Journal of Rural and Community Development

Pharmacy Disparities In Rural Georgia

Authors: Anthony Oliveira, Marcus Singletary, & Jia Lu

Citation:
Oliveira, A., Singletary, M, & Lu, J. (2021). Pharmacy disparities in rural Georgia. *The Journal of Rural and Community Development*, *16*(3), 32–55.

Publisher:
Rural Development Institute, Brandon University.

Editor:
Dr. Doug Ramsey

Open Access Policy:
This journal provides open access to all of its content on the principle that making research freely available to the public supports a greater global exchange of knowledge. Such access is associated with increased readership and increased citation of an author's work.

ISSN: 1712-8277 © Authors
www.jrcd.ca

Pharmacy Disparities in Rural Georgia

Anthony Oliveira
Valdosta State University
Valdosta, Georgia, USA
aoliveira@valdosta.edu

Marcus Singletary
Valdosta State University
Valdosta, Georgia, USA
marsingletary@valdosta.edu

Jia Lu
Valdosta State University
Valdosta, Georgia, USA
jlu@valdosta.edu

Abstract

The investigators of the present study have identified Georgia as an area that could potentially have spatial equity issues with pharmacy deserts in rural areas and small cities. However, limited studies have been conducted for spatial equity of pharmacies in Georgia. Fewer studies have investigated these phenomena at the state level, and few have performed spatial correlations. Spatial equity refers to the idea that people should have equal or near-equal access to certain services (Hu et al., 2019). To fill in the gap of the literature and aid in forming solutions to pharmacy deserts in Georgia, the present study analyzed geographical patterns of spatial equity of pharmacy. Because large portions of Georgia are rural, such an analysis will elucidate how spatial equity affects such rural communities.

Correlational analyses, logical regressions, and spatial analyses using Geographic Information Systems (GIS) were performed to understand the relationship between variables such as race, income level, poverty rate, and the total number of pharmacies. The study applied spatial autocorrelation and cluster analyses in ArcGIS, and statistical correlational analyses, and logical regressions in SPSS. Furthermore, the study used the 5-year (2014–2018) American Community Survey (ACS) database.

At the county level, the results showed that a dense population, high median family income, and low poverty rate—among other variables—correlated with more pharmacies. In particular, total population ($r(148) = .95$) and population density ($r(148) = .83$) had a strong, positive relationship with the number of pharmacies in each county. Furthermore, the county level logical regression showed that total population and poverty rate significantly predict the number of pharmacies in each county, $F(2, 146) = 648.91$, $P < .001$, $R^2 = .95$. At the census tract level, a low unemployment rate, high percentage of Hispanic Americans, and high median family income—among other variables—were associated with more pharmacies. In particular, total population ($r(1967) = .28$) had the strongest positive relationship

ISSN: 1712-8277 © Authors
www.jrcd.ca

with the number of pharmacies in each census tract. GIS global spatial autocorrelation and high-low cluster analyses further confirmed the spatial clustering of pharmacies in urban areas.

Overall, results showed that counties and census tracts with lower populations and lower population densities tended to have fewer pharmacies. Because small populations and small population densities tend to couple with rurality, the results indicate that rural Georgia has less access to pharmacies than urban and suburban Georgia. In general, many pharmacy deserts exist in Georgia, and large urban areas have more access to pharmacies than rural areas and small cities. Rural areas of Georgia could experience the adverse effects of pharmacy deserts more than other non-rural areas. Overall, this analysis showed that there is a clear, positive relationship between rural counties and a lower number of pharmacies. Policy suggestions were proposed to increase access in pharmacy deserts.

Keywords: spatial equity, GIS, accessibility, pharmacy desert, spatial analysis

Disparités pharmaceutiques dans la Géorgie rurale

Résumé

Les enquêteurs de la présente étude ont identifié la Géorgie comme une zone qui pourrait potentiellement avoir des problèmes d'équité spatiale avec les déserts pharmaceutiques dans les zones rurales et les petites villes. Cependant, des études limitées ont été menées sur l'équité spatiale des pharmacies en Géorgie. Peu d'études ont étudié ces phénomènes au niveau de l'État, et peu ont effectué des corrélations spatiales. L'équité spatiale fait référence à l'idée que les personnes devraient avoir un accès égal ou quasi égal à certains services (Hu et al., 2019). Pour combler les lacunes de la littérature et aider à trouver des solutions aux déserts pharmaceutiques en Géorgie, la présente étude a analysé les modèles géographiques d'équité spatiale de la pharmacie. Étant donné que de grandes parties de la Géorgie sont rurales, une telle analyse élucidera comment l'équité spatiale affecte ces communautés rurales.

Des analyses de corrélation, des régressions logiques et des analyses spatiales utilisant des systèmes d'information géographique (SIG) ont été effectuées pour comprendre la relation entre des variables telles que la race, le niveau de revenu, le taux de pauvreté et le nombre total de pharmacies. L'étude a appliqué l'autocorrélation spatiale et les analyses typologiques dans ArcGIS, ainsi que des analyses de corrélation statistique et des régressions logiques dans SPSS. De plus, l'étude a utilisé la base de données de l'American Community Survey (ACS) sur 5 ans (2014-2018).

Au niveau du comté, les résultats ont montré qu'une population dense, un revenu familial médian élevé et un faible taux de pauvreté, parmi d’autres variables, étaient en corrélation avec un nombre plus élevé de pharmacies. En particulier, la population totale ($r(148) = .95$) et la densité de population ($r(148) = .83$) avaient une relation forte et positive avec le nombre de pharmacies dans chaque comté. De plus, la régression logique au niveau du comté a montré que la population totale et le taux de pauvreté prédisent de manière significative le nombre de pharmacies dans chaque comté, $F(2, 146) = 648{,}91$, $P < 0{,}001$, $R2 = 0{,}95$. Au niveau du secteur de recensement, un faible taux de chômage, un pourcentage élevé d'Hispano-Américains et un revenu familial médian élevé, parmi d’autres variables, étaient associés à un nombre plus élevé de pharmacies. En particulier, la population totale (r (1967) = 0,28) avait la relation positive la plus forte avec le nombre de pharmacies dans chaque secteur de recensement. L'autocorrélation spatiale globale du SIG et les analyses de classification typologique haut-bas ont confirmé le regroupement spatial des pharmacies dans les zones urbaines.

Dans l'ensemble, les résultats ont montré que les comtés et les secteurs de recensement ayant une population et une densité de population plus faibles avaient tendance à avoir moins de pharmacies. Étant donné que les petites populations et les faibles densités de population ont tendance à se regrouper avec la ruralité, les résultats indiquent que la Géorgie rurale a moins accès aux pharmacies que la Géorgie urbaine et suburbaine. En général, de nombreux déserts pharmaceutiques existent en Géorgie, et les grandes zones urbaines ont plus accès aux pharmacies que les zones rurales et les petites villes. Les zones rurales de Géorgie pourraient subir les effets néfastes des déserts pharmaceutiques plus que d'autres zones non rurales. Dans l'ensemble, cette analyse a montré qu'il existe une relation claire et positive entre les comtés ruraux et un nombre plus faible de pharmacies. Des suggestions de politiques ont été proposées pour accroître l'accès aux déserts pharmaceutiques.

Mots clés: équité spatiale, SIG, accessibilité, désert pharmaceutique, analyse spatiale

---

1.0 Introduction

In 2019, 4.38 billion prescriptions were filled at pharmacies across the United States (Statista, 2020). Pharmacies are used for various reasons, including, but not limited to, filling prescriptions, seeking advice from pharmacists, and receiving vaccinations (Bahlol & Dewey, 2020; Hedima et al., 2020). Community pharmacies make these services available, accessible, and affordable for their communities (Hasan et al., 2020; Meghana et al., 2020).

Because community pharmacies offer quick and affordable pharmaceutical services, the total number of pharmacies in the United States increases every year (Qato et al., 2017). Further research shows that the increase in pharmacies has grown at a similar rate as the population (D'Arrigo, 2017). In addition to the total increase, community pharmacies have been adding services such as vaccinations, remote filling prescriptions, telehealth services, and home deliveries, all of which are designed to be convenient for their clientele (DeBenedette, 2018).

Although community pharmacies have been, overall, increasing and adding new services, additional research shows that some areas of the United States have experienced an inverse trend (D'Arrigo, 2017). For example, pharmacies in predominately Black and Hispanic communities fall behind in measures of quality and availability of care (Amstislavski et al., 2012; Barber et al., 2019; Pednekar & Peterson, 2018; Qato et al., 2014). Furthermore, pharmacies in urban and rural areas largely do not offer the same services as their suburban counterparts (Gebhart, 2019; Pednekar & Peterson, 2018). Essentially, rural, urban, and predominately minority neighborhoods, among others, do not receive the same quality of care and accessibility as other communities. The present study defines quality of care based on patient experience, safety, and effectiveness (General Pharmaceutical Council, 2017). Essentially, there is a concern for spatial equity.

Spatial equity has been a popular topic in recent research. Spatial equity is the notion that residents in any given area should have equal access to specific services (Hu et al., 2019). Soon after its inception, spatial equity was understood and studied as a function of spatial dimensions (Garrison, 1960; Ingram, 1971; Talen & Anselin, 1998). Such definitions have since been considered too narrow in focus. Thus, spatial equity currently includes social characteristics as a function of equal access to services. For instance, some studies have analyzed the accessibility of parks and green spaces among Hispanics, African Americans, and low-income residents (Wen et al., 2013), the spatial equity of hospitals in developing cities (Zhao et al., 2020), and the spatial equity of HIV testing in areas of Mozambique (Yao et al., 2014). The focus of spatial equity analyses has broadened to include both spatial dimensions and social characteristics. Therefore, studies that aim to understand both aspects of accessibility are considered studies of spatial equity.

In the literature, the lack of pharmacy access in certain communities or pharmaceutically underserved areas has been referred to as Pharmacy Deserts (Bonner, 2015; Pednekar & Peterson, 2018). People living in Pharmacy Deserted areas receive lower quality pharmaceutical services and have less access to such services, creating disparities in pharmaceutical care. For example, research shows that overall low quality and limited availability of care contributes to lower medication adherence rates (Akinbosoye et al., 2016). Furthermore, a person in an underserved community may not receive the same in-depth explanation of their drug treatment plan as a person in a well-served community, increasing the likelihood of premature termination of drug treatment (Davis et al., 2017). Additional research shows that people living in low-income neighborhoods pay higher prices for their prescription medication than people in middle- and high-income neighborhoods, contributing even further to lower medication adherence rates (Qato et al., 2003). For some chronic conditions, premature termination of treatment can exacerbate the condition and, in some cases, can increase the likelihood of mortality (Davis et al., 2017).

Furthermore, the literature review revealed a hole in the current literature. Georgia is a state with a diverse population of 10.6 million and a complex physical environment. The pharmacy distribution is unevenly distributed in the state. The adverse effects of pharmacy deserts and spatial equity must be researched and understood in order to propose better public health solutions. However, no such study has been attempted in Georgia at the state level. Moreover, most previous studies did not apply spatial correlations.

Therefore, the present study aims to fill in the hole in the current literature, analyze the spatial equity of pharmacies in the state of Georgia with spatial correlations, as well as identify patterns of accessibility to pharmacies across the state and which variables correlate with such patterns. To achieve our objectives, the research questions and hypotheses are as following:

1. Where are the pharmacy deserts located in Georgia? The present study defined pharmacy deserts in the following ways. In rural areas, any given point that was over 10 miles away from the nearest pharmacy was considered a rural pharmacy desert; for urban areas, any given point that was over 1 mile away from the nearest pharmacy was considered an urban pharmacy desert (Qato et al., 2017). Which parts of Georgia have more pharmacy deserts? We hypothesize that low-income urban areas, small towns, and rural parts of Georgia have more pharmacy deserts.

2. Which socio-economic and transportation variables correlate with the presence of pharmacy deserts? We hypothesize that race, income level, unemployment, and poverty level correlate with pharmacy deserts.
3. Which areas of Georgia have access to quality pharmaceutical care and which areas do not? We expect that suburban areas and non-minority areas have access to quality pharmaceutical care, and the opposite areas do not.

The current literature provides a rationale for the research questions and hypotheses presented by this study. For instance, the literature suggests that the urban, rural, and low-income areas have more pharmacy deserts (Amstislavski et al., 2012; Barber et al., 2019; Pednekar & Peterson, 2018; Qato et al., 2014). Furthermore, Qato et al. (2014) suggested that race and income level may correlate with pharmacy deserts. Additional research has shown that suburban and non-minority areas have more access to quality pharmaceutical care (Gebhart, 2019; Pednekar & Peterson, 2018).

Overall, this study will be the first of its kind in that no previous study has investigated pharmacy deserts and spatial equity of pharmacies in Georgia at the state level and applied spatial correlations, which most previous studies did not do. This study will provide findings that will enrich the literature in understanding pharmacy deserts and spatial equity of pharmacies in Georgia, and suggestions of strategies and best practices for pharmacies in Georgia to increase their accessibility to the residents.

2.0 Methods

Our research applied spatial autocorrelation and cluster analyses in ArcGIS, statistical correlational analyses, and logical regressions in SPSS.

The study used several estimates from the 5-year (2014-2018) ACS (US Census, 2019). First, the ACS was used to derive the total population, total population 65 and older, total population 18 and under, total number of people employed, poverty rate, median family income, unemployment rate, and percentage of Caucasians, African Americans, and Hispanic-Americans at the county and census tract level in the state of Georgia.

Second, the study used ArcGIS to derive the square mileage of average road density in each county and census tract, as well as global spatial autocorrelation and high-low cluster analyses for pharmacies at the county level.

3.0 Results

3.1 County Level Descriptive Statistics

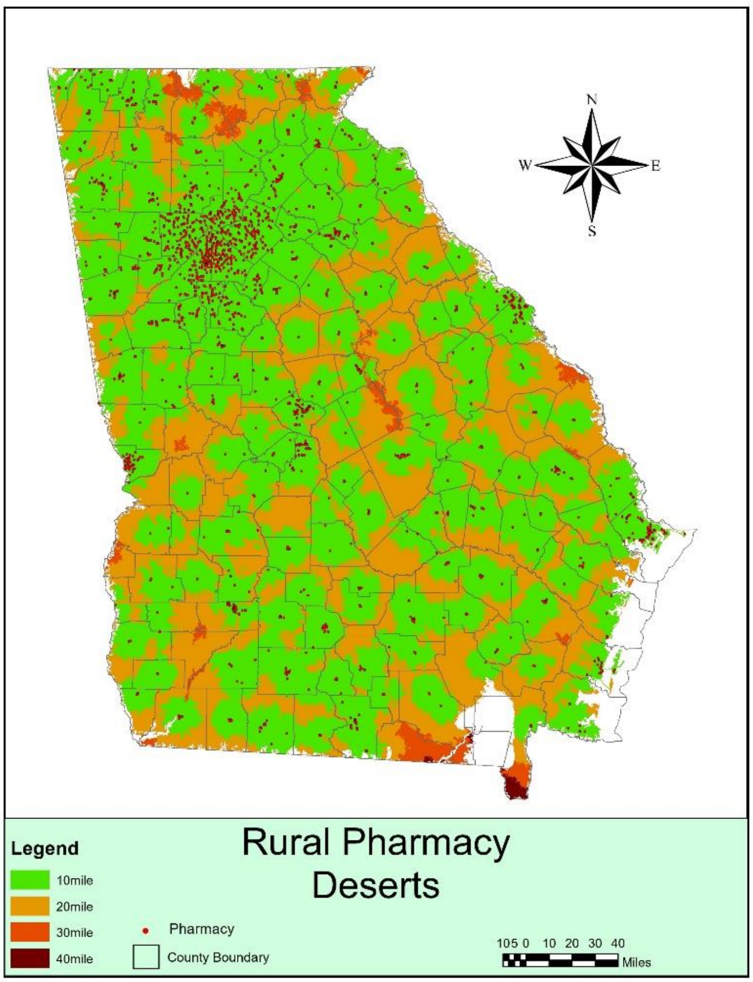
We calculated the descriptive statistics for 159 counties in Georgia as follows. The average population in each county was 64,764 people, ranging from 1,665 to 1,021,902 people. The average population density was 206 people per square mile, ranging from 8 people per square mile to 2,777 people per square mile. The average median family income was $55,346, ranging from $27,500 to $112,835. The average percentage for African Americans, Caucasians, and Hispanic-Americans was 28.2%, 62.3%, and 6.4%, respectively. On average, there were 14 pharmacies in each county, ranging from 0 to 224 pharmacies.

3.2 GIS Mapping Analysis

To conduct the GIS mapping analysis, the study used the definition of pharmacy deserts presented by past research (Qato et al., 2017). In our analysis of rural areas, any given point that was over 10 miles away from the nearest pharmacy was considered a rural pharmacy desert. For urban areas, any given point that was over 1 mile away from the nearest pharmacy was considered an urban pharmacy desert.

Figure 1 illustrates a pattern of spatial inequity, highlighted by areas over 10 miles from the nearest pharmacy. This map is meant to depict rural pharmacy deserts, not urban ones. There is a clear pattern to show large swaths of pharmacy deserts all over the south and middle Georgia which are mostly rural areas. Additionally, pharmacy deserts are widespread in areas north of metro-Atlanta. This map illustrates that, on a statewide scale, rural Georgia does not have the same access to pharmacies that urban Georgia does. There are a few places in the north, south and some scattered in the middle are over 20 miles away from the nearest pharmacy.

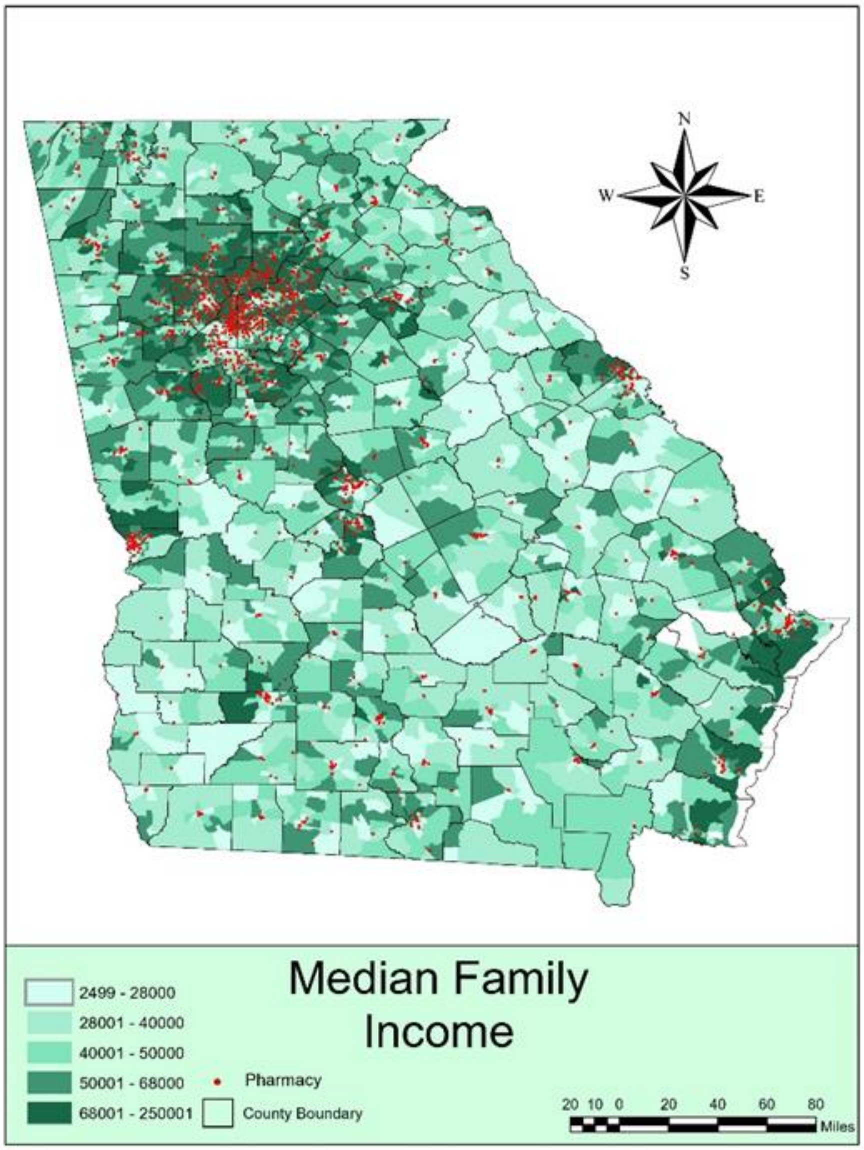
Figure 1. Map depicting pharmacy deserts in rural Georgia



Source: US Census Bureau, 2019.

Figure 2 highlights the relationship of county-level data on median family income and the total number of pharmacies. For instance, areas such as Albany, Athens, Atlanta, Augusta, Brunswick, Columbus, and Savannah, in general, have higher median family incomes than the rest of mostly rural part of the state and they account for most of the pharmacies in the state. Atlanta alone accounts for 854 pharmacies, close to 40% of all pharmacies in the state. The pattern explains how income-level factors into spatial equity of pharmacies in Georgia.

Figure 2. Map depicting median family income in Georgia



Source: US Census Bureau, 2019.

Figure 2 shows that larger cities have higher median family income levels than rural areas because larger cities are likely to offer more job opportunities. Furthermore, such job opportunities are likely to pay more than they do in rural areas. Consequently, such areas are likely to attract more people. Thus, these higher-income areas are likely to grow quicker than lower-income areas. As a result, more people, more jobs, and more money are injected into the area's economy. Additionally, there is more capital for businesses in these areas. Consequently, businesses tend to open in such areas because they need capital to be successful. Thus, areas with high median family incomes are likely to have more businesses and, subsequently, pharmacies.

The following could be an alternative reason: compared to rural areas, large portions of the urban population work in high-paying industries. For example, the counties with the highest median family incomes are Forsyth, Fayette, Oconee, Cherokee, and Cobb; their median family incomes are $112,835, $101,209, $101,082, $95,523, and $90,727, respectively. In these counties, the largest industries are professional services, entertainment, real estate, and information, all of which are high-paying jobs. Combined, these counties have 280 pharmacies. Furthermore, on average, Cobb, Cherokee, Fayette, Forsyth, and Oconee counties service 4,840 people per pharmacy. On the other hand, Clay, Telfair, Randolph, Stewart, and Candler counties with the lowest median family incomes are mostly rural counties, with their median family incomes of $27,500, $32,466, $35,327, $35,848, and $36,845, respectively. In these counties, the largest industries are retail, education/health care/social assistance, construction, manufacturing, and agriculture, most of which are relatively low-paying jobs. Combined, these counties have 11 pharmacies. Furthermore, on average, these counties service 3,916 people per pharmacy.

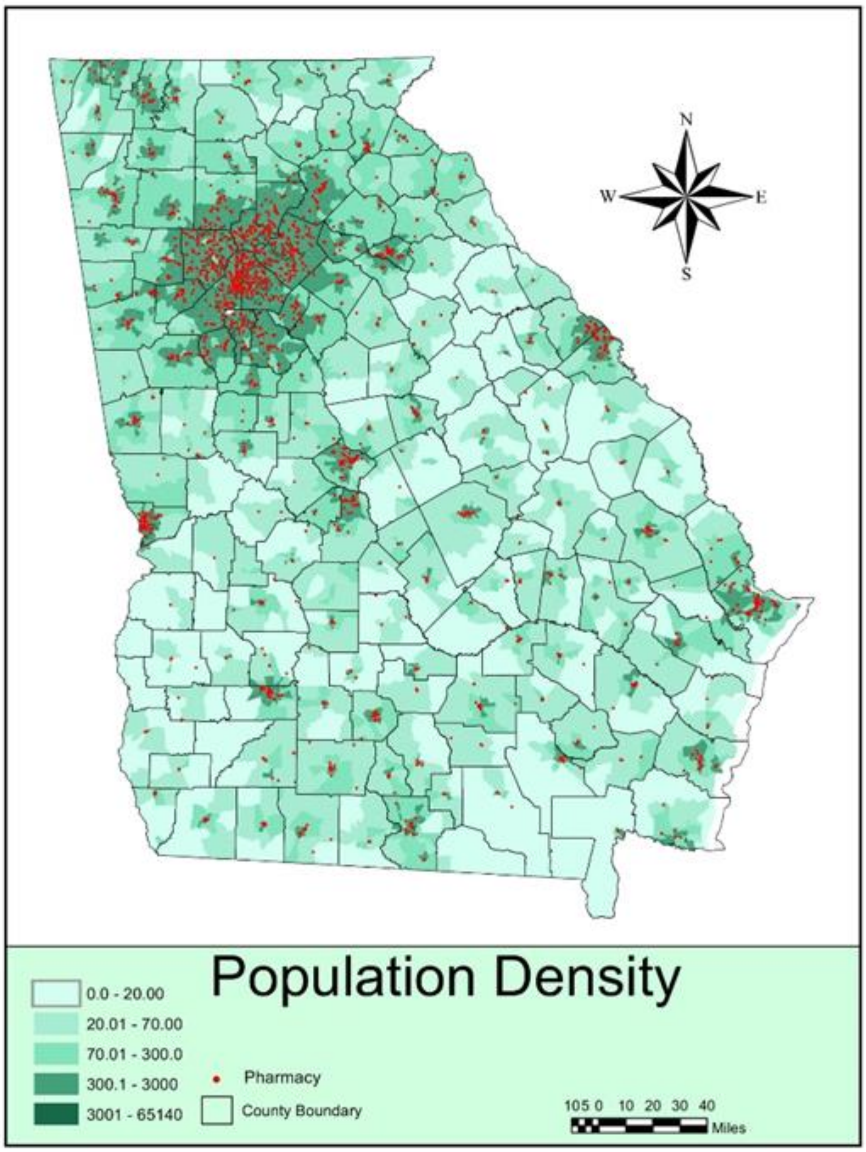
Additionally, some low-income counties have significant portions of their populations receiving food stamps. For example, both Clay County and Randolph County are rural, with over 30% of their population receiving food stamps. Such areas may not attract businesses in the same way, because business owners may have the perception that such areas do not offer as much capital and will generate less profit. Hence, counties such as Clay and Randolph have fewer pharmacies (e.g., Clay has one pharmacy, Randolph has three pharmacies).

Additionally, Figure 3 depicts a map of each county's overall population density. This map suggests that areas with higher population densities have more pharmacies. For instance, three counties with the highest population densities are Dekalb (i.e., 2,777 people per square mile), Cobb (i.e., 2,194 people per square mile), and Gwinnett (i.e., 2,096 people per square mile), and they have 130, 155, and 175 pharmacies, respectively. On the other hand, three rural counties with the lowest population densities are Clinch (i.e., eight people per square mile), Taliaferro (i.e., eight people per square mile), and Baker (i.e., nine people per square mile). Clinch has three pharmacies, while both Taliaferro and Baker have no pharmacies. This pattern reveals that sparsely populated rural counties have less access to pharmacies than densely populated urban counties.

Furthermore, the analyses revealed that sparsely populated rural counties have lower median family incomes and higher poverty rates. The figure shows that densely populated counties create a vacuum effect of resources, leaving fewer for sparsely populated urban counties. Outside of Atlanta and other large metros (Savannah, Columbus, and Macon), public transportation does not exist. There are on-demand public van services that offer to transport people, but they have to be ordered 24 hours ahead of time—unlike many bus systems in other metros. If a person required quick access to medication, such a service would not be helpful.

Moreover, there is a strong positive relationship between lucrative industries and population density. For instance, Cobb and Fulton Counties have among the highest percentages of people working in real estate, a high-paying job (ZipRecruiter, 2021). Interestingly, Cobb and Fulton Counties are the second and third most densely populated counties in the state, respectively. Cobb and Fulton Counties have 155 and 224 pharmacies, respectively. Furthermore, in counties with lower population densities, less lucrative industries are more common. For example, rural counties, Baker and Calhoun, have the highest percentages of people working in agriculture, a traditionally low-paying job. Furthermore, Baker and Calhoun Counties have zero and two pharmacies, respectively. Such a pattern attracts people, well-paying jobs, and resources to densely populated urban areas. Hence, pharmacies tend to be in densely populated areas because such areas typically offer more higher-paying jobs, consumers, and capital.

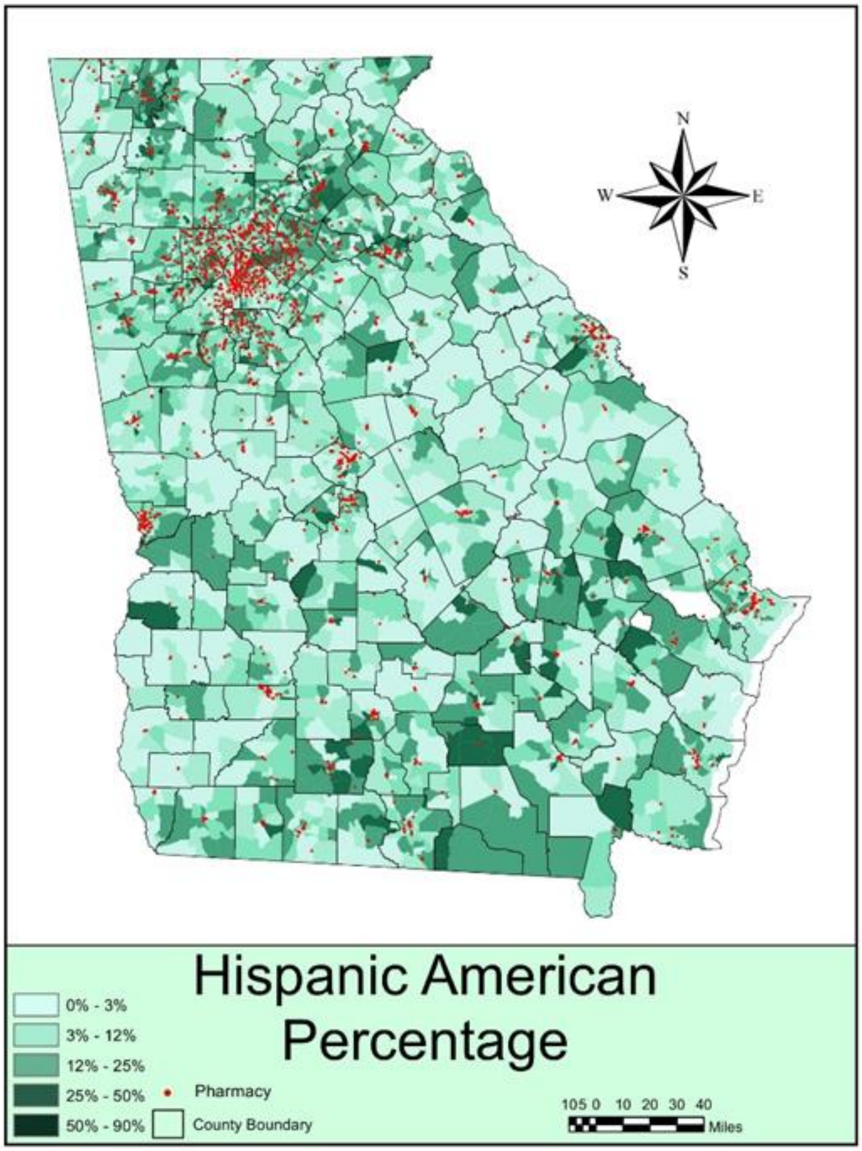
Figure 3. Map depicting the population density of each county in Georgia



Source: US Census Bureau, 2019.

Figure 4 depicts the relationship between the number of pharmacies and the percentage of Hispanic-Americans in each county. It is difficult to conclude from this figure because Hispanic-Americans are not spread out across the state enough. There are no clear patterns displaced.

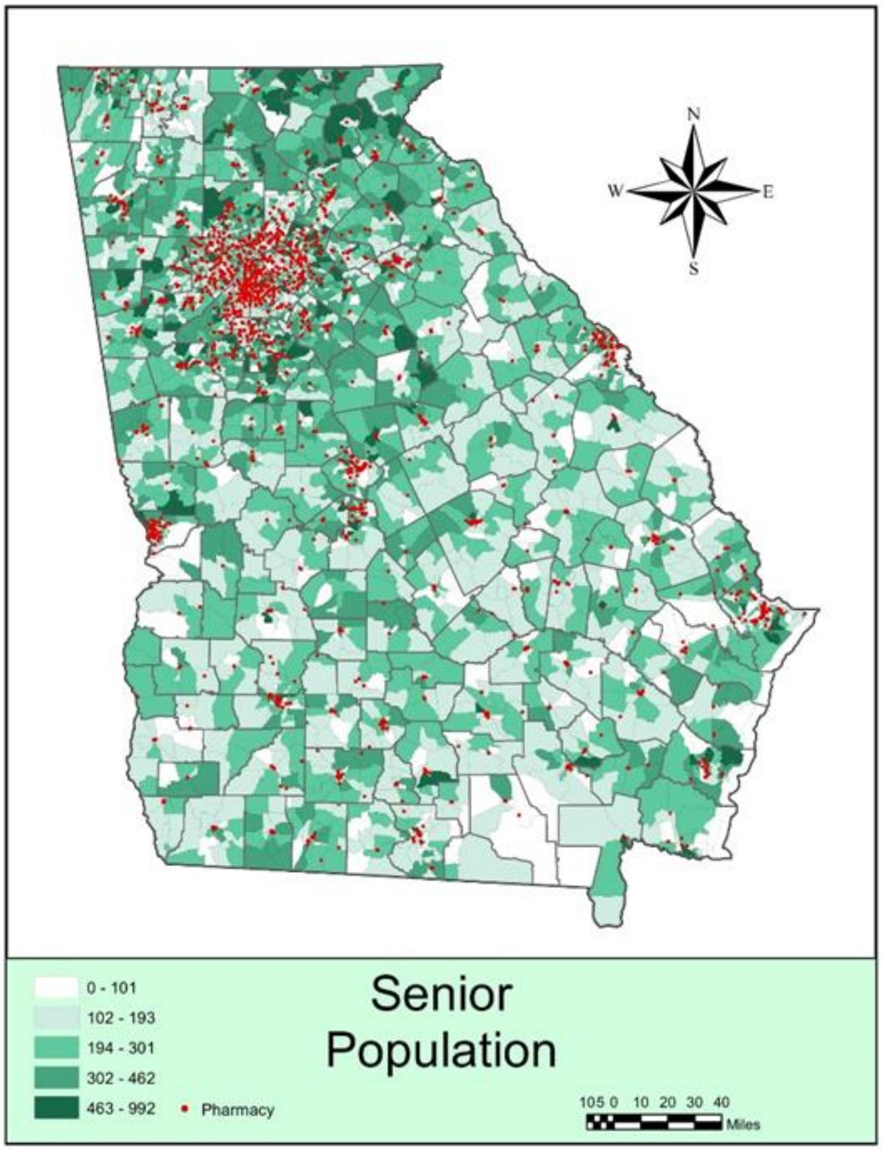
Figure 4. Map depicting the percentage of Hispanic Americans in Georgia



Source: US Census Bureau, 2019.

Figure 5 depicts where most seniors live in Georgia. Most seniors live in or immediately around metro-Atlanta. Furthermore, almost half of Georgia's pharmacies are in the nine metro-Atlanta counties. Thus, people living in or around this area would likely have more access to pharmacies than people living elsewhere in Georgia. In such a case, this map reveals a clear pattern between seniors and pharmacies. Seniors are typically retired with no dependents and would likely be willing to move if it meant having more access to the services they need. However, a younger person might be occupied with their family and job and, consequently, would not be willing to make the same move. There is also a possibility that the retired seniors have more disposable income and are more in need of healthcare; thus, they attract more pharmacies to locate nearby.

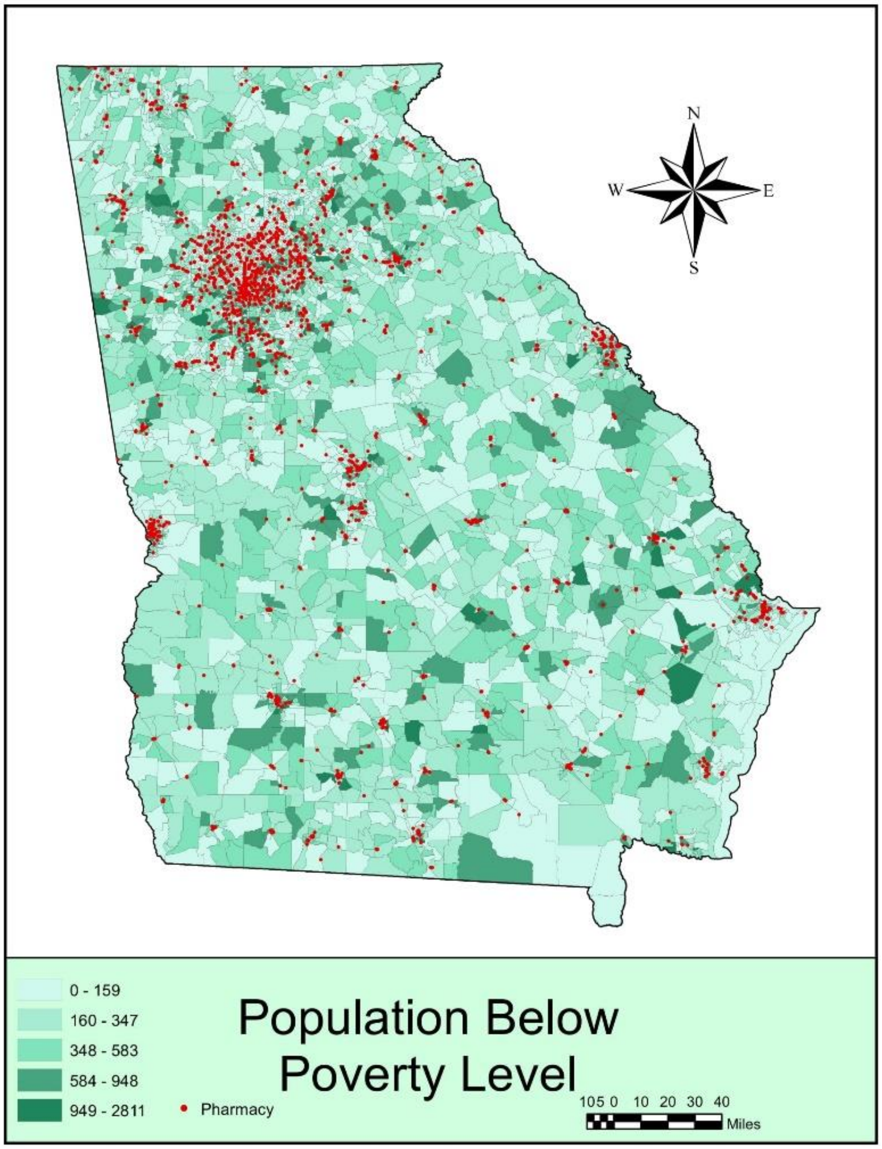
Figure 5. Map depicting where most seniors live in Georgia



Source: US Census Bureau, 2019.

Figure 6 depicts where children live in Georgia. Similar to seniors, most children live in or around metro-Atlanta. Other metropolitan areas such as Brunswick and Savannah also have large populations of children. Interestingly, it seems that in almost every area with large populations of children, there are equally large portions of pharmacies. In fact, there is a strong positive relationship between the number of pharmacies and the portion of children in each county. Children seem to have relatively decent access to pharmacies.

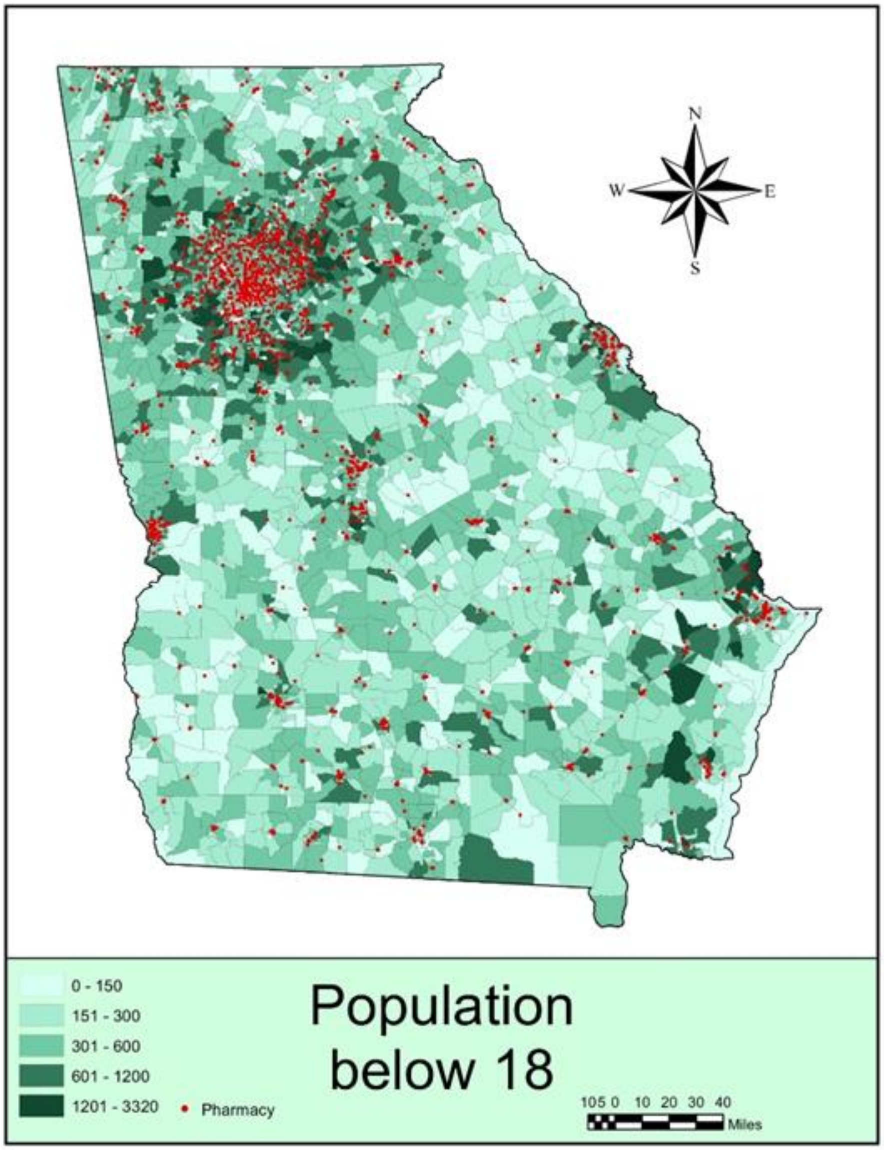
Figure 6. Map depicting where children live in Georgia



Source: US Census Bureau, 2019.

Figure 7 depicts the population below the poverty level in Georgia. In general, poverty is distributed throughout the state. However, certain regions have more poverty than other regions. For instance, non-metropolitan areas have the most poverty, and most of these areas are in rural Georgia.

Figure 7. Map depicting rates of poverty across Georgia

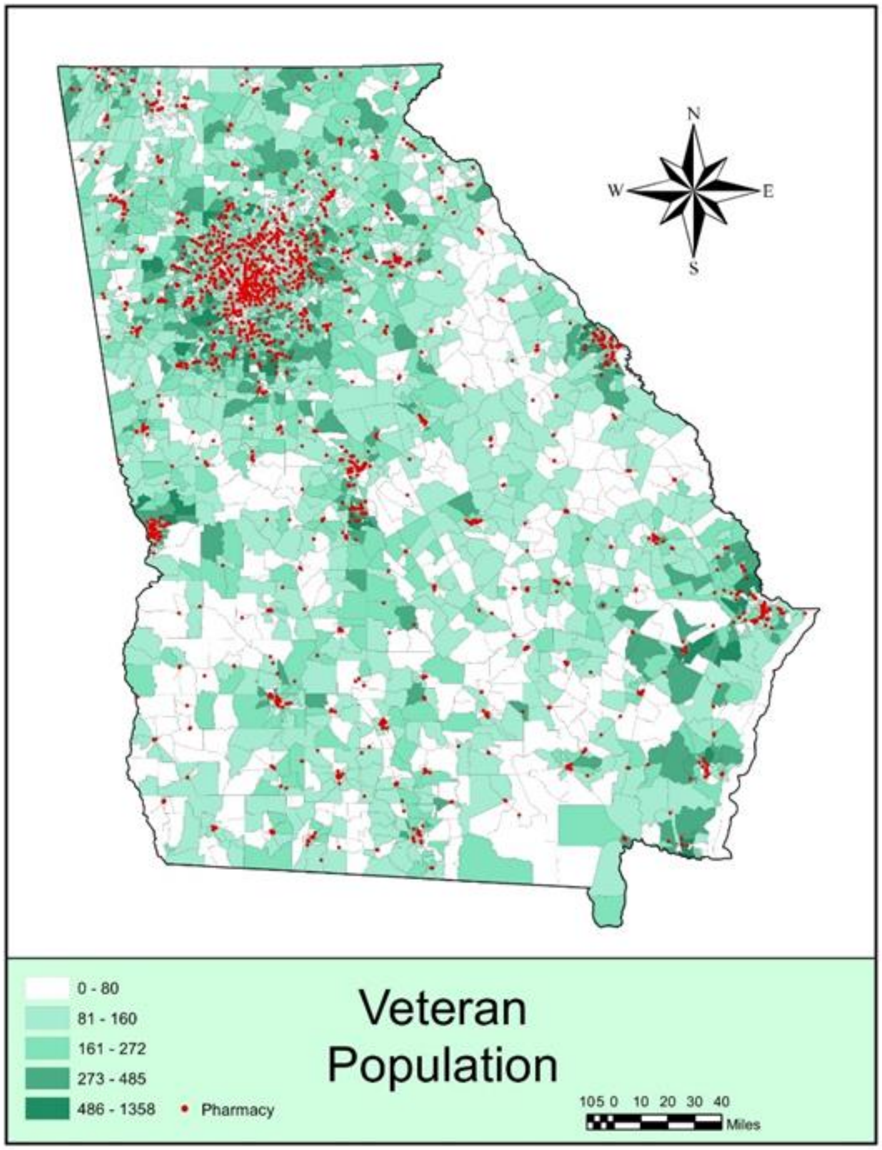


Source: US Census Bureau, 2019.

For example, areas north and east of Atlanta, South Georgia, and, excluding Macon, Middle Georgia do not have many pharmacies. In general, areas with higher poverty rates have fewer pharmacies. Thus, people in poverty have more problems accessing pharmacies.

Figure 8 depicts the veteran population in Georgia. The present study investigated veterans because past research has shown them to be a vulnerable population (Cogan et al., 2018; Duquesne University, 2020). Most veterans live in or near metropolitan areas such as Atlanta, Augusta, Macon, and Savannah. Furthermore, most pharmacies in Georgia are near these big metropolitan areas. Because veterans live in these areas, they likely have access to these pharmacies. This map illustrates a somewhat positive relationship between veterans and the number of pharmacies in each county.

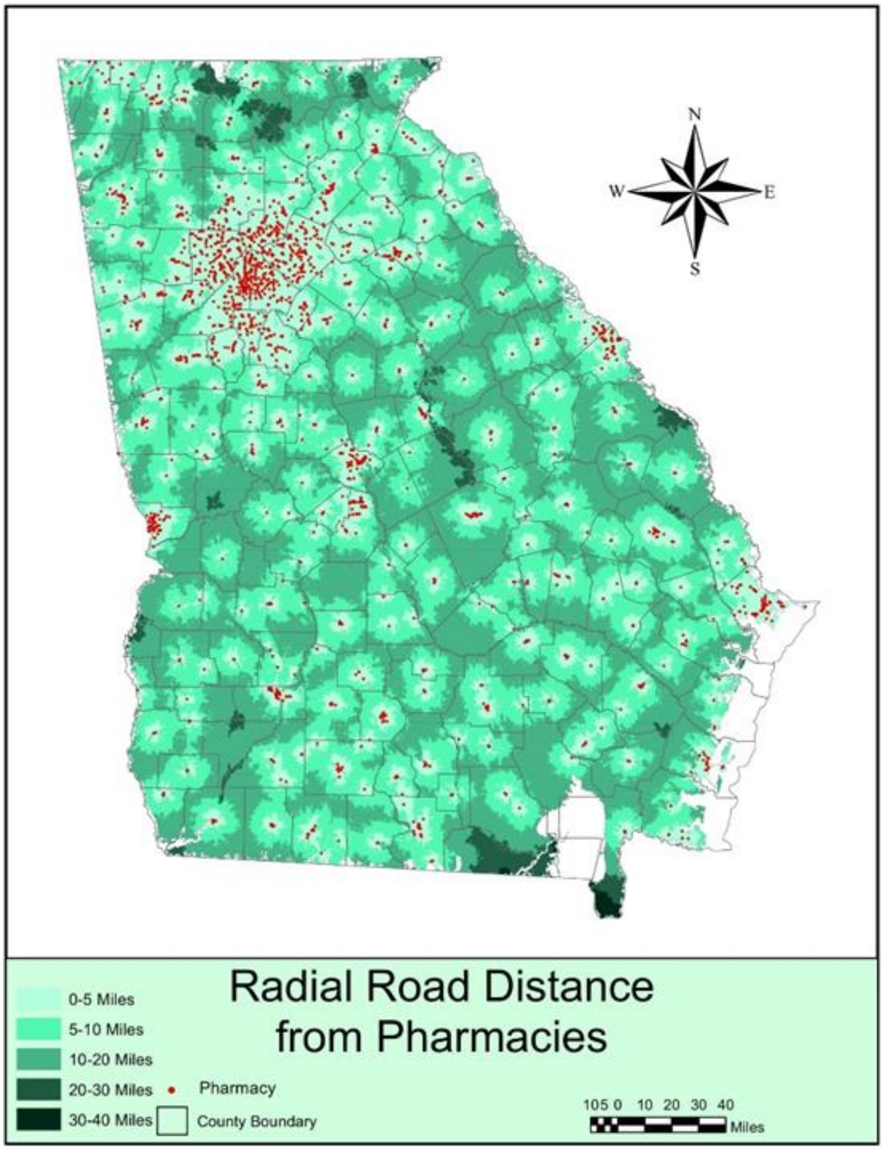
Figure 8. Map depicting where veterans live in Georgia



Source: US Census Bureau, 2019.

Figure 9 illustrates the radial road distance from pharmacies in Georgia. Most of the metro-Atlanta is less than two miles away from the nearest pharmacy. On the other hand, some areas north and northeast of Atlanta, in the southwest, southeast, east, and middle regions of rural Georgia, are as far as 40 miles away from the nearest pharmacy. However, significant portions of these regions are between 10 and 20 miles from the nearest pharmacy. This map shows that non-metropolitan areas and rural areas have less access to pharmacies than metropolitan areas. For example, the areas where the nearest pharmacy is less than two miles are mostly metropolitan areas such as Atlanta, Augusta, Macon, and Savannah. This figure reveals that non-metropolitan areas have less access to pharmacies.

Figure 9. Map depciting each point's distance from the nearest pharmacy in Georgia.



Source: US Census Bureau, 2019.

3.3 County Level GIS Spatial Analysis

To measure the overall spatial relations of GA pharmacy locations, global spatial autocorrelation and high-low cluster analyses were performed for the pharmacies at the county level. Moran's I measures how one object is similar to others surrounding it as seen in (1).

$$I = \frac{n}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \quad (1)$$

where N is the number of spatial units indexed by *i* and *j*; *x* is the variable of interest; x is the mean of x; w_{ij} is a matrix of spatial weights with zeroes on the diagonal (i.e., $w_{ij} = 0$); and W is the sum of all w_{ij}.

The results show that Moran's Index is 0.545403, the z-score is 11.524356, and the p-value is 0.000000. Given the z-score of 11.5243556855, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

The high-low cluster analysis (Getis-Ord General G) is calculated as:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} x_i x_j}{\sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j}, \ \forall j \neq i \quad (2)$$

Where x_i and x_j are attribute values for features ***i*** and ***j***, and $w_{i,j}$ is the special weight between feature ***i*** and ***j***. ***n*** is the number of features in the dataset and $\forall j \neq i$ indicates that features ***i*** and ***j*** cannot be the same feature.

The high-low cluster analysis shows that Observed General G is 0.000003, z-score is 10.985472, and the p-value is 0.000000. Given the z-score of 10.9854718763, there is a less than 1% likelihood that this high-clustered pattern could be the result of random chance.

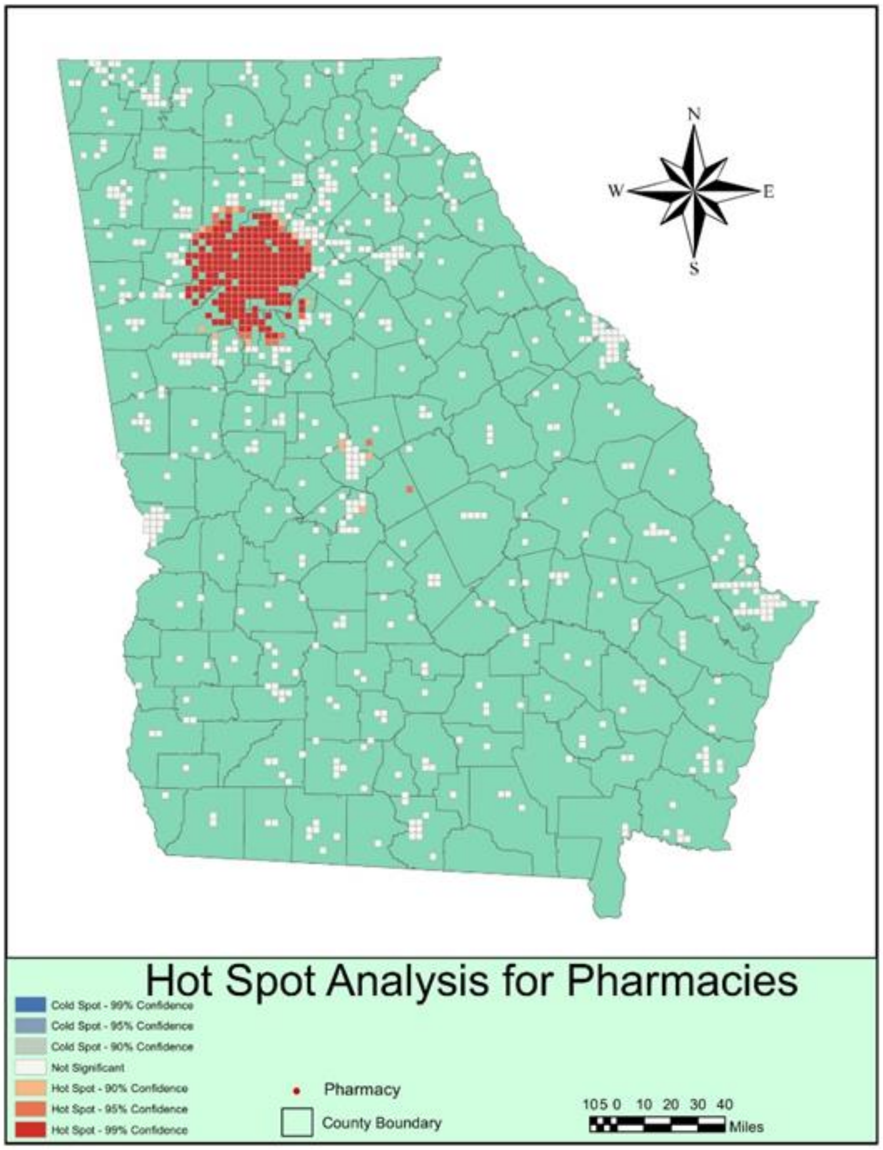
Figure 10 illustrates the optimized hotspot analysis. The hotspot analysis showed that most hotspots are centered around the Metro-Atlanta area with 90–99% confidence, and three hotspots in Jones, Bibbs, Houston Counties with 90% confidence, and one hotspot in Twiggs County with 95% confidence in the center of the state. There is also a cold spot in rural Liberty County in the east of the state, with 95% confidence.

Thus, we can conclude that both spatial autocorrelation and high-low cluster analyses demonstrate that the pharmacy patterns in Georgia are highly clustered around Atlanta, and not by random chance.

3.4 Correlational Analyses at the County Level

After examining the results of several correlational analyses and logical regressions, it became evident that nine counties in the Atlanta metropolitan area were statistical outliers in almost every regard. Because of this, those nine urban counties were excluded from further statistical analyses, including Clayton, Cobb, Coweta, Dekalb, Douglas, Fayette, Fulton, Gwinnett, and Henry counties. The new model focuses on the state of Georgia outside of the metro-Atlanta area, which is mostly rural areas and small cities.

Figure 10. Map depicting hot spot clusters for pharmacies in Georgia



Source: US Census Bureau, 2019.

A bivariate correlation was conducted. As seen in Table 1, the results showed that the total number of pharmacies was significantly correlated with the total population, percentage of population 65 and older, percentage of population 18 and under, total number of people employed, poverty rate, median family income, population density, employment density, percentage of the population on food stamps, percentage of the population that works in agriculture, information, construction, manufacturing, real estate, professional services, entertainment, and public administration, and percentage of Hispanic Americans.

3.5 Logical Regressions at the County Level

A stepwise logical regression model was conducted. It was determined that the total population and poverty rate at the county level significantly predict the number of pharmacies in each county, $F(2, 146) = 684.91$, $P < .001$, $R^2 = .95$. The R^2 is high for a social science study. Thus, the regression model is a suitable model for our study. This is further proof that rural areas have less access to pharmacies due to their small population sizes.

Table 1: *Correlational Analyses at Country Level*

Variables	***r*-value**
Total population	.95**
Total number of people employed	.94**
Population density	.83**
Employment density	.82**
Percent working in professional services	.45**
Percent working in agriculture	-.45**
Percent working in entertainment/recreation/accommodation/food	.42**
Median family income	.41**
Percentage of population 65 & over	-.37**
Percent working in real estate	.34**
Percent working in information	.30**
Percentage of population 18 and under	.29**
Poverty rate	-.29**
Percentage of Hispanic Americans	.21*
Percent working in construction	-.21*
Percent working in public administration	-.18*
Percent working in retail	.15
Percent working in manufacturing	-.14
Road density	.13
Percentage of Caucasian Americans	-.09
Unemployment rate	-.07
Percent working in education/health care/social assistance	-.07
Percent working in wholesale trade	-.03
Percentage of African Americans	-.03
Square mileage	.02

*** = p < .001; * = p < .050*
[+] County level data retrieved from the ACS 2014-2018 database

3.6 Second Analysis at the Census Tract Level

After performing these analyses, it became evident that an analysis at the county level might not accurately depict the dynamics within each county. As a result, the study conducted correlational analyses and logical regressions at the census tract level.

3.7 Basic Descriptive Statistics of Census tracts

There are 1,968 census tracts in Georgia. On average, the total population in each census tract was 2,399 people, ranging from 0 to 12,755 people. The average population density was 1,717 people per square mile, ranging from 0 to 25,034 people per square mile. On average, the median family income was $67,827, ranging from $9,779 to $247,500. The average percentage for African Americans, Caucasians, and Hispanic-Americans was 32.6%, 53.0%, and 8.7%, respectively. On average, there was one pharmacy in each county, ranging from zero to nine pharmacies.

3.8 Correlational Analyses at the Census Tract Level

A bivariate correlation was conducted. As seen in Table 2, the results indicated that the number of pharmacies in each census tract was significantly correlated with the total population, total employment, square mileage, unemployment rate, and percentage of Hispanic Americans. This is consistent with the county-level analyses.

Table 2: *Correlational Analyses at Census Tract Level*

Variables	**r-value**
Total population	.28**
Total number of people employed	.27**
Square mileage	-.11**
Population density	-.10
Unemployment rate	-.08*
Road density	-.08
Percentage of Hispanic Americans	.05
Percentage of African Americans	-.04
Employment density	-.02
Percentage of population 18 and under	.02
Median family income	.01
Percentage of Caucasian Americans	.01
Percentage of population 65 & over	.01

*** = $p < .001$; * = $p < .050$*
Census Tract level data retrieved from the ACS 2014-2018 database

3.9 Logical Regressions at the Census Tract Level

A stepwise logical regression model was conducted. It was determined that the total population, percent of the population over 65, median family income, unemployment rate, and square mileage at the census tract level significantly predict how many pharmacies are in each census tract, $F(5, 1933) = 43.61$, $P < .001$, $R^2 = .10$. The R^2 is small; thus, the model is not a suitable one for our study.

4.0 Conclusions

The results show that Georgia is a tale of two states, the Metro-Atlanta area and everyone else. There is a strong contrast between large urban areas and rural areas and small towns. The GIS mapping analyses, spatial autocorrelation, and high-low cluster analyses demonstrate that the pharmacy patterns in Georgia are highly clustered, and not by random chance. Thus, there is a spatial inequity of pharmacy distribution in the state, and areas outside of Metro-Atlanta have a high level of pharmacy deserts, especially in small cities and rural areas. Thus, our statistical analyses focused on rural areas and small cities. The results at the county level partially supported our hypothesis that low-income urban areas, small towns, and rural parts of Georgia have more pharmacy deserts. The county-level correlational analyses indicated that variables such as total population was positively correlated with the number of pharmacies. These results showed that urban counties have more pharmacies, while rural counties have fewer; thus, illustrating the notion that rural counties have less access to pharmacies than urban areas. Because a large portion of Georgia is considered rural, these results show that most of the state is a pharmacy desert. As the hotspot analysis showed, there are large clusters of pharmacies in and around Metro-Atlanta, deserting the surrounding areas and the rest of the state. These rural areas do not have the same access to pharmaceutical services as non-rural areas.

Furthermore, counties with higher median family incomes would have more pharmacies, which confirms the low-income aspect of the hypothesis. The county-level logical regressions revealed a similar pattern. The poverty rate and total population were shown to account for the most variance, which further supports the hypothesis that low-income areas, small towns, and rural parts of Georgia have more pharmacy deserts. In general, the first hypothesis was supported. The results revealed that urban counties had more pharmacies than rural counties.

The census tract level results revealed a different pattern. Regarding the first hypothesis, the correlational analyses showed that the total population positively correlated with the number of pharmacies. Census tracts with more people have more pharmacies, which supports the notion that rural census tracts and census tracts with smaller populations have less access to pharmacies. However, the notion that low-income, urban census tracts have fewer pharmacies was not supported. Therefore, at the census tract level, our first hypothesis was partially supported.

Furthermore, the correlational analyses and logical regressions at the county level partially supported the hypothesis that race, income level, unemployment, and poverty rate would correlate with pharmacy deserts. The correlational analyses revealed that median family income positively correlated with the number of pharmacies. The notion that counties with a lower median family income have less access to pharmacies was supported. Moreover, the logical regressions showed the poverty rate to be a strong predictor of the number of pharmacies, partially supporting the hypothesis. On the other hand, race and unemployment neither correlated significantly nor were shown to be predictors of the number of pharmacies. Race was likely not shown to correlate or predict the number of pharmacies for a few reasons. Namely, the number of counties which have a large percentage of a certain race and higher numbers of pharmacies offset the number of counties which have a large percentage of the same race but very few pharmacies.

At the census tract level, the second hypothesis was partially supported. The correlational analyses revealed that the unemployment rate had a negative relationship with the number of pharmacies in each census tract. Census tracts with higher poverty rates have less access to pharmacies. Furthermore, the logical regressions showed that both median family income and unemployment were predictors of the number of pharmacies. The logical regressions further supported the notion that census tracts with higher levels of unemployment, poverty, and lower income levels have less access to pharmacies. At the census tract level, race was not shown to correlate with or predict pharmacy deserts.

The results showed disparities in access to pharmaceutical care outside the Metro-Atlanta area. In general, rural counties with lower population densities have fewer pharmacies. For instance, there were nine counties with no pharmacies. Out of those counties, seven counties had a population density equal to or less than 20 people per square mile. In other words, most of the counties with no pharmacies are among the most sparsely populated in Georgia. Therefore, these areas are pharmacy deserts. Furthermore, counties with lower population densities, lower median family incomes, and higher unemployment and poverty rates have fewer pharmacies. For instance, 10 total counties had a median family income below $40,000. Of those 10 counties, nine had fewer than five pharmacies. Additionally, there are 19 counties with an unemployment rate greater than 10%. Of those counties, 12 have fewer than five pharmacies. There are 118 counties with poverty rates greater than 15%, some close to 40%. Of those counties, 52 have fewer than five pharmacies. These figures support the notion that counties with lower population densities, lower median family incomes, and higher unemployment and poverty rates have less access to pharmacies; thus, illustrating the pattern of pharmacy deserts in Georgia. In effect, the present study showed that rural parts of Georgia do not have the same access to pharmacies as urban areas.

Furthermore, such findings contribute to the overall understanding of the spatial equity of pharmacies in the state of Georgia. Adding spatial correlation analysis further confirmed disparities in access to pharmacies among certain populations, and some areas do not have access to pharmacies within 20 miles. Such findings indicate a lack of spatial equity of pharmacies in Georgia.

5.0 Limitations and Future Research Recommendations

During the GIS processing, it was discovered that the pharmacy database from the federal government had significant errors in the X and Y coordinates. These errors caused pharmacies to be plotted at random points, often overlapping each other. Using google maps, errors were corrected by manually replacing the incorrect coordinates with the correct ones, and it was very time-consuming for thousands of pharmacies.

We also advise a cautious interpretation of the correlational analyses and logical regressions at the census tract level. The census tract level data were used to account for the geographical dynamics within each county that the county-level analyses would fail to capture. Due to the high number of tracts without pharmacies, the results were not satisfactory.

Furthermore, the present study was not able to accurately study intra-county dynamics. Future research endeavors could include a comprehensive review of pharmacy deserts in each metropolitan area in Georgia. Such a project would be insightful because it would reveal which variables are associated with pharmacy deserts in these metropolitan areas. Moreover, detailed consumer surveys in pharmacy deserts would be able to gain more insights into the pharmacy accessibility issue.

Additionally, future studies could conduct a similar analysis of counties in pharmacy deserts. Understanding the intra-county geographical dynamics would help future research better account for the internal factors. For example, a study should investigate access to pharmacies for areas with high percentages of African American and Hispanic Americans, such as Atlanta and Savannah. Furthermore, if such data can be found, future studies should investigate whether insurance drug coverages correlate with pharmacy deserts.

Overall, we would recommend local and state governments address spatial equity issues of pharmacies in their public health plans. Perhaps, government entities should create incentives—potentially grants and tax credits—to add pharmacies in those pharmacy deserts. For instance, the state government should offer tax exemptions to investors and entrepreneurs who pursue building a pharmacy in an area that this study identified as a pharmacy desert. Moreover, the Georgia government should offer subsidized support and tax credits for pharmacies in underserved areas. Such efforts would likely aid in minimizing the stark disparity of accessibility between urban and rural areas in the State of Georgia.

References

Akinbosoye, O. E., Taitel, M. S., Grana, J., Hill, J. & Wade, R. L. (2016). Improving medication adherence and health care outcomes in a commercial population through a community pharmacy. *Population Health Management, 19*(6), 454–461. https://doi.org/10.1089/pop.2015.0176

Amstislavski, P., Matthews, A., Sheffield, S., Maroko, A. R., & Weedon, J. (2012). Medication deserts: Survey of neighborhood disparities in availability of prescription medications. *International Journal of Health Geographics, 11*(48), 1–13. https://doi.org/10.1186/1476-072x-11-48

Bahlol, M., & Dewey, R. S. (2020). Pandemic preparedness of community pharmacies for COVID-19. *Research in Social & Administrative Pharmacy*, Advance online publication. https://doi.org/10.1016/j.sapharm.2020.05.009

Barber, J. S., Ela, E., Gatny, H., Kusunoki, Y., Fakih, S., Batra, P., & Farris, K. (2019). Contraceptive desert? Black-White differences in characteristics of nearby pharmacies. *Journal of Racial and Ethnic Health Disparities, 6*(4), 719–732. https://doi.org/10.1007/s40615-019-00570-3

Bonner, L. (2015). Pharmacy deserts: Community access less likely for minorities. *Pharmacy Today, 21*(4), 58. https://doi.org/10.1016/S1042-0991(15)30390-X

Cogan, A., Cervelli, L., Dillahunt-Aspillaga, T., & Rossiter, A. G. (2018). Treating military service members and veterans in the private sector. *Information and Resources for Clinicians, 99*(12), 2659–2661. https://doi.org/10.1016/j.apmr.2018.06.006

D'Arrigo, T. (2017). Keep pace with population growth, but geographic disparities remain. *Pharmacy Today, 23*(11), 42. https://www.pharmacytoday.org/article/S1042-0991(17)31662-6/pdf

Davis, A. M., Taitel, M. S., Jiang, J., Qato, D. M., Peek, M. E., Chou, C. H., & Huang, E. S. (2017). A national assessment of medication adherence to statins by the racial composition of neighborhoods. *Journal of Ethnic and Health Disparities*, *4*(2017), 462–471. https://doi.org/10.1007/s40615-016-0247-7

DeBenedette, V. (2018, October 5). Nine ways community pharmacies can enhance services. *Drug Topics.* https://www.drugtopics.com/view/nine-ways-community-pharmacies-can-enhance-services

Duquesne University. (2020). *Social justice and health care for veterans.* LibGuides. Retrieved August 15, 2021, from https://guides.library.duq.edu/veterans

Garrison, W. L. (1960). Connectivity of the interstate highway system. *Papers in Regional Science*, *6*(1), 121–137. https://doi.org/10.1111/j.1435-5597.1960.tb01707.x

Gebhart, F. (2019). The growing problem of pharmacy deserts. *Drug Topics*, https://www.drugtopics.com/view/growing-problem-pharmacy-deserts

General Pharmaceutical Council. (2017). *A question of quality.* Retrieved August 15, 2021 from https://www.pharmacyregulation.org/regulate/blog/question-quality

Hasan, S. S., Kow, C. S., & Zaidi, S. T. R. (2021). Social distancing and the use of PPE by community pharmacy personnel: Does evidence support these measures? *Research in Social & Administrative Pharmacy*, 17(2), 456–459. https://doi.org/10.1016/j.sapharm.2020.04.033

Hedima, E. W., Adeyemi, M. S., & Ikunaiye, N. Y. (2021). Community Pharmacists: On the frontline of health service against COVID-19 in LMICs. *Research in Social & Administrative Pharmacy*, *17*(1), 1964–1966. https://doi.org/10.1016/j.sapharm.2020.04.013

Hu, S., Song, W., Li, C., & Lu, J. (2019). The spatial equity of nursing homes in Changchun: A multi-trip modes analysis. *International Journal of Geo-Information*, *8*(5), 1-13. https://doi.org/10.3390/ijgi8050223

Ingram, D. R. (1971). The concept of accessibility: A search for an operational form. *Regional Studies*, *5*(2), 101-107, https://doi.org/10.1080/09595237100185131

Meghana, A., Aparna, Y., Chandra, S. M., & Sanjeev, S. (2021). Emergency preparedness and response (EP&R) by pharmacy professionals in India: Lessons from the COVID-19 pandemic and the way forward. *Research in Social & Administrative Pharmacy*, *17*(1), 2018–2022. https://doi.org/10.1016/j.sapharm.2020.04.028

Pednekar, P., & Peterson, A. (2018). Mapping pharmacy deserts and determining accessibility to community pharmacy services for elderly enrolled in a State Pharmaceutical Assistance Program. *PLOSOne*, *13*(6), 1–19, https://doi.org/10.1371/journal.pone.0198173

Qato, D. M., Daviglus, M. L., Wilder, J., Lee, T., Qato, & Lambert, B. (2014). 'Pharmacy Deserts' are prevalent in Chicago's predominately minority communities, raising medication access concerns. *Health Affairs, 33*(11), 1958–1965. https://doi.org/10.1377/hlthaff.2013.1397

Qato, D. M., Wilder, J., Zenk, S., Davis, A., Makerlarski, J. & Lindau, S. T. (2003). Pharmacy accessibility and cost-related underuse of prescription medications in low-income Black and Hispanic urban communities. *Journal of the American Pharmacists Association*, *57*(2), 162–169. https://doi.org/10.1016/j.japh.2016.12.065

Qato, D. M., Zenk, S., Wilder, J., Harrington, R., Gaskin, D., & Alexander, G. C. (2017). The availability of pharmacies in the United States: 2007–2015. *PLOSOne, 12*(8), 1–13. https://doi.org/10.1371/journal.pone.0183172

Statista. (2020). *Total number of retail prescriptions filled annually in the US 2013–2025*. Retrieved November 19, 2020, from https://www.statista.com/statistics/261303/total-number-of-retail-prescriptions-filled-annually-in-the-us/

Talen, E., & Anselin, L. (1998). Assessing spatial equity: An evaluation of measures of accessibility to public playgrounds. *Environment and Planning A: Economy and Space, 30*(4), 595–613. https://doi.org/10.1068%2Fa300595

U.S. Census Bureau. (2019). *2015–2018 American Community Survey 5-year estimates*. [Excel Data File]. Retrieved June 2, 2020, from https://data.census.gov/cedsci/table?q=United+States&tid=ACSDP5Y2018.DP05&hidePreview=true

Wen, M, Zhang, X., Harris, C. D., Holt, J. B., & Croft, J. B. (2013). Spatial disparities in the distribution of parks and green spaces in the USA. *Analysis of Behavioral Medicine*, *45*(1), 18–27, https://doi.org/10.1007/s12160-012-9426-x

Yao, J., Agadjanian, V., & Murray, A. T. (2014). Spatial and social inequities in HIV testing utilization in the context of rapid scale-up of HIV/AIDS services in rural Mozambique. *Health & Place*, *28*(2014), 133–141. https://doi.org/10.1016/j.healthplace.2014.04.007

Zhao, P., Li, S., & Liu, D. (2020). Unequable spatial accessibility to hospitals in developing megacities: New evidence from Beijing. *Health & Place*, *65*(2020), 1–11. https://doi.org/10.1016/j.healthplace.2020.102406

ZipRecruiter. (2021). *Real estate agent salary*. Retrieved August 15, 2021, from https://www.ziprecruiter.com/Salaries/Real-Estate-Agent-Salary