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Geospatial analysis of Hospital Consumer Assessment of Healthcare Providers and Systems pain management experience scores in U.S. hospitals

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ABSTRACT

Although prior work has investigated the interplay between demographic and intrasurvey correlations of Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) scores, these prior studies have not included geospatial analyses, or analyses that take into account location effects. Here, we report the results of a geospatial analysis (not equivalent to simple geographical analysis) of patient experience scores pertaining to pain. HCAHPS data collected in 2011 were examined to test the hypothesis that HCAHPS patient experience with pain management (PEPM) scores were geospatially distributed throughout the United States using Moran's Index, which measures the association between PEPM scores and hospital location. After limiting the dataset to hospitals in the continental United States with nonzero HCAHPS response rates, 3645 hospitals were included in the analyses. "Always" responses were geospatially clustered amongst the analyzed hospitals. Clustering was significant in all distances tested from 10 to 5000 km ($P < 0.0001$). We identified 6 demarcated groups of hospitals. Taken together, these results strongly suggest a regional geographic effect on PEPM scores. These results may carry policy implications for U.S. hospitals with regard to acute pain outcomes. Further analyses will be necessary to evaluate policy explanations and implications of the regional geographic differences in PEPM results.

1. Introduction

Data regarding the quality of health care in the United States has itself been of variable quality [27]. A consortium of public and private organizations formed the Hospital Quality Alliance overseen by The Joint Commission and the Centers for Medicare and Medicaid Services in response to this deficit. The Hospital Quality Alliance began releasing data from the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey in March of 2008 [15]. Although prior work examining these data investigated the interplay between demographic and intrasurvey correlations of HCAHPS scores, these prior studies have not included geospatial details [17,22]. Yet geospatial effects, or the effects of geographic location itself, play a critical role in a host of public health concerns, including substance abuse, crime, trauma, infectious disease, and heart disease [3–6,8,24,28,31,32]. Further, while geographic variation in both patient-reported and clinical quality-of-care measures have been well documented, similar descriptions do not yet exist for patient experience with pain [19,20]. The HCAHPS survey assesses multiple domains of patient experience, including doctor and nurse communication, discharge instructions, hospital cleanliness, overall satisfaction, and pain control. With continuing questions concerning the association between patient experience with pain management (PEPM) and the quality of delivered pain care, there is a need to identify potential sources of variance in patient experiences with pain management. It stands to reason that patient experiences with pain management may vary based on hospital location, given regional differences in demographics and socioeconomic drivers of hospital-based health care. Such findings could provide opportunity to more closely examine factors leading to "high success" geographical regions and therefore, provide actionable information regarding regions in which educational and/or health care system interventions may be most needed to improve pain care.

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Here, we report the results of a geospatial analysis of patient experience scores pertaining to pain management. Patient experience scores were collected from the 2011 HCAHPS survey system. The geospatial analyses were designed to answer 2 questions pertaining to geographic differences in PEPM scores. First, are PEPM scores clustered, randomly distributed, or dispersed across U.S. hospitals? And second, are there regional differences in PEPM profiles for U.S. hospitals? Taken together, the results can provide valuable information regarding patient access to satisfactory inpatient pain care in U.S. hospitals.

2. Methods

This study was approved by Institutional Review Board-01 at the University of Florida. This was a cross-sectional study performed on HCAHPS data collected in 2011. The study was designed to test the hypothesis that HCAHPS PEPM scores were geospatially or regionally distributed throughout the United States. Two analytical approaches were used to test this hypothesis. In the first, we tested whether PEPM scores were distributed across U.S. hospitals in a clustered, dispersed, or random geospatial distribution. In the second approach, we combined PEPM hospital profiles with geospatial data to examine regional differences in PEPM scores.

Geospatial analyses refer to those statistical analyses that incorporate the effects of the relative location of an object. Mathematically, it is worth noting that this is a subtly more generalized approach compared with geographic analyses, which may also incorporate information on the natural features (eg, rivers, mountains, forests) found on the Earth's surface. Geospatial analyses may be used to independently describe certain features of an object, or as an extension of other inferential statistical approaches to incorporate the effects of spatial location amongst other variables. For example, a geospatial analysis of body mass index would consider the effects of living in a given location, taking into account the distances and direction between different locations. Compare this with a typical statistical approach, whereby location would be considered as a nominal variable, and the effects on body mass index from the relative relationship between locations as measured by distance and direction are not considered.

HCAHPS data for 2011 were obtained from the medicare.data.gov Web site. The dataset included hospital name, street address, zip code, county, state, and responses to HCAHPS questions. The relevant PEPM data were formatted as, "Percent of patients who reported that their pain was 'always' well controlled," where "usually" and "never" were substituted for "always" to create 3 separate variables. Those hospitals not within the continental United States, and those hospitals with a 0% HCAHPS survey response rate, were excluded from further analysis. The street address for each hospital was converted to a geo-coordinate system using the ArcGIS geocoding schema. The coordinates were then converted to a Mercator projection to ensure stable distance measurements across different types of analyses. Classes of responses were defined using the Jenks Natural Breaks algorithm, which reduces variance within classes and maximizes variance between classes [21].

In our first analytic approach, we determined how HCAHPS PEPM scores were spatially organized within the United States. Organizational patterns were determined separately for "always" and "never" PEPM ratings for those hospitals with a response rate of over 5% on the HCAHPS survey. When HCAHPS is used as a hospital performance measure, U.S. hospitals are typically graded via a binary schema: either a patient rates their experience for a typical measure as "always," or not. Any grade other than "always" is considered a failing grade. We elected to include "always" and "never" PEPM ratings to demonstrate the polarized proportion of patients who were presumably strongly satisfied or strongly dissatisfied with the pain management aspect of their hospitalization. To provide additional insights into the relationship of "always" and "never" responses within hospitals, we included the ratio of "always" to "never" responses as an additional metric of comparison. Of the included hospitals, 22 had a positive value for "always" yet a zero value for "never"; the ratio here was considered to be 100%.

The geospatial distribution of U.S. hospital performance measures reflects how these measures are distributed by location. One of the more common methods of measuring this geospatial distribution is via measures of spatial organization. The 3 main categories of spatial organization include clustering (whereby closer hospitals would exhibit similar PEPM characteristics than would more distant hospitals), random (no association between hospital location and PEPM characteristics), and dispersed (more distant hospitals have more PEPM characteristics in common than do those hospitals in proximity to one another). Spatial organization was assessed at 3 different scales. The first simply examined the general spatial arrangement of PEPM scores across the United States by testing for Global Moran's Index, which is a measure of the spatial autocorrelation between attributes (PEPM scores) and feature location (where the hospitals were located) [29]. Positive scores for Moran's Index suggest a tendency toward clustering, and negative scores a tendency toward dispersion. For instance, given the example of a black and white checkerboard, the perfectly dispersed arrangement of alternating black and white squares would yield a Moran's Index of -1, whereas a board arranged such that all black squares were clustered on one side and white squares clustered on the other would have a Moran's Index of +1. If the black and white squares were randomly distributed throughout the board, the Moran's Index would be 0. Spatial relationships were assessed using the inverse distance method based upon Euclidean, or "airplane" distances, as opposed to "Manhattan," or roadway distances.

To further assess how autocorrelation between PEPM scores and hospital location changed across different interhospital differences, we also conducted an incremental spatial autocorrelation test. This test replicates the Global Moran's Index at different distance thresholds to determine whether clustering and/or dispersion differ with increasing interhospital distance. Here again, higher positive Index scores (and z-scores when statistically significant) for incremental spatial autocorrelation suggest higher degrees of clustering for a given distance, and negative scores suggest greater degrees of dispersion. Ten distances were tested, ranging from 10 km to 5000 km between hospitals.

To repeat the above tests at the hospital level, we conducted an Anselin Local Moran's Index to identify "hot spots," "cold spots," and spatial outliers [1]. Here, Moran's Index is again calculated, this time reflecting the contribution of each hospital to the Global Moran's Index. Each hospital is assigned a code distinguishing it as part of a cluster, thus sharing PEPM characteristics with neighboring hospitals based on the Moran's Index, or as an outlier, with a negative Moran's Index and different PEPM characteristics compared with neighboring hospitals. Thus, hospitals are assigned to 1 of 5 separate categories: no statistically significant difference between hospitals; a high-scoring hospital surrounded by other high-scoring hospitals; high-scoring hospitals surrounded by low-scoring hospitals; low-scoring hospital surrounded by high-scoring hospitals; or low scoring hospitals surrounded by other low-scoring hospitals. These assignments are then plotted on a map of the United States for visual comparison. This approach was included given the relatively small range of values given for "always," thus permitting the detection of statistical outliers within a geospatial context.

In our second analytic approach, we combined PEPM hospital profiles with geospatial data using graph analytic approaches to