and location-specific factors are also associated with physician decisions in AMI treatment. Limited resources in rural hospitals limit cardiologists' options for treating AMI patients. If patients cannot obtain timely care from a specialist, they will seek care from a generalist, who might not order necessary tests and cardiology referrals.[31] Finally, the care received in the pre-hospital settings in rural areas may not be adequate, because many long-distance EMS transport and most ambulance systems in rural areas are staffed by volunteers who may not trained to provide advanced cardiac life support interventions.[18]

We also assessed out-of-hospital and overall rural–urban survival differences. A long-term survival pattern is important because it may be subject to availability of secondary prevention measures, such as public health services, that may be different from short-term survival predictors. After controlling for age and comorbidities, patients in urban areas had a better overall survival outcome than patients in rural areas. Behavioral interventions (a healthy diet, increased physical activity, and smoking cessation) after AMI are known to be associated with a substantially lower risk of recurrent cardiovascular events.[35] Rural Nebraskans are less physically active, more obese, and use more tobacco products than their urban peers.[24,36] Perception of risks may also play a role in the rural–urban disparity for heart disease. Some rural inhabitants do not perceive themselves to be at risk for heart disease and stroke, and their behaviors are modeled by these misperceptions. This lower perceived risk is exacerbated by the decreased availability of screening services in rural areas.[37,38] Cardiac rehabilitation is also associated with reduced mortality, a finding that has previously not been reported at the population level. Nebraska has one of the highest cardiac rehabilitation rates in the United States.[39] We found that AMI patients who attended a cardiac rehabilitation session had a significantly reduced chance of mortality than patients with no cardiac rehabilitation. Interestingly, our data suggest that more rural than urban AMI patients received at least 1 cardiac rehabilitation session.

Additionally, older age and a previous history of heart failure increased 30-day mortality, while presence of other comorbidities, such as atrial fibrillations, diabetes mellitus, and chronic kidney disease, along with a history of heart failure, mainly reduced overall survival. Consistent with a previous study, we found that anemia is not an independent risk factor for 30-day mortality; however, it is associated with lower long-term survival outcome for AMI patients.[40] Several previous studies found no or a weak association between diabetes mellitus and 30-day mortality in patients with AMI.[41,42] Interestingly, we found a negative association between diabetes mellitus and 30-day AMI mortality. However, diabetes mellitus significantly lowered the long-term survival outcome.

There are several limitations to our study. First, we did not account for case severity and treatment variation between rural and urban patients, because hospital discharge data do not contain this information. Second, we had no information for the patients we studied on some important risk factors, such as smoking status, physical activity status, and body mass index. Third, we did not have data on the frequency of cardiac rehabilitation. Fourth, some records might be missing due to a problem in linkage. Finally, our study did not account for transfer patients, which may explain the higher 30-day in-hospital mortality in rural hospitals.

Conflicts of interest

All authors have none to declare.

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