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Geographic access to interventional cardiology services in one rural state

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ABSTRACT

Objectives: Explore (1) the characteristics of the Maine population with delayed geographic access to interventional cardiology (IC) services and (2) the effect of delayed geographic IC access on coronary mortality.
Background: Acute coronary syndrome (ACS), ST-segment elevated myocardial infarction (STEMI), and non-ST segment elevated myocardial infarction (NSTEMI) are highly prevalent. Coronary mortality is minimized when victims have prompt IC access.
Methods: The study design was (1) an exploration of census data to investigate disparities in geographic IC access and (2) a secondary analysis of administrative claims data to investigate coronary mortality relative to delayed geographic IC access.
Results: Delayed access was associated in the Maine population with rural residence, advanced age, high school education, and lack of health insurance. Delayed access was associated with increased unadjusted coronary mortality, but not age-adjusted coronary mortality.
Conclusion: Delayed geographic IC access was associated with disparity but not with increased age-adjusted coronary mortality.

Introduction

Coronary heart disease (CHD) causes one of every seven deaths in the United States. Victims of ST-segment elevated myocardial infarction (STEMI), the most severe acute coronary syndrome (ACS), require primary percutaneous coronary intervention (PPCI) within 90 min of presentation, available only at interventional cardiology (IC) centers.[1] Fibrinolysis within 30 min, an effective alternative if PPCI access is delayed, carries an increased risk of intracranial hemorrhage.[2] Unstable victims of non-ST segment elevated myocardial infarction (NSTEMI) should likewise undergo prompt angiography at an IC center with intent to intervene if necessary. Rural residence is associated with non-receipt of PPCI and greater risk-adjusted in-hospital mortality.[3] Among U.S. adults, 21% live outside of a 60 min drive time to an IC center and therefore have delayed geographic IC access and higher mortality risk.[4] Helicopter transport when IC access is delayed is limited by lack of continuous availability.

Given the relationship between untimely care and mortality, investigators have employed geographic information systems (GIS) to assist with determining disparities in care due to distance from health care services. GIS is defined as "… a system for input, storage, processing, and retrieval of spatial data."[5] Many health care databases now include spatial variables such as patient residence and location of first medical response, treating facility, and post-acute care. GIS can be used to define travel burden as an explanatory

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variable to examine an outcome of interest occurring in remote locales. The usefulness of GIS in health services research is evidenced by the Centers for Disease Control[6] supporting a website dedicated to GIS methods and Esri,[7] the principal vendor of GIS software, has a website dedicated to health and human services.

Graves[8,9] employed GIS to explore IC access in Alabama within 30, 60, and 90 min and found that rural residence was associated with delayed access. A large poorly-resourced geographic region was identified with no access at all even within 90 min. In Alabama and Mississippi, using GIS and multiple regression modeling, Graves found that rural residence alone was not a significant predictor of mortality; however, social factors associated with rural residence (e.g. poverty, education, and race) explained 32% of the variability in mortality.

To better understand the relationship between geographic access and ACS outcomes we examined the associations between these two factors in the highly rural state of Maine. The purpose of this study was to determine the relationships among delayed geographic IC access (greater than 60 min drive time to an IC center) and ACS, NSTEMI, or STEMI outcomes. Research questions were: (1) What proportion of Maine residents have delayed geographic IC access? (2) Is delayed IC access associated with disparate social factors (e.g. rural residence, race, gender, age, education, poverty, or lack of health insurance)? and (3) Are delayed IC access and social factors associated with excess ACS, NSTEMI, or STEMI mortality?

Methods

This was a population-based secondary analysis of census and administrative claims data overlaid on a GIS-derived basemap to investigate (1) the demographic differences in the population with delayed IC access and (2) the impact of delayed IC access and patient factors on ACS mortality in Maine. Institutional review board approval was obtained from the Maine Medical Center Office of Research Compliance and the University of Alabama at Birmingham. Since the only risk to human subjects was inadvertent re-identification from a database entry, a waiver of informed consent was granted.

Setting

Maine is the most rural U.S. state, with 61.3% of the population residing in rural areas.[10] Other geographic challenges in access to health care include multiple populated islands, a long rocky coast, and a mountain range northwest of the urban areas. National incidence rates, extrapolated to the Maine population of approximately 1,329,000,[11] predict about 4000 incident ACS events per year; approximately one-third of these are STEMI and the remainder are either NSTEMI or unstable angina without infarction. The national Center for Heart Disease and Stroke Prevention[12] and the Maine Centers for Disease Control and Prevention[13] report that mortality is highest in the northern Maine counties toward the Canadian border and the so-called “downeast” counties toward the Atlantic coast. Despite these geographic challenges, Maine has earned high ratings from the Agency for Healthcare Research and Quality[14] and the Commonwealth Fund[15] for health care quality and access. The Leapfrog Group named 13 rural hospitals as the best in the U.S.; of these, five are in Maine, the only state with more than one hospital on the list.[16]

Data sources

Three data sources were used to create a map and define the explanatory variable: (1) the Medicare Hospital Compare database, (2) the Esri U.S. zip code address locator, and (3) the Maine Next Generation 911 road network. Hospitals providing IC services ($n = 3$) were defined as those in Maine reporting at least one case to Medicare of the PPCI within 90 min performance measure during the one-year reporting cycle.[17] The addresses of these hospitals were geocoded with the Esri U.S. zip code address locator.[5] The Maine Next Generation 911 road network[18] was used to define the 60 min drive time IC service area polygon. Questions 1 and 2 were answered with census data from the U.S. Census Bureau 2013 American Community Survey.[19] This is the primary source of data regarding the characteristics and needs of small communities and small population groups such as one would expect in rural areas.[20] Question 3 was answered with claims data from the Maine Health Data Organization (MHDO) (data request number 511135, https://mhdo.maine.gov) for all ACS hospitalizations during calendar 2010. This is the state agency responsible for collecting health care data for authorized use by researchers and other stakeholders. The location of all hospitals contributing claims data to MHDO was obtained from the Maine Hospital Association.[21]

Table 1
Definitions of disparities investigated with American Community Survey 2013 data.

Variable	Numerator	Denominator
Gender	Female population	Total population
Age	Individuals aged 75 or greater	Total population
Rural residence	Rural residents	Total reporting urban/rural status
High school education	High school graduates	Total population aged 25 or greater
Poverty	Individuals living below fifty percent of federal poverty level	Total population reporting poverty status
Insurance	Individuals lacking health insurance	Total civilian non-institutionalized population

Sample and definition of variables

We calculated the proportion of Maine residents with delayed geographic IC access (question 1) using the total population of Maine respondents to the 2013 American Community Survey.[19] Definitions of rural residence, race, gender, age, education, poverty, and lack of health insurance (question 2) are reported in Table 1. Next, to determine disparities (question 2), proportions were defined with a numerator for the phenomenon of interest and a denominator for the relevant segment of the population. Proportions representing zip code level data aggregated to the “within” and “beyond” groups were compared. Table 1 reports the definitions for the disparity variables.

The sample for mapping and descriptive statistics was defined as all unique ACS events ($n = 5617$). Inclusion criteria for the overall ACS sample were age 20 or greater and any primary ICD-9 diagnosis

Table 2
Descriptive statistics for analysis sample from Maine Health Data Organization.

Group/size	All ACS ($n = 3126$)	NSTEMI ($n = 2247$)	STEMI ($n = 879$)
Age (mean/SD)	68.3/13.7	69.4/13.4	64.9/13.8
Gender (percent male): *n*(%)	1767 (56.5)	1267 (56.4)	500 (56.9)
Race (percent white): *n*(%)	3072 (98.3)	2214 (98.5)	858 (97.6)
Mortality: *n*(%)	137 (4.4)	81 (3.6)	56 (6.4)
Length of stay in days: (median/IQR)	3/(2–5)	3/(2–5)	3/(2–5)
Delayed geographic access: *n*(%)	817 (26.1)	630 (28.0)	187 (21.3)

ACS = acute coronary syndrome; IQR = interquartile range; NSTEMI = non-ST segment elevated myocardial infarction; STEMI = ST-segment elevated myocardial infarction; SD = standard deviation.