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Evaluating county-level spatial prevalence and clustering of medicare beneficiaries in Mississippi

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ABSTRACT

Objective: This study seeks to examine how the extent of socioeconomic deprivation, racial and ethnic isolation, and health disadvantage differ among Medicare beneficiaries in Mississippi. Methods: Geographical information system (GIS) mappings are used in conjunction with cluster analysis to examine patterns of disparities in disease distribution, healthcare utilization and socioeconomic well-being among different counties in Mississippi.

Results: Results reveal that counties in these two clusters are markedly different in terms of socioeconomic well-being but are somewhat similar in terms of disease distributions and healthcare utilization.

Conclusion: Addressing the geographic disparities in disease distribution and healthcare utilization that exist among the counties should be a public health priority. Specifically, health policies and programs should be renewed to target people living in counties that are either predominantly rural or predominantly Black or have higher percentages of population living below the poverty level.

Introduction

Mississippi is the most unhealthy state in the United States [1] even though various forms of discriminations in terms of educational and occupational attainment were outlawed after the Civil Rights Movement. A number of critical issues and obstacles to overcoming inequality remain inadequately addressed in Mississippi [2]. To date, income and wealth inequalities [3,4], unequal access to affordable housing and health care [5], and residential segregation [6] are still the persistent problems facing Mississippi. The burden of chronic and other types of diseases and the limited success in removing the barriers to health improvements may be attributed to the longstanding historical and cultural factors and the lack of coordination among stakeholders in Mississippi [2].

Previous epidemiological studies on geographic variation of Medicare beneficiaries tend to focus on diabetes [7–9], chronic obstructive pulmonary disease (COPD) [10,11], heart failure [12,13], stroke [14], hypertension [15], lung disease [16], and macular disease [17]. In addition, the few studies focus on healthcare access and utilization focus on Medicare beneficiaries' access to primary care services and the utilization of inpatient psychiatric care [18,19]. Most of these studies focus on the entire United States [7,8,11,12,18–21]. Little attention has been paid to geographic variation of socioeconomic deprivation, racial and ethnic isolation, disease distribution, and healthcare utilization in Mississippi. In addition, seldom is these health conditions addressed simultaneously among Medicare beneficiaries in Mississippi. To date, Mississippians are not well represented in national health surveys; thus, their health status, health access, and health disadvantage, as well as their extent of socioeconomic deprivation, and racial and ethnic isolation remains poorly understood. To fill this research gap, this study seeks to examine how the extent of socioeconomic deprivation, racial and ethnic isolation, and health disadvantage differ among Medicare beneficiaries across counties in Mississippi. Geographical information system (GIS) is used in conjunction with cluster analysis to explicitly model the spatial distribution and clustered pattern of the above-mentioned deprivations and disadvantages in Mississippi.

Methods

Measures

Variables included in the analysis can be categorize into the socioeconomic deprivation of Medicare beneficiaries, racial and ethnic isolation among Medicare beneficiaries, health disadvantage of Medical beneficiaries, and the patterns of healthcare

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utilization among Medicare beneficiaries. Socioeconomic deprivation is represented by per capita income, percent below poverty, and percent unemployed. Racial and ethnic isolation is represented by the racial compositions and percentages of rural population (i.e. percent Non-Hispanic Whites and Blacks). Health disadvantage is represented by the number of fee-for-service beneficiaries and the percentage of fee-for-service beneficiaries who are eligible for Medicare for at least one month in a year and disease prevalence (i.e. the percentage of beneficiaries with chronic kidney disease, chronic obstructive pulmonary disease, diabetes, Ischemic heart disease, heart failure, Alzheimer's disease, hypertension, high cholesterol, arthritis, breast cancer, and prostate cancer). Patterns of healthcare utilization is represented by the percentage of Medicare beneficiaries using hospital inpatient (IP) services with at least one covered stay, skilled nursing facilities (SNF) with at least one covered stay, and hospital outpatient (OP) services. A list of the variables included in this study are listed in Table 2.

Data

Data on per capita income, percent below poverty, percent unemployed, and racial composition (percent Non-Hispanic Whites and Blacks) were obtained from the 2009 to 2013 Census estimates [22]. Data on the number of beneficiaries, the percentage of Medicare beneficiaries who are eligible for Medicare, illness, and healthcare utilization are obtained from the 2012 Geographic Variation Public Use File from the Center for Medicare and Medicaid Services (CMS) [23].

Analytic strategy

Cluster analysis (also called data segmentation) is both an exploratory data analysis tool that classifies and assigns observations (e.g. (people, cities, countries, regions, events, etc.) to distinctive groups or clusters based on similar characteristics. Classification and assignment is done in such a way that observations in the same cluster are more similar to one another than to those in different clusters. This technique can be used to classify localities such as counties based on their socioeconomic, demographic, health, and environmental characteristics. This approach can help policymakers and practitioners tailor their delivery approaches according to the distinctive socioeconomic, demographic, health, and environmental characteristics of the different clusters of counties in Mississippi.

Both hierarchical agglomerative and k-means clustering techniques were used to segment Mississippi counties based on the socioeconomic, demographic, health, and environmental characteristics detailed in the *Measures* subsection. Because identifying and determining the correct number of clusters by looking at the dendogram can sometimes be challenging, hierarchical agglomerative clustering was used first to generate centroids of the hierarchical clusters. Under this approach, a hierarchy of clusters is first established using a bottom-up approach and each data point is treated as a singleton cluster. Each singleton cluster will then be successively merged into a single remaining cluster.

The centroids of these clusters were then used as initial seeds for the k-means clustering.

In the second step, *k*-means clustering is then used to randomly select a center (nearest mean) for each cluster. Under this approach, a computer algorithm is used to estimate the straight line (Euclidean) distances from each observation to the geometric center of the cluster (centroid). Observations are randomly assigned to their respective clusters, the centroids for each cluster recomputed, and the distances from each observation to the new centroid recomputed. If this new assignment reduces the distances from each observation to the new centroid, observations will be reassigned to the new clusters. If otherwise, the original cluster assignment is retained. The combination of hierarchical agglomerative and k-means clustering techniques was used by the Fabian Premium Investment Resource in 1999 to analyze the performance of mutual funds [24]. Under these two techniques, no optimization was used and all variables were treated with equal weight. Analysis is conducted using Statistical Analysis System (SAS) software version 9.4.

Table 1
Cluster by county.

County	Cluster	County	Cluster	County	Cluster
Adams	1	Itawamba	1	Perry	1
Alcorn	1	Jackson	1	Pike	1
Amite	1	Jasper	1	Pontotoc	1
Attala	1	Jefferson	2	Prentiss	1
Benton	1	Jefferson	1	Quitman	2
Bolivar	2	Jones	1	Rankin	1
Calhoun	1	Kemper	1	Scott	1
Carroll	1	Lafayette	1	Sharkey	2
Chickasaw	1	Lamar	1	Simpson	1
Choctaw	1	Lauderdale	1	Smith	1
Claiborne	2	Lawrence	1	Stone	1
Clarke	1	Leake	1	Sunflower	2
Clay	1	Lee	1	Tallahatchie	2
Coahoma	2	Leflore	2	Tate	1
Copiah	1	Lincoln	1	Tippah	1
Covington	1	Lowndes	1	Tishomingo	1
DeSoto	1	Madison	1	Tunica	2
Forrest	1	Marion	1	Union	1
Franklin	1	Marshall	1	Walthall	1
George	1	Monroe	1	Warren	1
Greene	1	Montgomery	1	Washington	2
Grenada	1	Neshoba	1	Wayne	1
Hancock	1	Newton	1	Webster	1
Harrison	1	Noxubee	2	Wilkinson	2
Hinds	1	Oktibbeha	1	Winston	1
Holmes	2	Panola	1	Yalobusha	1
Humphreys	2	Pearl River	1	Yazoo	2
Issaquena	2				

Results

Cluster analysis yielded two distinct clusters based on the above-mentioned characteristics (See Table 1). As reported in Table 1, the percentages of beneficiaries with chronic kidney disease, chronic obstructive pulmonary disease, Alzheimer's disease, high cholesterol, breast cancer, and prostate cancer are somewhat similar between counties located in the two clusters. Likewise, the percentages of inpatient and outpatient care as well as skilled nursing facilities (SNF) utilization are somewhat similar between counties located in the two clusters. The percentages of Medicare beneficiaries with diabetes, heart failure, and hypertension are relatively higher for counties located in Cluster 2. In contrast, the percentages of Medicare beneficiaries with Ischemic heart disease and arthritis are relatively higher in Cluster 1.

The first group of counties constitutes the *predominantly white, low poverty, and low unemployment* cluster (see second column of Table 2). The per capita income of individuals residing in these counties is somewhat higher than individuals residing in the second clusters. For counties located in this cluster, the percentages of people who live below the poverty level ranges from 9.8 to nearly 33.70 percent. The percentages of people who are unemployed in these counties range from 5.7 to nearly 16.8 percent. For counties located in this cluster, the percentage of population living in rural areas ranges from 15.30 to 100.00 percent. The number of fee-for-service beneficiaries for these counties ranges from 1,416 to 28,361 individuals. The percentages of Medicare fee-for-service beneficiaries who are eligible for Medicare for counties located in this cluster ranges from 14.29 to 40.74 percent.