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SM Journal of Public Health and Epidemiology

Research Article

Considering Community: The Relationship between Neighborhood Socioeconomic Status and Risk Standardized Mortality Rates in United States

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Article Information

Received date: Sep 26, 2017
Accepted date: Dec 21, 2017
Published date: Dec 24, 2017

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Keywords Risk-standardized mortality rates; Hospital re-admission; Median income; Neighborhood; Socioeconomic status

Abstract

Objective: To examine whether the 30-day Risk-Standardized Mortality Rate (RSMR) of hospitals across the US are associated with neighborhood Socioeconomic Status (SES).

Data sources: Secondary data were collected from the US Census Bureau, Centre for Disease Control (CDC) and US Department of Health and Human Services between 5/2013 and 7/2013.

Study design: Income data, mortality rates and RSMRs were gathered from their respective databases. These data were compared in terms of income (SES) and stratified according to state or specific zip-codes. Linear regression, T-test and ANOVA were performed.

Principal findings: Both at the local and at the state level, as the SES increases, RSMR for myocardial infarction, heart failure and pneumonia were reduced. Mortality rates further showed a negative association between income and RSMR for all such causes. This trend was not observed for RSMR on readmission.

Conclusions: As the SES of an area increases, the RSMR of the associated hospitals is reduced both at the local and at the state level across US. Such information may be helpful in resource allocation towards health improvement.

Introduction

Variations in Socioeconomic Status (SES) have been demonstrated to cause disparities in health care outcomes [1-6]. An individual's SES comprises of their education level, income and occupation [7]. The measurement of SES may reflect affluence and in many instances is a predictor of future health outcomes [1-4,6,8,9]. In addition to these individual effects of SES, there are also community-wide impacts of neighborhood SES. Not only may there be a lower level of services and infrastructure in low SES communities, the existing services attend to a higher burden of illness. It is generally accepted that hospitals located in areas of low SES receive a heavier patient burden, affecting their ability to provide care. This cause's increased stress on the public sector, as patrons of these hospitals can rarely afford private services. Furthermore, in such areas, there is an abundance of chronic disease including diabetes and heart failure [10]. Chronic diseases lead to increased burden on the hospitals resources and capacity to treat patients, requiring longer working hours and stretching thin the limited funding available. The size of the hospital also affects the service it provides to its patrons. Generally larger hospitals have lower mortality rates [11] and these hospitals are rarely found in low SES areas [12]. The combination of these factors may further cause dissatisfaction of healthcare workers [13], potentially leading to substandard levels of care.

Hospital mortality rates are standardized measurements designed to give an indication of the success of a given healthcare institution [11]. Specifically, the 30-day Risk-Standardized Mortality Rate (RSMR) is used for such measurement. RSMR is a measure of deaths due to acute Myocardial Infarction (MI), Heart Failure (HF) and Pneumonia (PN) within 30 days of arrival to a specific hospital for care [14], It is calculated by multiplying raw mortality rate for each hospital with the US national mortality average [15]. Higher quality hospitals have lower RSMR rates [15] and patients can access these publicly available ratings to help select which hospital to choose when seeking care.

Hospital re-admissions, especially for individuals with chronic disease cause increase in the RSMR [16]. The majority of readmissions are for individuals in the lowest income quartile [10], demonstrating that socioeconomic conditions can greatly affect health and health care needs. Consequences of low socioeconomic conditions including increasing poverty, a lack of education and

increased violence in these areas have a well-established association with poorer health status [17-20]. Poverty increases individual's stress [21] and levels of stress-related hormones, resulting in hypertension. This increased burden causes one to be more susceptible to additional diseases and ultimately to hospitalization. Furthermore, poverty prevents access to private health insurance [22] and therefore potentially a lower standard of care.

Individuals lacking a proper education have fewer opportunities for career advancement and higher income [21]. This ultimately reduces one's ability to access healthcare services, especially in countries, such as the United States, without a single payer system. There is a negative association between years of education and mortality [23]. Additionally, people with low levels of education are generally unengaged or misinformed about preventive healthcare [24]. This notion is further supported by recurrent hospital visits from this population, who demonstrate a lack of symptom awareness [25] and either does not access timely care or access hospital services when primary care would be more appropriate.

Studies also demonstrate an inverse association between violent crime and family income [21]. In areas of low socioeconomic conditions, there are large numbers victims of physical trauma crowding hospital emergency rooms. Furthermore, large numbers of physical trauma cases increases the burden on hospital staff and facilities which can lead to sub-standard care [22].

This study is based on the hypothesis that in the United States, hospitals in areas with low household income (identified by ZIP-codes with low SES according to the National Census Bureau) are likely to have higher RSMR compared to the hospitals in areas with high-income areas. To test this hypothesis, we performed statistical analyses and specific comparison to determine whether RSMR is influenced by socioeconomic conditions (measured by household income).

Methods

The United States Census Bureau publishes income information from all regions across US. The state specific information is further segregated by zip-code. These data were organized based on the lowest to highest average household income and the associated zip-code. Following such organization, each zip-code was assigned one income level group following those demarcating social classes as outlined by Thompson and Hickey [7] (Suppl. Table1). Data from the Upper classes were not included in this study due to low numbers and our focus on low SES. The following data sets were used for analysis: 1) Mortality rates for overall causes of death from the Centre for Disease Control in 2013, arranged according to state; 2) Household income data from all US states in 2010 (from the public information published by the US Census Bureau) and 3) RSMR for each hospital in the United States in 2013 sorted according to zip-code (information in the public domain).

The Department of Health and Human Services (HHS) provides a publicly available database on all hospitals in the US, organized by zip-code. This database provides hospital location as well as the RSMR for Myocardial Infarction (MI), Heart Failure (HF) and Pneumonia (PN), Hip/Knee replacements and all other causes including RSMR at readmission, as a raw value along with its comparison to the national average. Hip/Knee in this database denoted the hospital level Risk-Standardized Complication Rate (RSCR) following elective primary Total Hip Arthroplasty (THA) and Total Knee Arthroplasty (TKA). These values were aligned with the zip-codes sorted by household income acquired from the census data.

CDC releases mortality data on all causes that can be sorted by a number of factors. Here, overall deaths due to specific causes were organized by state and compared with the corresponding household income. Hip/Knee was not an option for cause of death in this database. Under the category of MI causes included: acute or subsequent trans-mural MI of anterior wall, inferior wall, other sites or unspecified site. In terms of HF we included hypertensive heart disease with/without renal disease with (congestive) heart failure, congestive heart failure; left ventricular failure and heart failure (unspecified) were included in the analyses.

Finally, a large list of conditions are included for PN: Varicella pneumonia; Measles complicated by pneumonia; HIV disease resulting in Pneumocystis carinii pneumonia; Influenza with pneumonia with or without identified influenza virus; adenoviral pneumonia; Respiratory syncytial virus pneumonia; Parainfluenza virus pneumonia; Other viral pneumonias (including 'unspecified'); Pneumonia due to Streptococcus, Haemophilus influenza, Klebsiella, Pseudomonas, Staphylococcus, Streptococcus group-B or other Streptococci, Escherichia coli, other aerobic gram-negative bacteria; Mycoplasma, other bacterial pneumonia (including unspecified). We also included unspecified bronchopneumonia or lobar pneumonia; hypostatic pneumonia; abscess of lung with pneumonia; congenital pneumonia due to viral agent, Staphylococcus, Streptococcus Group-B, Escherichia coli, other organisms (including 'unspecified').

The zip-codes which were not associated with an RSMR value for any of MI, HF or PN were discarded. Additionally, the zip-codes which did not have any income value associated (i.e. overseas military bases) were discarded along with its associated RSMR data for MI, HF and PN.

Linear regression analyses were conducted between the RSMR for MI, HF, PN, Hip/Knee and other causes against the corresponding median household income for individual states. Regression was also performed for overall mortality rates due to MI, HF and PN against the corresponding state household income. Analysis of variance was performed to determine difference in means between RSMR for MI, HF and PN between states. Regression analysis was further performed between the RSMR for MI, HF and PN as well as Readmission against the median household income for each zip-code.

Analyses of the data were conducted using a one-tailed two sample independent t-test for unequal variance in order to determine differences between the RSMR for each income level category. Overall differences were examined using ANOVA. Microsoft Excel® was used for analysis.

Results

Linear regression analysis of overall mortality due to MI, HF, PN and other causes demonstrated a decrease with increasing income on a state-by-state basis (Figure 1). This negative association between income and mortality for MI, HF and PN were significant. Similar to these results, analysis on hospital RSMR demonstrated a decrease with increasing income on a state-by-state basis (Figure 2). There

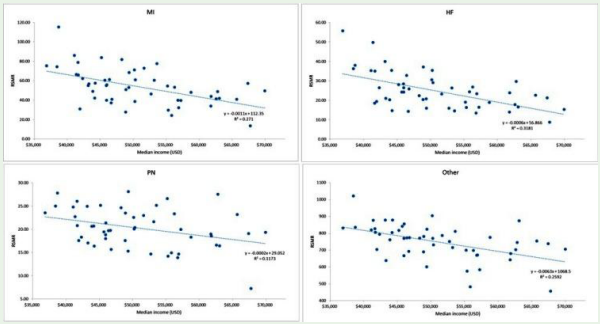

Figure 1: Linear Regression analysis of the overall mortality rate of Myocardial Infarction (MI), Heart Failure (HF), Pneumonia (PN) and other causes (Other) against income in the corresponding state. There was a significant negative association between the overall mortality rate due to MI ($p<0.05$), PN ($p<0.05$), HF ($p<0.05$) and Other ($p<0.05$) and the income in the corresponding state.

was a significant negative association between income and the RSMR of MI, HF and PN. Though there was a negative trend between income and the RSMR of readmission for MI, HF and PN, it was not significant. Interestingly, with respect to Hip/Knee and other causes, there were positive associations between income and RSMR, RSMR on readmission for Hip/Knee with median household income.

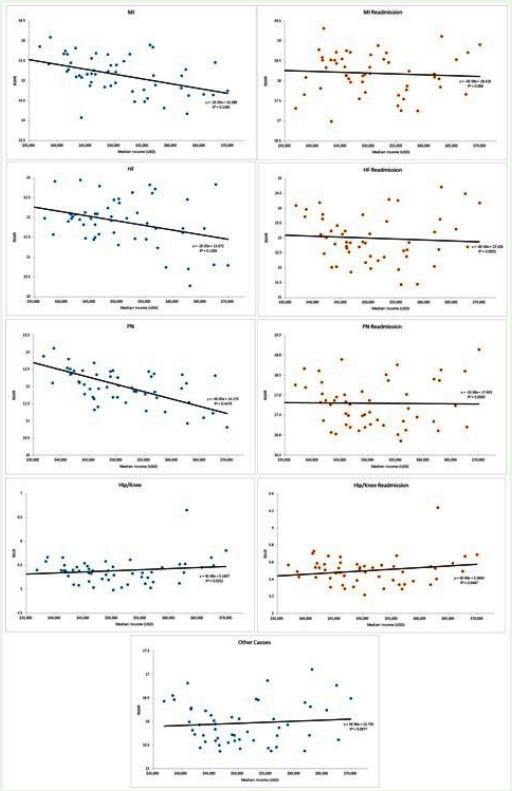

Figure 2: Linear Regression analysis of the 30-day risk-standardized mortality rate of Myocardial Infarction (MI), Heart Failure (HF), Pneumonia (PN), hip/knee (Hip/Knee) and other (Other) causes against income in the corresponding state. There was a significant negative association between the overall mortality rate due to MI ($p<0.05$), PN ($p<0.05$), HF ($p<0.05$) and the income in the corresponding state. There was a positive association between the overall mortality rate due to Hip/Knee and other.

Table 1(A): Linear Regression analysis of the 30-day risk-standardized mortality rate of myocardial infarction, heart failure and pneumonia against income in the corresponding zip codes.

Table 1(B), 1(C): ANOVA analysis for the 30-day risk-standardized mortality rate of myocardial infarction, heart failure and pneumonia across B) States and C) Social classes. There were significant differences the RSMR for MI ($p<0.05$), HF ($p<0.05$) and PN ($p<0.05$) between states. Difference were also significant between RSMR on readmission for MI ($p<0.05$), HF ($p<0.05$), and PN ($p<0.05$) in both categories.

1(A):

RSMR	R^2-value	*P*-value
MI	3.43E-02	2.33E-21
HF	1.27E-02	5.22E-12
PN	2.01E-02	3.10E-19
MI Readmission	1.70E-03	6.15E-02
HF Readmission	2.37E-03	3.57E-03
PN Readmission	9.35E-04	6.09E+00

1(B):

RSMR	*P*-Value
MI	2.63E-17
HF	5.03E-52
PN	8.29E-40
Hip/Knee	4.63E-17
Other	8.62E-124
MI Readmission	5.42E-29
HF Readmission	8.22E-88
PN Readmission	1.02E-80
Hip/Knee Readmission	0.00155

1(C):

RSMR	*P*-Value
MI	3.41E-12
HF	2.95E-06
PN	1.84E-09
MI Readmission	0.000844
HF Readmission	8.47E-09
PN Readmission	9.61E-07

Regression analyses of mortality rates stratified according to zip-code (Figure 3) further showed a significant negative association between income and the RSMRs for MI, HF and PN (Table 1A). There was a negative trend between income and the RSMR upon readmission for MI, HF and PN; however it was only significant for HF.

ANOVA showed differences in means between average state household incomes for RSMR due to MI, HF, PN, Hip/Knee and Other causes as well as for RSMR on readmission due to MI, HF, PN, Hip/Knee and other (Table 1B). Further analyses showed that there are disease-specific variations with respect to deaths across states (see below).

Table 2: Descriptive Statistics for the 30-day Risk-Standardized Mortality Rate (RSMR) of Myocardial Infarction (MI), Heart Failure (HF) and Pneumonia (PN) in social classes stratified according to Thompson and Hickey (2005) [7].

Social Class		MI	HF	PN	MI Readmission	HF Readmission	PN Readmission
Lower	Count	43	44	47	31	34	33
	Mean	15.905	10.932	12.764	20.278	25.719	19.073
	SD	1.59	1.53	2.272	1.653	2.065	1.429
Working	Count	1059	1747	1911	765	1671	1796
	Mean	16.022	11.508	12.111	20.017	25.033	18.526
	SD	1.54	1.467	1.797	1.329	1.909	1.541
Lower Middle	Count	1462	1925	1996	1245	1857	1912
	Mean	15.654	11.305	11.814	19.785	24.67	18.289
	SD	1.576	1.501	1.797	1.353	1.895	1.473
Upper Middle	Count	13	16	16	12	15	15
	Mean	13.746	10.413	10.725	19.975	25.447	18.877
	SD	1.252	1.434	1.452	1.372	1.865	1.06

Table 3: One-sided Student's t-test between social classes for the 30-day, Risk-Standardized Mortality Rate (RSMR) of Myocardial Infarction (MI), Heart Failure (HF) and Pneumonia (PN). For each cause of death, as the social class increases, there is an upward trend in RSMR. This trend however is not seen for RSMR on readmission for MI, PN or HF.

RSMR		W-L	LM-W	LM-L	UM-LM	UM-W	UM-L
MI	*T* Statistic	0.319	2.50E-09	0.1565	6.64E-05	1.24E-05	1.48E-05
	P Value	> 0.05	< 0.05	> 0.05	< 0.05	< 0.05	< 0.05
HF	*T* Statistic	0.009	1.68E-05	0.0584	0.013	0.00405	0.116625
	P Value	< 0.05	< 0.05	> 0.05	< 0.05	< 0.05	> 0.05
PN	*T* Statistic	0.03	1.08E-07	0.0035	0.006	0.001084	0.000112
	P Value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
MI Readmission	*T* Statistic	0.199	8.85E-05	0.0576	0.328	0.461115	0.279516
	P Value	> 0.05	< 0.05	> 0.05	> 0.05	> 0.05	> 0.05
HF Readmission	*T* Statistic	0.034	7.78E-09	0.0336	0.071	0.211318	0.330663
	P Value	< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	> 0.05
PN Readmission	*T* Statistic	0.02	9.12E-07	0.002	0.029	0.11977	0.30365
	P Value	< 0.05	< 0.05	< 0.05	< 0.05	> 0.05	> 0.05

UM: Upper Middle class; LM: Lower Middle class; W: Working class; L: Lower class

We further examined similar associations with SES through a zip-code proxy. This trend was also observed in the RSMR of readmission for MI, HF and PN. Significant differences in means for all income categories were seen by ANOVA analysis (Table 1C) both for RSMR and for RSMR upon readmission. The mean RSMR for MI in the upper middle class was significantly lower than lower middle class, working class and Lower class (Tables 2,3). The mean RSMR for MI upon readmission in the lower middle class was significantly lower than the working class and the lower class (Table 3). The mean RSMR for MI upon readmission for the upper middle class was lower, but not significantly different than other social classes and showed an upward trend versus the lower middle class (Table 3).

In terms of HF, among all income groups, RSMR differed significantly both in first contact and in readmission (Table 1C). The mean RSMR was significantly lower for upper middle class compared to lower middle class and working class (Table 3). However, it was not significantly lower than the mean RSMR for lower class (Table 3). The mean RSMR for HF upon readmission amongst the upper middle class was higher than the lower middle class. It also trended (non-significant) higher than the working class and lower than the Lower class.

The final aspect of RSMR studied was PN. The mean RSMR between income groups differed significantly both in first contact and in readmission (Table 1C). The mean RSMR for the upper middle class was significantly lower than other classes (Tables 2,3). Similarly, upon readmission, mean RSMR for PN among the lower middle class was lower than that of the working class and lower middle class (Table 3). The mean RSMR for PN upon readmission for the upper middle class was significantly higher than the lower middle class. It was also non-significantly higher than the working class and lower than that of the lower middle class.

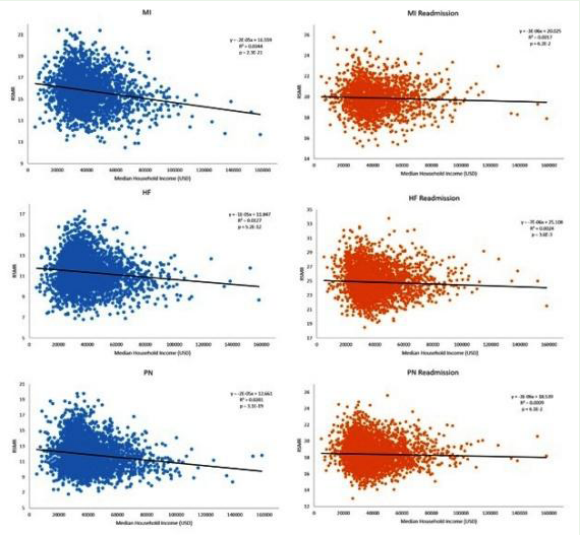

Figure 3: Linear Regression analysis of the 30-day risk-standardized mortality rate (RSMR) of Myocardial Infarction (MI), Heart Failure (HF) and Pneumonia (PN) against income in the corresponding zip code. There was a significant negative association between the RSMR due to MI ($p<0.05$), PN ($p<0.05$), and HF ($p<0.05$) and the median income in the corresponding zip code. There was a negative association between the RSMR due to MI and PN and the median income in corresponding zip code which was not significant. However, there was significant negative association between the RSMR due to HF ($p<0.05$) and the median income in corresponding zip code.

Discussion

The results of our study indicate that in the United States, regions with a lower SES (as estimated by income level), experience higher rates of RSMR for MI, HF and PN both initially and upon readmission. This was true both at the state and at the zip-code level. These data are in keeping with previous results in this area. Although similar patterns have been reported in the western world [26], developing countries [1,9] and in the pre-industrial period [8], such comprehensive analyses across the whole country has not been previously explored.

Uniformly, the mean RSMR for each income level is lower than the corresponding RSMR on readmission. This is likely due to the fact that, individuals being readmitted to hospice care have deteriorated in their level of health and are therefore more likely to die. This relationship between RSMR of admission and readmission has been previously identified [27], adding further validity to these results.

As noted above, the novel aspect of this study is that it examined the data on RSMR across the entirety of the United States. Unlike other studies comparing mortality to income, we examined individuals who died while in hospital care. Here we examined hospital mortality rates and demonstrated higher mortality in low income areas. This study used both state and zip-codes as tools for analyzing these data. It was assumed that a significant number of the patient population may come from that zip-code in which the hospital is located. As household income data with regards to specific zip-codes are available, such an approach easily identified the income level of a particular area. This tool was used to stratify mortality rates according to income level.

There are many possible explanations for the observed outcomes of this study. Residents in the low income areas, in general, are less likely to have completed higher education and may not be aware of disease symptomatology [23]. Lack of education and symptom awareness can lead to patients waiting until their disease has reached an advanced stage before seeking health care [28,29]. Additionally, some of the findings may also be related to health care access barriers, due to lack of health coverage or transportation [30]. Therefore, these patients may come to the hospital at a much later stage in the course of their illness. Such causes may also increase mortality rates outside of hospice care. As this study only takes into account hospital deaths; there is a likelihood that the standard of care differs depending on the location of these facilities. It is also possible that hospitals in these areas, based on the factors listed above, see an influx of terminal patients leading to shortages of beds and other resources. Further studies are needed to identify the importance of these potential factors.

This study has a number of strengths that provide unique insights. The information gathered is available in the public domain, which makes it inexpensive and time-sensitive to ascertain. Additionally, a comprehensive comparison of hospital RSMR based on socioeconomic conditions (measured using household income) for the United States as a whole has not yet been reported in the published literature. Moreover, the raw RSMR values are available for analysis. The data presented on the HHS online database compared the RSMR to the national average and gave a ranking of better, worse, or the same as this value. Using the actual RSMR values adds validity to the comparisons of different socioeconomic conditions. Finally, the study examined all hospitals across the United States, not solely one state or region.

The limitation of this study is the use of only household income as a representation of an area's socioeconomic conditions. These zip-codes are ranked by income level. It is well established that income is not the only contributing factor and that education level and life expectancy are also a core part of this measurement. A more all-encompassing study would include the omitted components of socioeconomic status. In addition, another limitation of this study is the assumption that the feeder population of a particular hospital is limited to the zip-code within which the hospital is located. Individuals trying to access healthcare services may be empowered to decide which areas or hospitals to choose to receive the best standard of care. It will be of further interest to examine the effects on these important parameters in future following implementation of systems with potential to improve health care access, as we see in the Affordable Care Act. Finally, it is likely that all hospitals do not offer the same quality of care, irrespective of their location. This would lead to higher mortality rates in some areas purely on the basis of the hospital rather than the overall health of the community. Further analyses of the collected data may also reveal additional factors of value for future research.

The results of this study provide further evidence of income-based health disparities and can inform new policies both to foster health education that identifies specific symptomatology and improves health care access, specifically designed for low income populations. Such initiatives should be targeted across the lifespan, addressing both child and adult populations. Furthermore, ways to improve the standard of living in areas where hospitals have higher RSMR should

be explored, along with strategies to improve the standard of care in these hospitals that are experiencing a high burden of disease. The results presented here further suggest that the quality indicators of a particular hospital may also be dictated by the socioeconomic conditions of the population it serves.

The problems of higher mortality rates in low SES communities demonstrate that upstream solutions, such as community development and public education programs, could help address the hospital mortality rates and thus lower hospital costs and improve the effective use of hospital resources. Public health officials are well-placed to take the lead in initiatives that would be beneficial to both community members and health service providers. These approaches need dedicated resources and a concerted effort with the involvement of policymakers, healthcare providers, health educators and community groups. Although these approaches may appear to be resource intensive, the rewards are substantial.

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