ANALYSIS OF FACTORS ASSOCIATED WITH ACCESS TO PHARMACY SERVICES AND PHARMACY CLOSURES

A Dissertation

by

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ABSTRACT

The scope of pharmacy practices has expanded over the years to include non-dispensing activities such as the provision of vaccinations, diagnostic tests, blood pressure monitoring, and medication therapy management services. It generally is believed that pharmacies are the most available healthcare facility in the United States (US); about 90% of the US population live within five miles of a pharmacy. However, systematic evidence to confirm this is lacking. Furthermore, pharmacy availability and accessibility may not be consistent across various local areas and regions of the country.

The goal of this dissertation is to better understand the pharmacy landscape in the United States, with a particular focus on Texas. This research consists of three studies: 1) a systematic literature review that synthesized published evidence on the factors associated with pharmacy availability and pharmacy accessibility in the US; 2) a geospatial secondary data analysis of the sociodemographic factors associated with pharmacy availability and accessibility in Texas at the census tract level; and 3) an analysis that examined the factors associated with pharmacy closures in the state of Texas.

The analysis in the systematic review chapter showed that, while pharmacies were generally available, pharmacy access varied within less populous regions in the country, and in areas with low-income or minority populations. The analysis in the chapters focused on pharmacies in Texas found that total census tract population was the most important factor accounting for greater pharmacy availability and pharmacy access, although larger population also was associated with a greater likelihood of a pharmacy closure. Geospatial analysis showed that the mean distance to a pharmacy in a census tract in Texas was 0.9 miles, however the farthest distance was about 15 miles. People living in rural areas traveled further to the pharmacy

compared to urban areas. A census tract in Texas was likely to experience pharmacy closure if it had a relatively high total population, high percentage of uninsured and high percentage of bachelor degree holders.

Future studies should examine the impact of pharmacy closures on access to pharmacy services such as vaccination and other health services and the effect on population health outcomes.

DEDICATION

This dissertation is dedicated to the Almighty God and my family.

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I would like to thank my dissertation committee for their support and patience throughout the process of completing this dissertation. Dr. Ohsfeldt was very instrumental for the completion of the project but the support and fine tuning from the idea stage to the completion stage. Without Dr. Wunneburger, this dissertation would have been impossible to complete. Having met him via recommendation from his former student and sending him a random email for technical assistance on a class project, I am still amazed at his readiness and dedication to the dissertation and my non-dissertation related research. He also, made sure I got the student version of the software I needed so I could work from anywhere and this was extremely helpful during the pandemic. Dr. Washburn and Dr. Ofili were very instrumental on this project. I appreciate their kind and encouraging words and their availability to provide assistance where necessary.

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Contribution

Dr. Ohsfeldt's immense contribution made this dissertation a reality. My dissertation committee members Dr. Wunneburger, Dr. Ofili and Dr. Washburn made crucial technical and non-technical contributions to this dissertation. Dr. Margaret Forster and Samson Olowolaju contributed to the systematic review part of this dissertation.

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NOMENCLATURE

ACS	American Community Survey
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CMS	Centers for Medicare and Medicaid Services
COVID	Corona Virus Disease
FDA	United States Food and Drug Administration
JBI	Joanna Briggs Institute
LR	Logistic Regression
KFF	Kaiser Family Foundation
MTM	Medication Therapy Management
NBR	Negative Binomial Regression
NCPDP	National Council for Prescription Drug Programs
OLS	Ordinary Least Square
PICO	Problem Intervention Comparison and Outcome
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RUCA	Rural Urban Commuting Area Codes
TX	Texas
TSBP	Texas State Board of Pharmacy
SLR	Systematic Literature Review
US	United States

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

CHAPTER 1

INTRODUCTION

The Centers for Medicare and Medicaid Services (CMS) reported that in the United States (US) in 2018, prescription drug expenditure totaled $335 billion (9% of total health care expenditures), representing a 2.5% increase in drug expenditures from 2017[1]. According to data from the Kaiser Family Foundation (KFF), almost 3.8 million prescriptions were filled in retail pharmacies in the US in 2019[2]. Pharmacies remain the most widely available category of health care facility in the US[3]. As of 2015, there were 67,753 community pharmacies in the US, or about 2.1 pharmacies per 10,000 population in the US, a ratio that has remained stable from 2007 to 2015[4].

However, access to pharmacies and pharmacy services is limited in many areas, particularly in low-income communities and rural areas, and these access limitations may have been exacerbated by recent trends in pharmacy closures. About 9,600 pharmacies closed between 2009 and 2015, and independent pharmacies were most likely to close, in both urban and rural areas[5]. A market dynamics study in Minnesota found that, between 2002 and 2017, the ratio of independent to chain pharmacy changed from 1:1 to 1:3[6]. These closures have negative consequences on medication adherence and can increase rates of hospitalization and health care costs due to poor health outcomes[7–9]. Although independent pharmacies in urban areas are at the greatest risk of closing, independent pharmacy closures in rural areas often result in an absence of any form of clinical provider of pharmacy services within the community[10]. About 630 rural communities in the US that had at least one pharmacy in 2003 did not have any retail pharmacy by 2018[11].

Over the years, pharmacies have grown beyond just the provision of dispensing services. The scope of pharmacy practice has expanded, with pharmacists now providing vaccination services, medication therapy management and specialty pharmacy services, such as specialized pharmaceutical services for cancer patients, usually with complex medication administration and monitoring procedures[3,12,13]. To date, pharmacists are not recognized as health care providers at the federal level, so they generally are unable to directly bill the Centers for Medicare and Medicaid for non-dispensing related services, despite the expansion of the scope of pharmacy practice over the years[14,15]. Recently, there has been increased push for pharmacists to be classified as healthcare providers at the federal level so they can be able to directly bill for Medicare Part B services that they provide[16–19]. This change in policy would provide a means to cushion the effect of shortages of primary care physicians in certain areas[15]. Some states, such as Texas and California, have laws that enable pharmacies to bill for healthcare services provided by pharmacists that are within the scope of the pharmacy profession license to practice within the state[16,20]. These services have been found to be cost saving, to reduce waste, and to improve quality of care patients' clinical outcomes [3]. Meanwhile, most states during the 2020 COVID-19 pandemic provided pharmacists with temporary provider status to enable them to render health services without specific collaborative physician agreement, or using a statewide collaborative physician agreement, for the period of the pandemic[16,21].

Despite the aforementioned importance and wide availability of pharmacies, pharmacies are not equally distributed in all areas. Specifically, access to pharmacy services varies across different regions of the country and is often related to the characteristics of the local area population and other factors, such as payer reimbursement and pharmacy recruitment difficulties[11,22]. Qato et al. found that fewer pharmacies in Chicago were located in areas where minority race and ethnic groups represent the majority of the community population[23]. Furthermore, Chisholm-Burns et al. found that high minority population and socioeconomic factors such as a low employment rate and a high crime rate were associated with reduced access to home medication delivery services and higher medication prices in Shelby County, Tennessee[24].

Inadequate pharmacy access can result in inability to obtain the services provided by pharmacies and difficulty in obtaining medications, resulting in medication non-adherence. Thus, it is important to understand the factors that determine pharmacy closures and access. Also, it is crucial to understand the variance in pharmacy availability and access to various sociodemographic groups within the population and how this may affect provision of pharmacy services.

Overview of the dissertation

This dissertation aims to assess the availability and accessibility of pharmacies and factors associated with pharmacy closures using a three-paper format. This chapter (Chapter 1) provides an overview of relevant literature and the content of the three studies included in the dissertation. The first study (Chapter 2 of the dissertation) is a systematic literature review (SLR) of evidence on pharmacy availability and accessibility in the United States. The second paper (Chapter 3) used ArcGIS for spatial analysis to characterize the geographic distribution of community pharmacies in Texas, and regression modeling to assess relationships between local area population characteristics and community pharmacy availability and access. The third paper (Chapter 4) examined the relationships between local area population characteristics and the likelihood of community pharmacy closures in Texas over time. The final chapter (Chapter 5) summarizes the results of the three studies and their implications for public health policy and future research.

Significance of the three studies

Specific aims and objectives for each study are presented in more detail within their respective chapters in this dissertation, but are outlined briefly as follows:

Study 1

There currently is no published systematic literature review on the topic of pharmacy accessibility and availability in the US, despite the availability of a number of peer-reviewed studies on the topic. Researchers often use pharmacy counts, pharmacy density, geographic/geospatial methods, distance to pharmacy (estimated or actual), pharmacy closures, and the presence of pharmacy deserts as means to describe pharmacy availability and accessibility. Thus, the first of the three studies in the dissertation will fill a gap in the literature by characterizing and grouping existing studies based on the definitions of accessibility and availability and the assessment methodology used. Specifically, the review seeks to find and describe the themes and concepts that emerge across studies. The analysis will focus particular attention on evidence relating to the effect of rurality, race and population density on pharmacy access and availability. We searched Medline, Ovid, CINAHL and Embase databases using relevant keywords (Table 1). This resulted in 1,744 articles that were reviewed, of which 22 remained after applying all inclusion and exclusion criteria, and subsequently included in the final analysis.

Study 2

The variability in pharmacy availability across geographic areas in the US and the potential impact of recent pharmacy closures highlights the importance of analyzing the relationship between community population characteristics and pharmacy accessibility within smaller geographic units. This can aid local authorities, investors and other stakeholders to proffer solutions based upon better understanding of the pharmacy landscape within their jurisdiction. However, there is no such research specifically focused on Texas pharmacies. The second paper described community pharmacies currently licensed and physically present within Texas as of 2019, as well the range of services provided by these pharmacies, such as Medicaid and vaccination services. Furthermore, geospatial analysis using ArcGIS was used to describe pharmacy availability in Texas. Pharmacy volume (number) and accessibility (using distance to the pharmacy and pharmacy per 10,000 population) in these areas was to be mapped and described. Also, the relationship between pharmacy availability and pharmacy access and population characteristics such as rurality, number of residents and race distribution was assessed. Furthermore, the distribution of services provided by pharmacies (i.e., Medicaid services and vaccination) and the population characteristics was spatially described.

Study 3

Lastly, the third study examined the relationship between the socio-demographic characteristics of census tracts and pharmacy closures in Texas. Pharmacy closures impact pharmacy access and prevent communities from accessing medications and other non-prescription services such as vaccination services, medication therapy management, disease management, tobacco cessation programs, health checks such as blood pressure monitoring and COVID-19 testing. Also, pharmacies in communities engage in prescriber communication about potentially harmful adverse effects of prescribed medications or potential cost savings through generic substitutions. They also engage in the education of other healthcare providers about newly approved medications, drug therapy protocols and collaborative practice agreements. Often, pharmacies may also act as a source of detection of particular illnesses within a community due to treatment seeking patterns. The likelihood for a census tract to experience at least a pharmacy closure and the number of pharmacy closures that occurred was analyzed, based on census tract population characteristics, such as the number of existing pharmacies in the census tract, rurality, number of residents and racial composition of the population.

CHAPTER 2

AVAILABILITY AND ACCESSIBILITY OF PHARMACIES IN THE US:

A SYSTEMATIC LITERATURE REVIEW

Introduction

Pharmacies represent one of the most available facilities for medication provision services, typically being available during evenings hours and weekends. However, in recent years, they have been providing an expanding range of services such as medication therapy management, blood sugar and blood pressure checks, vaccination services, poison centers, naloxone access, and specialty services such as oncology. Also, pharmacies often serve as the first port of call for some ailments, because pharmacists can be seen without prior appointments.

The population of the United States continues to increase and to age, with about 10,000 baby boomers reported to have reached the age of 65 years every day since January 2011[25]. In recent years, it is estimated that 90% of adults aged 65 years and over are taking at least one prescription drug and about 54% taking 4 or more prescription drugs[26]. Over $300 billion was spent on prescription medications in 2018[27]. Also, many new and expensive medications, especially biologics, have been approved by the United States Food and Drug Administration (FDA) over the past several years. All of these provide avenues for expansion of pharmaceutical services.

A number of prior studies have described and assessed pharmacy availability and accessibility at various locations and population levels. However, their results have not been systematically combined to delineate common or contradictory findings. This study aims to synthesize evidence on pharmacy availability and accessibility within the US.

Research Objectives

1. Are pharmacies available or accessible in the geographic unit (located within the US) specified in the study?
2. Are there differences between rural and urban locations?
3. Are there racial differences in pharmacy access and availability?
4. Are there differences based on socioeconomic status?
5. Are there differences by types of pharmacy (e.g., independent, chain)?
6. What are the impacts of pharmacy availability on health services and outcomes?

Methods

Studies were reviewed and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Protocol and Registration

We created a review protocol to predetermine the aim of the review, search strategy, inclusion and exclusion criteria and variables of interest. This protocol was registered with PROSPERO (ID 181220).

Eligibility Criteria (Inclusion and exclusion criteria)

Since this was the first systematic review on this topic, we made our search as broad as possible to capture as many publications as possible. We adapted the Problem, Intervention, Comparison and Outcome (PICO) framework to facilitate the eligibility criteria. We excluded abstracts and non-peer reviewed studies. Our search strategy included qualitative, quantitative, observational and geographic studies. There is no universally acceptable measure or definition of pharmacy access or availability, so all measures were accepted as described by the researchers of each article. We also included studies about access to certain products (e.g., naloxone) if the study initially provided a description or explored the pharmacy structure and distribution of pharmacies within the local area that was the focus of the study. In other words, we included such studies if we were able to ascertain pharmacy availability or accessibility from their report, even though that was not their primary or only research question. Also, studies that used pharmacists as a proxy for pharmacies were included if they reported their results in terms of pharmacies and described the pharmacy distribution of the location. Studies that did not meet these two criteria were excluded.

Finally, we excluded studies that focused exclusively on telepharmacy and mail order pharmacy (i.e., no physical patient contact). The studies included in the final analysis generally did not account for the mail order pharmacy or telepharmacy in their investigation, which some explicitly noted as a limitation of their analysis.

Literature search strategy

We conducted a comprehensive research of the Medline in October 2019, Embase and Cumulative Index to Nursing and Allied Health Literature **(**CINAHL) electronic databases in January 2020. Included articles were also manually searched for references and citations. There were no date, demographic, language, or study design exclusion restrictions. Search words included “Pharmacy closure”, “pharmacy deserts”, “pharmacy shortage”, “geospatial analysis of pharmacies”, “GIS”, “availability of pharmacies", "accessibility of pharmacies", "spatial analysis", "mapping", "health services analysis", and "location" (see Table 1).

Table 1: Search terms used to identify articles

Medline Ovid 10/16/19
1. exp Pharmacy/ or exp Pharmacies/
2. pharmac*.ti,ab.
3. or/1-2
4. exp Health Services Accessibility/
5. (availabilit* or accessibil* or closure* or desert*).ti,ab.
6. or/4-5
7. 3 and 6
8. "Spatial Analysis"/
9. (mapping or (spatial adj1 analy*)).ti,ab.
10. (geographic* or geospatial).ti,ab.
11. location*.ti,ab.
12. or/8-11
13. 3 and 6 and 12
Embase Ovid 1/23/2020
1. exp "pharmacy (shop)"/
2. pharmac*.ti,ab.
3. or/1-2
4. exp health care access/
5. (availabilit* or accessibil* or closure* or desert*).ti,ab.

Table 1: Search terms used to identify articles (continued)

Embase Ovid 1/23/2020
6. or/4-5
7. 3 and 6
8. exp spatial analysis/
9. (mapping or (spatial adj1 analy*)).ti,ab.
10. (geographic* or geospatial).ti,ab.
11. location*.ti,ab.
12. or/8-11
13. 3 and 6 and 12
CINAHL Ebsco 1/28/2020
((MH "Pharmacy, Retail") OR (MH "Pharmacy Service+")) OR TI pharmac* OR AB pharmac* AND (MH "Health Services Accessibility+") OR TI (availabilit* or accessibil* or closure* or desert*) OR AB (availabilit* or accessibil* or closure* or desert*) AND TI (mapping or (spatial adj1 analy*)) OR TI (geographic* or geospatial or location*) OR AB (mapping or (spatial adj1 analy*)) OR AB (geographic* or geospatial or location*)

Study selection and data collection process

Study search, selection, collation was performed using Rayyan software while Google form was used for coding and data extraction from the studies.

The review process entailed three steps. For pilot testing, Eniola Olatunji (EO) and Samson Olowolaju (SO), reviewed the first 100 articles from the Medline database via title and abstract. Then a full text review was done to further exclude some articles.

Conflicts were resolved by consensus between EO and SO. The resulting included articles were then used to create the coding scheme for data extraction by EO and SO. Afterwards, the process was repeated for all of the articles from the database search. Subsequently, the coding scheme was adjusted and used for full data extraction and data analysis.

Data items

Each included study was reviewed and information retrieved for:

1. Pharmacy access information, such as distance to pharmacy, pharmacy density, pharmacies are available, pharmacies are accessible, and pharmacies are geographically accessible.
2. Location details: National, state, county, city, rurality
3. Population: total number, gender-specific, Medicaid, elderly.
4. Comparisons: Rural/urban, racial comparisons, pharmacy types
5. Impact of access: Racial difference in access, rural-urban difference, issues with medication refills or adherence.

Quality assessment and risk of bias in the included studies

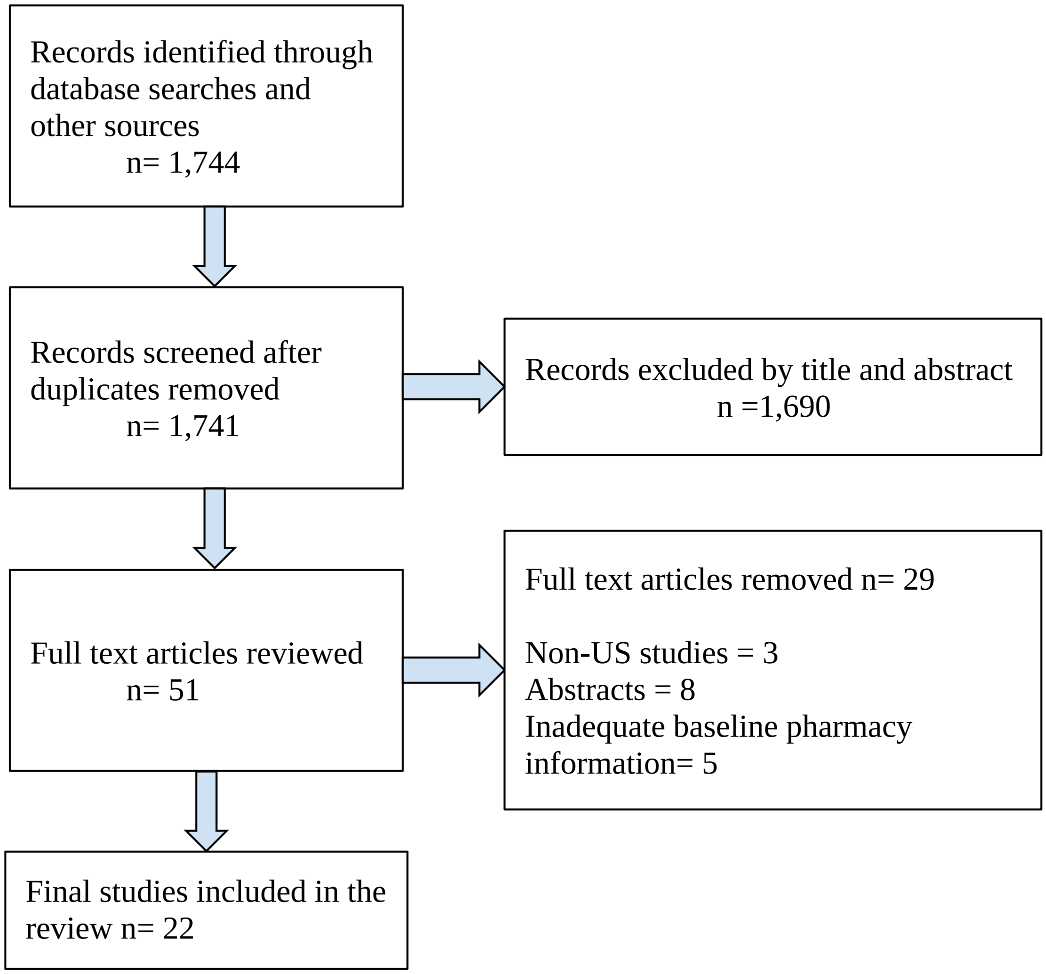
We assessed studies for risk of bias using a modified Joanna Briggs Institute (JBI) Critical Appraisal tool for cross-sectional studies to fit our research. Each study was evaluated independently by EO and SO.

Results

Study selection

A total of 1,744 citations were reviewed from all sources and 22 articles met the full inclusion criteria of our study and were included in the final review, as shown in Figure 1. To obtain the final articles, 3 duplicate articles were removed, and 1,690 articles remained after screening by title and abstract. A manual search of the references lists yielded 4 articles of which only one was selected for full text review. 51 articles were selected for full text review of which 22 were included for analysis in the review.

Figure 1: Flow Chart Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram



Characteristics of included studies

The studies included in the review span the years 1985 to 2019. Table 2 reports the detailed description of each included study, including the year of the study, the location of the study, the type of location (city, county, state, national), the study population, the type and number of pharmacies in the study, rurality, whether any spatial/distance analysis was performed, and the focus of the study.

A majority of the studies focused on pharmacy availability and accessibility, as shown in Table 3 and there was no clear definition of pharmacy availability and pharmacy access. Nearly all articles focused on pharmacy availability while over half reviewed pharmacy accessibility. A few included pharmacy closures and pharmacy deserts as their focus. The term “pharmacy desert” was first coined by Qato et al. in 2014, where they defined a pharmacy desert in Chicago as an area (census tract) that was characterized by “both low access and low income”[23]. They described low access measure analogous to the definition of food deserts, where over 33% of the residents resided more than 1 mile away from a pharmacy, or one half of a mile away from a pharmacy for low vehicle access census tracts (where over one hundred households did not have an automobile). They used the low income measure to identify areas with 20% or more of the census tract residents living below the federal poverty line, or below 80% of the city’s median household income in that period ($62,246)[23]. Most of the other studies that used the term pharmacy desert used a variation of this definition. Pednekar et al. defined pharmacy deserts in terms of distance, they defined pharmacy deserts in Philadelphia as areas with more than 33% of the population living more than 1 mile away from the pharmacy[28]. Barber et al. defined a desert as an area with a relatively small number of pharmacies per capita[29], whereas Amstislavski et al. referred to “medication deserts,” defined as areas with low availability of most commonly dispensed prescription medications[30]. While all studies included in our review focused on community pharmacies, 4 studies also incorporated other types of pharmacies, such as hospital, clinic or government pharmacies.

Table 2: Description of Included Studies

S/N	Author	Year	Location	Type of Location	Study Focus	Study Population	Setting	Rural / urban	Type of Pharmacy	Number of Pharmacy	Spatial/ Distance Analysis	Type of Study
1	Adams DW et al[31]	2000	Virginia	State	Availability	Total	Rural, urban	Yes	Community Hospital Outpatients	1,337	No	Pooled Cross-sectional
2	Adams EK et al[32]	1997	Multiple states	Multi-state	Availability	Total"	Rural, Urban	Yes	Community Hospital	27,000	No	Cross-sectional
3	Amstislavski et al[30]	2012	New York	City	Availability Accessibility	Total Population	Urban	No	Community	408	Yes	Cross-sectional
4	Barber et al[29]	2019	Michigan	State	Accessibility	Female	Rural, Urban	No	Community	82	No	Cross-sectional
5	Batra et.al[33]	2018	California	State	Availability	Female	Rural, Urban	Yes	Community	480	No	Cross-sectional

Table 2 (continued)

S/N	Author	Year	Location	Type of Location	Study Focus	Study Population	Setting	Rural / urban	Type of Pharmacy	Number of Pharmacy	Spatial/ Distance Analysis	Type of Study
6	Burrell et al[34]	2017	Allegheny, PA	County	Availability Accessibility	Total Population	Rural, Urban	No	Community Hospital	322	Yes	Cross-sectional
7	Casey et al[35]	2013	North Dakota, South Dakota and Minnesota	State	Availability Accessibility Closures Estimated Distance	Total Population	Rural	No	Community	537	Yes	Cross-sectional
8	Chisholm-Burns et al[24]	2017	Shelby	County	Accessibility	Total	Not stated	N/A	Community	90	No	Cross-sectional
9	Gadkari et al[36]	2009	Wisconsin	State	Availability Accessibility	Pharmacists	Rural	Yes*	Community	115	No	Cross-sectional

Table 2 (continued)

S/N	Author	Year	Location	Type of Location	Study Focus	Study Population	Setting	Rural / urban	Type of Pharmacy	Number of Pharmacy	Spatial/ Distance Analysis	Type of Study
10	Guadamuz et al[5]	2020	US	Country	Availability Closure	Total	Rural, Urban	Yes	Community	67,721	No	Longitudinal
11	Haag et al[37]	2010	Minnesota	State	Availability Accessibility	Sample	Rural, Urban	Yes	Community	564	No	Cross-sectional
12	Klepser et al[10]	2011	United States	Country	Availability Closure	Total Population	Rural, Urban	Yes	Community	70,000	No	Longitudinal
13	Olson et al[6]	2018	Minnesota	State	Availability	Total Population	Rural, Urban	Yes	Community	1,063	Yes	Pooled Cross-sectional
14	Pednekar et al[28]	2018	Pennsylvania	State	Availability	Elderly	N/A	N/A	Community	2,752	Yes	Cross-sectional

Table 2 (continued)

S/N	Author	Year	Location	Type of Location	Study Focus	Study Population	Setting	Rural / urban	Type of Pharmacy	Number of Pharmacy	Spatial/ Distance Analysis	Type of Study
15	Qato et al[4]	2017	United States	Country	Availability Accessibility Closures	Total Population	Rural, Urban	No	Community Hospital Clinic Government	67,753	Yes	Cross-Sectional, longitudinal
16	Qato et al[23]	2014	Chicago	City	Availability Accessibility	Total Population	Urban	N/A	Community	511	Yes	Cross-sectional
17	Samina et al[38]	2011	Chicago	City	Availability Accessibility Estimated Distance	Medicaid	Urban	No	Community	n/a	Yes	Cross-sectional
18	Schommer et al[39]	2006	Minnesota	State	Availability	Total, Elderly	N/A	N/A	Community	n/a	No	Cross-sectional

Table 2 (continued)

S/N	Author	Year	Location	Type of Location	Study Focus	Study Population	Setting	Rural / urban	Type of Pharmacy	Number of Pharmacy	Spatial/ Distance Analysis	Type of Study
19	Shannon et al[40]	1985	Northern Flint, Michigan	City	Availability Accessibility Estimated distance	Elderly	Not stated	No	Community	11	Yes	Cross-sectional
20	Stopka et al[41]	2014	Massachusetts	City	Availability Accessibility	Total Population	Urban	No	Community	809	Yes	Cross-sectional
21	Stopka et al[42]	2013	Los Angeles	County	Availability	Total	N/A	N/A	Community	1,623	Yes	Cross-sectional
22	Swu-Jane[43]	2004	Illinois	State	Accessibility Estimated Distance	Elderly	Rural, Urban	Yes	Community	1,373	Yes	Cross-sectional

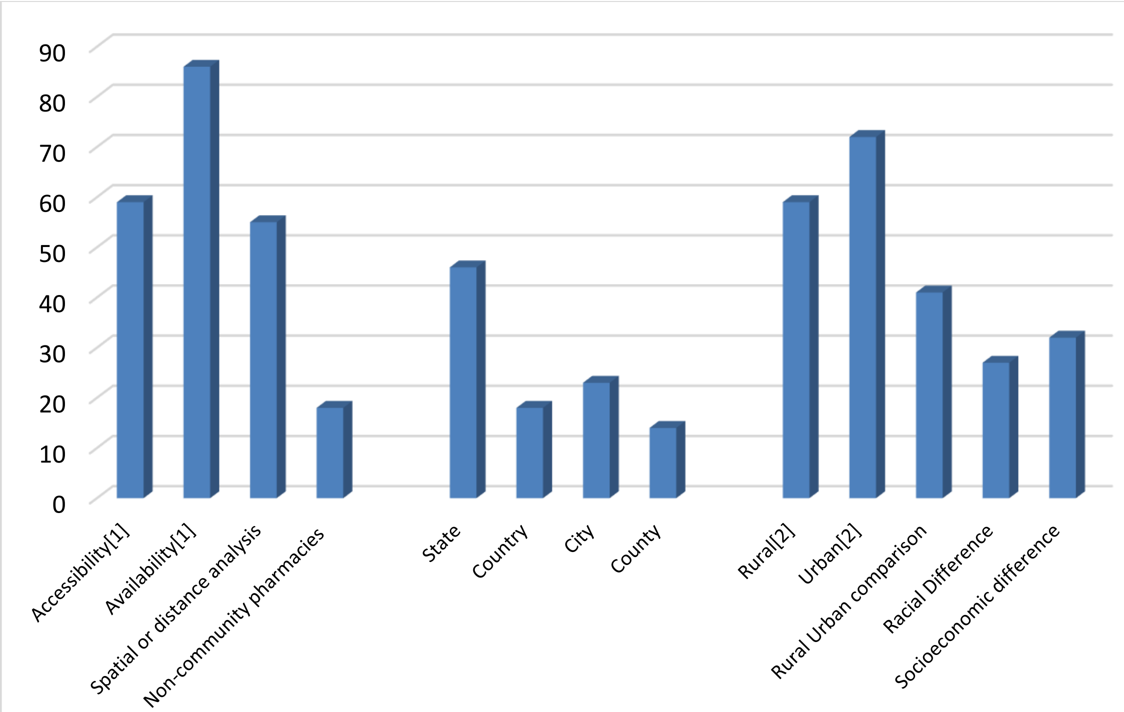
Table 3: Distribution of Characteristics Assessed by Included Studies

Characteristics Assessed by Study	**Number**	**Percent**	**Included Studies**
Accessibility[1]	13	59	3,4,6,7,8,9,11,15,16,17,19,20,22
Availability[1]	19	86	1,2,3,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21
Spatial or distance analysis	12	55	3,6,7,13,14,15,16,17,19,20,21,22
Included non-community pharmacies in their analysis	4	18	1,2,6,15
State	10	46	1,4,5,7,9,11,13,14,18,22
Country	4	18	2,10,12,15
City	5	23	3,16,17,19,20
County	3	14	6,8,21
Rural[2]	13	59	1,2,4,5,6,7,9,10,11,12,13,15,22
Urban[2]	16	72	1,2,3,4,5,6,710,11,12,13,15,16,17,20,22
Rural-Urban comparison	9	41	1,2,5,9[3],10,11,12,13,22
Racial Difference	6	27	4,8,14,15,17,19
Socioeconomic difference	7	32	1,2,3,8,10,16,21

1. *Availability and accessibility assessment are not mutually exclusive.*
2. *Rural and urban assessments are not mutually exclusive.*
3. *Comparison is between micropolitan and non-core areas (areas with less population density than micropolitan area).*

Rural-urban comparisons were included in 41% of the studies, as shown in Figure 2. Twenty-seven percent of the articles assessed the racial differences while thirty-two percent assessed the socioeconomic differences that affected pharmacy availability and accessibility.

Figure 2: Percentage Distribution of Articles that Assessed Specific Characteristics



1. Availability and accessibility assessment are not mutually exclusive.
2. Rural and urban assessment are not mutually exclusive.

Risk of bias in the included studies

We used a Modified Joanna Briggs Institute's (JBI) Critical Analysis tool for cross-sectional studies (see Appendix A). Because there was no standard definition for the concept of pharmacy availability and pharmacy access, we accepted and included only studies that gave their own definition of these concepts as an objective measure for the concepts.

Geography/Location of studies

Ten of the included studies (46%) reported results using state-level data[1,4,5,7,9,11,13,14,18,22], 26% (5) studies were conducted at a city level[3,16,17,19,20], 14% (3) used county-level data[6,8,21], and 18% (4) used national data[2,10,12,15].

National Trend Studies

Four studies reviewed the national trend of pharmacy availability and access [2,10,12,15]. They found that pharmacy availability and access increased over time. However, the trend in availability and access was variable regionally. Rural areas and areas with high rates of poverty or uninsurance tended to experience lower pharmacy availability and access, and have higher rates of pharmacy closures.

Population/Population Density

The majority of the studies included the total population of the area they studied. Some studies included percent females[29,33], Medicaid population[44] and elderly population[28,39,40,43]. In general, areas that have higher population or higher population density had greater pharmacy availability. Pharmacy access tended to be higher in these areas; however, this is often affected by the socioeconomic or racial composition of these areas.

Differences based on socioeconomic status

Areas with high levels of low-income households or high levels of poverty were found to be a major and consistent determinant of low pharmacy access and availability in all settings [1,2,3,8,10,16,21]. This finding was consistent across studies in diverse time periods and geographic locations, e.g., 1997 through 2020, across states (Virginia, California, Tennessee), and cities (New York and Chicago).

Pre-2010 versus post 2010 studies

Two[2,19] of the included studies were published before the year 2000, and 4 studies[1,9,18,22] were published between year 2000 and 2009. A majority of the studies (16) were completed after the year 2010[3,4,5,6,7,8,10,11,12,13,14,15,16,17,20,21].

Distance analysis/Geographic Information System (GIS)

A total of 12 studies performed some form of GIS or distance analysis in their research [3,6,7,13,14,15,16,17,19,20,21,22]. Various methods were used for GIS or distance analysis. One study measured actual distance to a pharmacy while the remaining measured estimated distance to the pharmacy[23,35,38,40,43,45].

Pharmacy Closures

Most studies that reviewed pharmacy closures were national-level or multi-state studies with only one focused on data for a single state[7,10,12,15]. Casey et al., in a study of closures in rural areas in the states of North Dakota, South Dakota and Minnesota, found that while the majority of the population lived within 20 miles of a pharmacy, pharmacy closures resulted in losing a sole existing community pharmacy in several areas in North Dakota and Minnesota but not in South Dakota. They also concluded that financial viability and pharmacy staffing was a major threat to survival of pharmacies in these areas[7]. Among the national-level studies, Guadamuz et al. showed that while independent pharmacies were more likely to close in both rural and urban areas, the risk factors differ. Risk factors in urban areas included a high percentage of low-income and publicly insured or uninsured population in their service area, whereas these were not risk factors for closure in rural areas[10].

Availability and Accessibility

Nineteen studies examined pharmacy availability [1,2,3,5,6,7,9,10,11,12,13,14,15,16,17,18,19,20,21] while 13 studies reviewed pharmacy accessibility [3,4,6,7,8,9,11,15,16,17,19,20,22]. The national-level studies showed that while there is modest increase in the number of pharmacies, pharmacy density has been relatively stable over the years. Guadamuz et al. showed that, of the 74,883 pharmacies available nationally in 2009, 9,564 (12.85%) eventually closed between 2009 and 2015, though the total number of pharmacies available grew by about 7% over the same period[5]. Qato et al. in a national analysis showed that pharmacy availability increased but accessibility remained the same from 2007 to 2015[4].

Rural/Urban Comparisons

Thirteen (59%) studies assessed pharmacies in rural areas [1,2,4,5,6,7,9,10,11,12,13,15,22] and 16 (72%) studies assessed urban areas[1,2,3,4,5,6,710,11,12,13,15,16,17,20,22]. Note, these were not mutually exclusive, as 9 (41%) studies compared rural-urban differences of pharmacy access or availability, as shown in Figure 2[1,2,5,9,10,11,12,13,22].

Chain versus Independent Pharmacies Trends

For the studies that compared pharmacy ownership, Adams DW et al. found that the number of independent pharmacies in Virginia decreased significantly between 1994 and 1999, while chain, mass merchandise and grocery pharmacies increased[31]. Guadamuz et al. found that independent pharmacies in the US were more likely to close compared to other types of pharmacies[5]. Also, Klepser et al. showed that independent pharmacies were more likely to close compared to chain pharmacies, resulting in reduced pharmacy access[10]. In Minnesota, Schommer et al. found that the ratio of independent-to-chain pharmacies changed from 2:1 to 1:1 despite a relatively constant number of pharmacies between 1992 and 2002. Population density was identified as a main factor that may affect independent pharmacy closure[6]. Furthermore, Olson et al. showed the independent-to-chain pharmacy ratio in Minnesota changed from 1:1 in 2002 to 1:3 in 2017. There was a 50% decrease in independent pharmacies and a 40% increase in community pharmacies in Minnesota within this period[6]. Qato et al., using the National Council for Prescription Drug Programs (NCPDP) data from 2007 to 2015, consistently found that the average percentage of chain pharmacies was 45%, compared to 35% independent pharmacies from 2007 to 2015. During this period, the number of chain pharmacies increased by 8.3% while the number of independent pharmacies increased by 3.85%[4].

Non-Community pharmacy

While all the studies assessed community pharmacies, 4 included analysis of non-community pharmacies along with their community pharmacy analysis[1,2,6,15]. Adams DW. et al, Adams EK et al., and Burrell et al. included hospital outpatient pharmacies and Qato et al. included hospital, clinic and government pharmacy types in their analysis[1,2,6,15].

Racial Comparisons

Six (27%) of the studies assessed racial differences in their analysis [4,8,14,15,17,19]. A study in Northern Flint, Michigan found no statistically significant differences in travel distances for blacks compared to whites, although white dominated areas have more pharmacies[19] (see Appendix B). In Chicago, while non-adherent Medicaid enrollees were more likely to be minorities, pharmacy availability and accessibility was noted to be adequate in the city[38]. In Pennsylvania, 39% of census tracts were pharmacy deserts. These communities had significantly more elderly whites, females and married people (see Appendix B). These communities also had less home delivery and 24-hour services [14]. In Chicago, despite overall increase in pharmacy availability, more pharmacy deserts were found in black and low-income counties. Furthermore, low-income black communities had even more pharmacy deserts compared to low-income white communities[16]. In Shelby County Tennessee, higher population of minorities led to lower pharmacy density, i.e., reduced pharmacy access[8].

Health Impact of Pharmacy Access and Medication Adherence

Only one study analyzed the effect of distance to pharmacy and medication adherence directly. Syed et al. found that there was no discernable difference between adherent and non-adherent Medicaid diabetic patients in Chicago related to pharmacy access[38]. Meanwhile, Qato et al. reported that a smaller number of pharmacies were found in the Pacific West and Southwest areas of the US[4]. These areas were reported by Ritchey et al. to have a greater likelihood of non-adherence to medication among Medicare-Part D beneficiaries in a separate study[46].

Discussion

This systematic review of existing peer reviewed literature attempted to show the sociodemographic and other factors affecting pharmacy availability and accessibility and its potential impact on pharmacy services and health outcomes. There are no standard definitions of pharmacy availability or pharmacy access. Studies tend to use the term "availability" when the study refers to the number of pharmacies in a region[4,6,31,33,39,42,45]. Meanwhile, studies tend to use the term "pharmacy access" when the study examines pharmacy density, pharmacy services and pharmacy deserts[23,24,29,34,40]. Nonetheless, these terms may be used interchangeably in certain studies or when spatial or distance analysis methods are employed in the studies[6,30,34,35,40,45]. Furthermore, when studies assess pharmacy closures, they may describe this in terms of pharmacy access as well as availability[5,10,35]. Given these imprecise descriptions, we believe having a standard definition or standard measures for describing these terms will be useful for better understanding and comparison of pharmacy availability and access across different regions and over time.

Some socioeconomic, demographic and other factors such as income status, pharmacy services, reimbursement, race, rurality and types of pharmacy were found to impact pharmacy availability and access.

Low income

While the high cost of prescription medication often is touted as a major concern for Americans, especially for low-income earners, poor access to pharmacy can further be a major impediment to prescription medication, medication adherence and health outcomes among this population. Our research consistently showed that poor communities or areas with a high percentage of low income or low socioeconomic status population consistently lacked pharmacy access at all geographic levels[5,23,24,30–32,42]. This finding further underscores the lack of access to health care in these areas. Policy makers should encourage pharmacies to enter or avoid closure in these underserved areas by instituting incentives to help sustain these pharmacies, through start-up funding or allocative policies such as enhanced reimbursement rates.

Race

Pharmacy availability and accessibility is affected by race as minorities tend to have lower access to pharmacies. Encouraging minorities themselves to pursue careers in pharmacy and the provision of mentorship, policy and finances to establish minority-owned pharmacies in these areas, could be away to alleviating this problem, since minorities may be more likely to understand the specific health needs in areas with higher minority population. Also, there may be better trust and less bias when providing services, which may foster improved health outcomes in these areas.

Rural-Urban Comparison

While pharmacy services are generally more available in urban areas, pharmacy access may still be an issue in both rural and urban areas[4]. Staffing can also be challenging for rural pharmacies[35,49]. Policy makers can make provisions and incentives such as loan repayment programs, pharmacy startup funds in areas that lack pharmacies or are medically underserved. Pharmacies in rural areas tend to provide more non-dispensing pharmacy services compared to urban areas. Haag et al. showed that rural pharmacies were more likely to provide Medication Therapy Management services (MTM) compared to urban pharmacies[37]. Also, Gadkari et al. found that pharmacies in non-core areas (areas with no urban core with lower population density in comparison to micropolitan areas) in Wisconsin provided more pharmacy services such as Medication Therapy Management (MTM) and Disease State Management programs (DSM) compared to pharmacies in micropolitan areas.[36] Less population and prescription volume in rural areas makes time available to focus these non-dispensing services that can lead to improved health outcomes. Also, since rural pharmacies may be the only existing pharmacy or health facility in the area, they are able to provide these services to improve their client base and also improve the survival of the business. Highly populated urban areas may lead to more competition and challenges to differentiation in a community that have similar needs. Also, independent pharmacies may experience unsustainable competition in urban areas from chain pharmacies and may end up closing.

Type of Pharmacy

Independent pharmacies tend to experience more closures and their number has reduced overtime. Often when an independent pharmacy closes, either there is no other pharmacy in the area or they transfer their client base to chain pharmacies[35,49]. This has ben the case as chain pharmacies have more robust structure, financial means and economies of scale to cope with declining reimbursements[10]. Independent pharmacies often try to differentiate themselves by being more customer friendly and providing more pharmacy services such as home delivery and compounding services [36].

Nonetheless, chain pharmacies may suffer from large bureaucracies which can make for inefficiencies such as slow response to local population needs which may be more quickly adopted and implemented by independent pharmacies.

Pharmacy Services

The extent to which pharmacies provide various services beyond provision of medications depends in part on state-level scope of practice regulations. Some states (e.g., Texas) in recent times have begun to allow pharmacies to be reimbursed for certain services, such as vaccination and medication therapy management, which may help provide financial incentives for pharmacies to utilize their capacity to provide services that will benefit the population within their service areas[20]. Our study found that rural pharmacies may provide more non-dispensing pharmacy services than pharmacies in urban areas, which may be related to the fact that these rural pharmacies may be the only existing health care facility within a large geographic radius[36,37]. Our research further showed that the impact of pharmacy closures may have a greater adverse impact in these areas[10]. Policy efforts to keep these pharmacies open, functional and providing these services may be necessary to improve population health.

Finance /Reimbursements

Pharmacy reimbursement is largely tied to the number of prescriptions filled with lower and lower reimbursement rates over the years[10]. Centers for Medicare and Medicaid often set low reimbursement rates for Medicaid prescriptions, and private payers have become increasingly effective in negotiating lower prescription payment rates[47,48]. Since higher prescription volume means higher revenue for pharmacies,

pharmacies that do not fill enough volume, or are in rural or low population areas, will find it difficult to survive due to insufficient prescription volume to cover fixed costs. Reimbursements may often be delayed, and ultimate payments maybe below cost for certain prescriptions when claim payments are finalized. This can be a source of financial strain and threaten the viability of pharmacies, especially independent pharmacies.

Other Pharmacy Access Mechanisms

Telepharmacy and mail order pharmacy are relatively new ways of expanding access to pharmacy but this study excluded studies focused on these pharmacies. These pharmacies may have their own limitations. For one, mail order pharmacies may provide prescription medications but not with face-to-face interaction and may be more amenable to patients that are already familiar with their condition and their medication. Telepharmacy may provide the face-to-face interaction with pharmacists, which may enhance provision of pharmacy services in areas that may otherwise lack access or provide another form of access in areas where pharmacies are already available[50,51]. However, telepharmacy may present challenges for patients learning how to use the service or with internet broadband requirements, especially in some remote areas[50]. Another challenge is the potential issue of privacy of protected health information[51]. There are also policy issues regarding provision of telepharmacy services in various states in the US. For instance, while some states like Arizona, Idaho and Illinois have no geographic restriction, telepharmacy services often are only allowed to be provided outside of specified mileage radius of an existing pharmacy ranging from 5 miles in

Hawaii to 50 miles in Nevada[52]. Staffing restrictions, e.g., pharmacist-technician ratios and provider permit, pharmacist oversight and pharmacist technician experience hours, are other policy challenges with telepharmacy.[51,53–55]

Limitations and Future Implications

There is currently no agreed upon standard definition of pharmacy access or availability in the US. Also, these terms were used interchangeably within and among studies. There is a need for standardization in the definition and measurement of pharmacy availability and accessibility, as lack thereof makes comparing results across studies difficult. Most studies have focused on different populations and types of location, adding to the difficulty summarizing study results.

As part of our exclusion criteria, this literature review did not include an assessment of the role of non-local pharmacies, such as mail-order and telepharmacy providers, in assuring pharmacy access. Future research should strive to assess how mail-order pharmacies and telepharmacy may affect pharmacy access. Further research to gain more insights into the impact of finances and reimbursement on pharmacy access should be conducted.

Furthermore, future research should include the impact of pharmacy access on health outcomes in their studies.

Conclusion

This study suggests that, while pharmacies are generally available in most areas of the US, pharmacy access may be less available in many local areas such as minority dominated areas in Chicago and Los Angeles and rural communities such as in Pennsylvania, North Dakota and Minnesota.

Various socioeconomic and demographic factors may affect local availability and accessibility of pharmacies. The main factors include rurality, race composition, and socioeconomic status of the community. Even when pharmacies are available in these areas, they may provide less pharmacy services such as home delivery services and shorter operating hours, compared to pharmacies in higher-income urban areas. Furthermore, while more closures may occur in urban areas due to competition, access is more likely to be affected when pharmacies close in rural areas. Overall, understanding the various factors that impact pharmacy availability and pharmacy access can help policy makers, pharmacy administrators and interested stakeholders in improving health care access and health equity.

CHAPTER 3

SOCIO-DEMOGRAPHIC FACTORS ASSOCIATED WITH AVAILABILITY AND ACCESSIBILITY OF PHARMACIES IN TEXAS

Introduction

Texas is the second most populous state in the US with about 29 million people as of 2019. It is the largest by land mass of the contiguous US states. The population density of Texas is 105 per square mile, and about 15% of its population live in rural areas. Texas has 254 counties, 172 of which are rural and the remaining 82 are urban counties. In 2019, the median annual household income was $64,034, slightly below the national average of $65,712[23]. About 20% of the population of Texas has no health insurance, making Texas the state with the highest percent uninsured population of any state in the US. Texas has also experienced more rural pharmacy closures than any other state in the US in the past decade[49,56].

The Bureau of Labor and Statistics estimated about 23,000 pharmacists were registered in Texas in 2020. The Texas State Board of Pharmacy is the state agency in charge of registration and regulating pharmacists and pharmacies in Texas. Pharmacies provide medication services along with immunization and medication therapy management. Pharmacy access has also been known to affect medication adherence even as over 74% of physician visits result in a prescription[1,2]. Pharmacy access and availability has been known to vary across different regions of the US[10]. Furthermore, upon closer assessment of smaller segments within a region, variation in the level of pharmacy access to different sociodemographic groups in the population has been known to exist. Understanding these differences can help regional or local authorities and stake holders make more informed decision about resource allocation as it pertains to increasing pharmacy access in areas that are already experiencing or are prone to pharmacy shortages.

There has been various research on pharmacy access and availability in certain states such as Illinois, Minnesota and Pennsylvania[6,37,39,43,45]. As noted in Chapter 2, studies in Illinois found that there was adequate pharmacy availability in the state but with reduced pharmacy access in rural areas[43]. However, a separate study in Chicago showed that many minorities live in areas with little or no pharmacy access[23,44]. In Minnesota, studies showed that the number of pharmacies available in the state fluctuated between 2002 and 2017. During the same period, the number of independent pharmacies decreased as the number of chain pharmacies increased[6,37,39]. Furthermore, a study in Pennsylvania found less pharmacy access in rural areas and in areas with higher white elderly population, married and females [28].

However, little is known about the distribution, availability and accessibility of pharmacies in the state of Texas. Furthermore, not much is known particularly about how race, ethnicity and other socioeconomic factors, such as poverty, age, education, health insurance, rurality, disability, and so on, affect pharmacy access and availability in Texas. This study will provide detailed answers to these questions.

Having to regularly travel long distance to the pharmacy may hinder medication adherence and affect overall health outcomes[9,57]. People visit their pharmacist more than they see their primary care physician[58]. Also, pharmacists occupy a vantage position to see all the prescriptions from all of the physicians a patient is consulting (primary care and specialists), so they are able to coordinate the patient's medications, make interventions and recommendations when necessary[59]. They are also able to detect potential adverse events, contraindications and polypharmacy issues. Lack of pharmacy access may reduce the chances of these activities and may predispose patients to suffer adverse health outcomes, and may result in higher cost to the health system[60].

As shown in the previous chapter, due to lower population in rural areas compared to urban areas, pharmacies are more likely to be located in urban areas compared to rural areas. Pharmacy closures in rural areas have been known to be more devastating due to greater tendencies for lack of other pharmacies or healthcare facilities in these areas[11,49]. Patients may have to travel further to seek medical help and ambulance services and emergency visits may also increase in such scenario.

Specific Aim

The aim of the study in this chapter is to provide evidence about factors that affect availability and access to pharmacies in the state of Texas.

Objectives

1. To identify the socioeconomic and demographic factors that affect pharmacy availability in Texas.
2. To identify the socioeconomic and demographic factors that affect pharmacy accessibility in Texas.
3. To understand the effect of rurality on pharmacy availability and accessibility.

METHODS

Data Sources

Various data sources were combined to conduct this analysis. First, the list of existing community pharmacies in Texas was obtained from the Texas State Board of Pharmacies. This list included their address and other characteristics, such as date of licensure, ownership and services they provide (Texas State Board of Pharmacy, 2019). Second, data from the American Community Survey (ACS) was used to derive the population characteristics of all census tracts in Texas. Due to small sample sizes within census tracts, only estimates for 5-year averages over the years 2014 to 2018 were used. Rural-urban commuting area (RUCA) 2010 codes, which range from 1 to 10, were used to classify the rurality designation of the census tracts by the United State Department of Agriculture Economic Research Service (listed below). Specifically, we used the 2019 updated version where census tracts with RUCA codes 1 to 3 were classified as "urban" while those with RUCA codes 4 to 10 were classified as "rural."

Primary Rural Urban Commuting Area Codes

1. Metropolitan area core: primary flow within an urbanized area (UA)
2. Metropolitan area high commuting: primary flow 30% or more to a UA
3. Metropolitan area low commuting: primary flow 10% to 30% to a UA
4. Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)
5. Micropolitan high commuting: primary flow 30% or more to a large UC
6. Micropolitan low commuting: primary flow 10% to 30% to a large UC

7. Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)
8. Small town high commuting: primary flow 30% or more to a small UC
9. Small town low commuting: primary flow 10% to 30% to a small UC
10. Rural areas: primary flow to a tract outside a UA or UC

Measures of Availability and Access

Four measures of availability and accessibility were operationalized for use in the analysis based on various definitions found in literature.

Measures of Availability

1. Number of pharmacies in the census tract (labeled as Number_RX).
2. Pharmacy presence, defined as at least one pharmacy in a census tract.

Measures of Access

1. Number of pharmacies per 10,000 population in a tract (labeled as RX_Pop10K).
2. Miles to nearest pharmacy (Graded distance from census tract centroid to the nearest pharmacy; less than 1 mile, 1 to 2 miles, 2 to 5 miles and greater than 5 miles).

Analytic Approach

Each of these four measures of pharmacy availability and access were defined as the dependent variable in alternative multivariable regression model specifications used to estimate factors affecting availability or access. The specific statistical analysis method used for each varied based on the level of measurement for the dependent variable.

First, for the sample of census tracts that have a pharmacy, a negative binomial regression model was used to estimate the estimate the number of pharmacies in the census tract.

Second, for all census tracts in Texas, a logistic regression model was used to estimate pharmacy availability, defined as the presence of at least one pharmacy in the census tract or not.

Third, for the sample of census tracts that have a pharmacy, ordinary least squares (OLS) regression was used to estimate pharmacy access, defined as the number of pharmacies per 10,000 population in the tract.

Fourth, for all census tracts in Texas, ordered logistic regression was used to estimate pharmacy access, defined as the categorical distance to the nearest pharmacy (within 1 mile, within 1 to 2 miles, within 2 to 5 miles and greater than 5 miles).

All of these models included as independent variables specific local area characteristics, such as urban-rural category and a number of sociodemographic variables. The total population of an area is crucial for the startup and long-term financial sustainability of community pharmacies. Within the population, the percentage of the population older than 65 years old is an important factor because this age group tends to take multiple prescriptions, making easy pharmacy access important for medication supply and medication adherence. To further assess the alignment of pharmacy services with the local population, the percentage of Medicaid population in the census tract was included in the model. Low income and minority population often has been shown to affect pharmacy access in previous studies, so the percent minority population and the percent of the population living below the federal poverty level in the census tract were included as explanatory variables. The percentage of the population living with disability was obtained from the American Community Survey and it represents the percentage of the population in a census tract that marked yes to any of the six questions about disability when filling the survey. This population will require easy pharmacy access and pharmacies being physically accessible to the disabled population for better quality of live. A complete list of variables included in the statistical analysis is shown in Tables 4 and 5.

Table 4 List of Dependent Variables Used in the Study

Dependent Variables	**Measurement**
Number of pharmacies in the tract	Continuous (count)
Presence of at least one pharmacy in a tract	1= Has a pharmacy; 0 = No pharmacy
Number of pharmacies per 10,000 population	Continuous
Miles, gradient of miles to nearest pharmacy: <1 mile, 1 to 2 miles, 2 to 5 miles, >5 miles	Ordinal

Table 5: List of Independent Variables Used in the Study

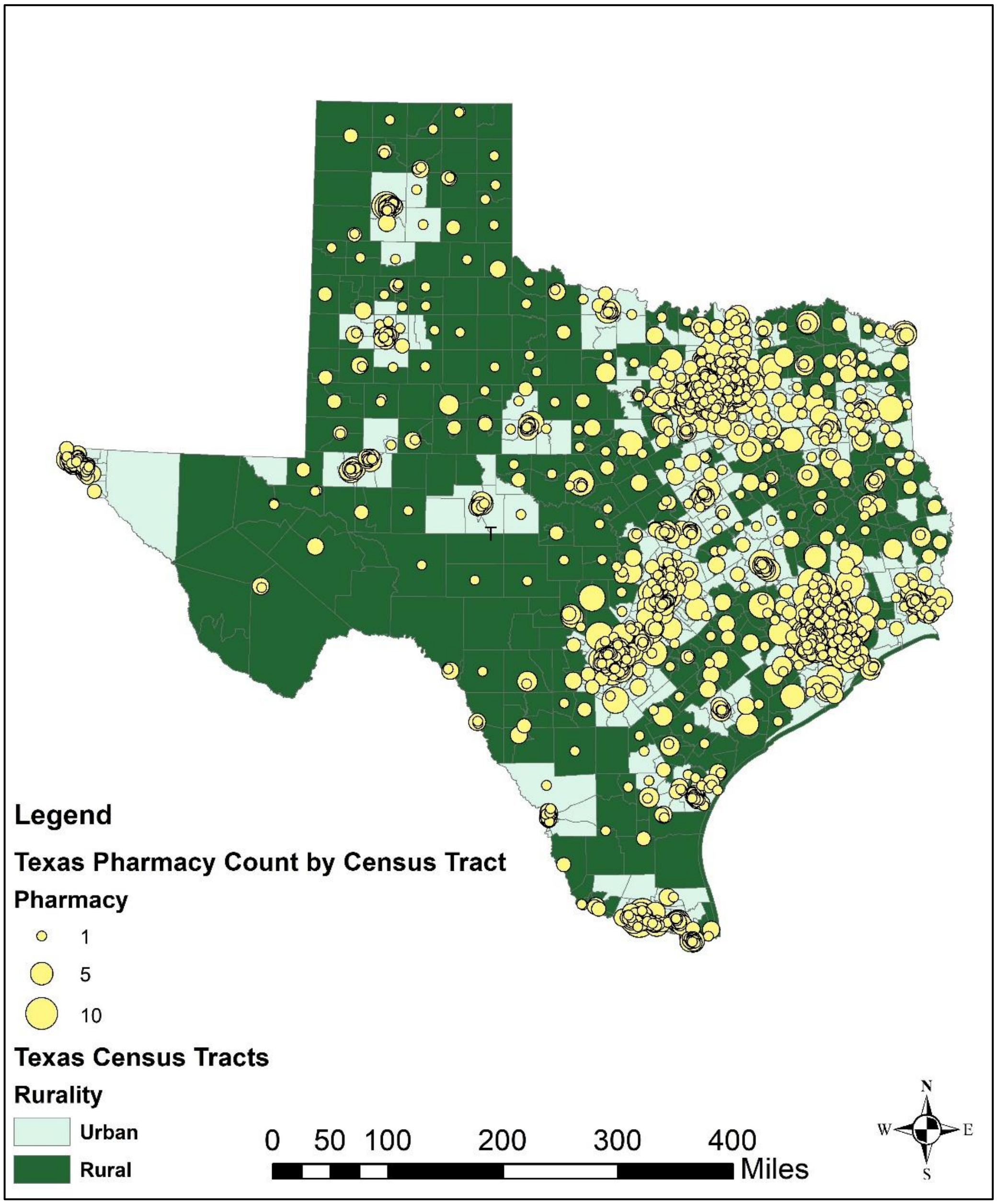
Independent Variables	**Measurement**
Total population	Continuous
Rurality	0= urban, 1= rural
Sociodemographic Variables	
Percent Female	Continuous
Percent Non-white	Continuous
Percent 65 years and over	Continuous
Percent without health insurance	Continuous
Percent Unemployed	Continuous
Percent Bachelor’s degree	Continuous
Percent Medicaid	Continuous
Percent Disabled	Continuous
Percent Below Poverty	Continuous

Results

Descriptive and Spatial Analysis

As of July 2019, there were 5,526 community pharmacies in Texas; 408 of these were in rural areas and the remaining 5,118 were in urban areas. There are a total of 5265 census tracts in Texas, of which 2,443 census tracts had at least a pharmacy as of 2019 (38 census tracts had no reported population). The map in Figure 3 illustrates the distribution of community pharmacies in Texas. The larger circles, indicating a greater number of pharmacies, are more common in the urban areas (light green census tracts), located mostly in the central, northeastern and southeastern portion of the state. Smaller and sparsely distributed circles, indicating fewer pharmacies, can be seen in the darker green colored rural areas, mostly in the western region of the state.

Figure 3**: Distribution of Pharmacies in Texas by Rurality**



Descriptive statistics for population characteristics in Texas census tracts with at least one pharmacy in the study sample are reported in Table 6. The mean population across these census tracts was 5577.7, and the mean population density was 4038.7. The mean pharmacy density (pharmacies per 10,000 population) was 5.42. The mean distance to a pharmacy was 0.899 miles. The mean of the percent of the population over 65 years of age was 12.6, and the mean of the percent non-white population was 57.7. The mean of the percent unemployed population was 2.71, and the mean of the percent uninsured population was 17.3. The mean of the percent disabled population was 5.97, and the mean of the percent of the population enrolled in Medicaid population was 17.1. The mean of the percent of bachelor degree holders was 20.0, and the mean of the percent of the population living below poverty was 16.1.

Table 6: Population Characteristics per Census Tracts with a Pharmacy (n=2443)

Variables	**Mean**	**SD**	**Min**	**Max**
Total Population	5577.680	3571.230	18.000	70271.000
Population* Density per m^2	4038.720	3551.430	1.670	41600.410
Pharmacy* per 10,000 population	5.424	12.676	0.465	555.550
Miles*	0.899	1.349	0.019	15.677
Percent Over 65 years	12.644	6.296	0.000	63.968

Table 6 (continued)

Variables	**Mean**	**SD**	**Min**	**Max**
Percent Non-White	57.695	26.230	0.000	100.000
Percent Unemployed	2.705	1.546	0.000	12.502
Percent Uninsured	17.349	9.982	0.000	57.741
Percent Disability	5.972	3.022	0.000	26.882
Percent Medicaid	17.145	10.744	0.000	43.762
Percent Bachelors	20.028	15.138	0.000	74.801
Percent Below Poverty	16.061	11.319	0.000	76.734

As shown in Table 7, among Texas census tracts with at least one pharmacy, the mean number of pharmacies per census tract in 2019 was 2.26. The mean percent of pharmacies that provided vaccination services per census tract was 68.96%. The mean percent of pharmacies that provided twenty-four-hour services per census tract was 6.07%; about 92% of pharmacies provided Medicaid services, and 98% of pharmacies were accessible for disabled populations. The mean percent of pharmacies that provided home delivery services per census tract was 39.9%.

Table 7: Mean and Standard Deviation of Percent Pharmacy Services per Tract in Texas Census Tracts with Pharmacies (n=2443)

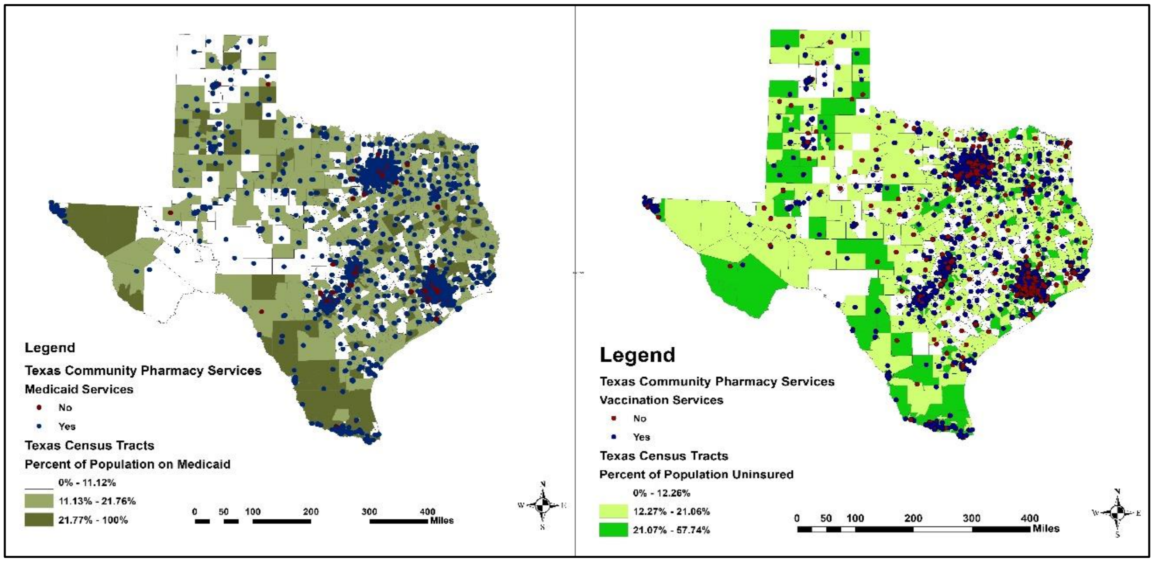
Percent providing pharmacy services	**Mean %**	**S.D**	**Min**	**Max**
Number of pharmacies	2.260	1.679	1.000	13.000
Percent with Vaccination services	68.960	39.140	0.000	100.000
Percent with 24-hour services	6.072	19.450	0.000	100.000
Percent Medicaid	91.880	21.690	0.000	100.000
Percent Disabled	98.010	11.260	0.000	100.000
Percent with home delivery services	39.920	39.690	0.000	100.000

Furthermore, the maps in Figure 4 display the spatial distribution of pharmacies that provide Medicaid services by the percentage distribution of census tract population enrolled in Medicaid (left frame). We can see that majority of the pharmacies do offer Medicaid services (blue dots) but they are not well matched with areas with a high percentage of Medicaid population. In addition, the spatial relationship between the percentage of pharmacies offering vaccination services and the distribution of the percentage of uninsured population is displayed in the right frame of Figure 4. Here, we first notice that not as many pharmacies offer vaccination services (brown dots) and areas with a high in percentage of uninsured may not have many pharmacies offering vaccination services.

The percentage of Medicaid population and the percentage of disabled population for the census tract levels were included in the regression models and not the pharmacy level services of percent providing Medicaid services or pharmacies that provide reasonable accommodation for easy accessibility for the disabled population.

To further illustrate pharmacy services and population characteristics, a map illustrating the spatial distribution of the disabled population and pharmacies providing services for the disabled population is shown in Appendix C. The map shows that most pharmacies do provide disability services however, some areas with a high percentage of disabled population may lack pharmacies hence may be unable to obtain pharmacy services. Finally, a map illustrating the spatial distribution of pharmacies offering 24 hours services and the distribution of percentage of population aged 65 years and above also is shown in Appendix C. It shows the majority of the pharmacies in Texas do not offer 24-hours service and they may not be found in areas where there are more elderly.

Figure 4: Pharmacies Providing Medicaid Services and Vaccination Services by Population Characteristics



Statistical Analysis

Model 1 estimated factors affecting pharmacy availability, defined as the number of pharmacies per census tract, among census tracts with at least one pharmacy. The negative binomial regression results, shown in Table 8, estimated an incident rate ratio (IRR) of 1.215 (p<0.001) associated with a one unit (5000-person) increase in total population, meaning an increase in census tract population of 5000 persons was estimated to increase the number of pharmacies present within the census tract by 21.5%. The model results also indicated an estimated an IRR of 1.028 (p<0.001) associated with a one percentage point increase in percentage of females in the tract (p<0.001); an IRR of 1.003 (p=0.012) associated with a one percentage point increase in the percent of non-white population in the tract (p=0.012); an IRR of 1.015 (p<0.001) associated with a one percentage point increase in the percent of bachelors' degree holders in the tract; and an IRR of 1.008 associated with a one percentage point increase in the percent of people living below poverty level in the tract.

Table 8: Model 1 (Pharmacy availability) - Negative Binomial Regression of Number of Pharmacies per Tract (n=2443)

Variable	IRR	Standard Error	P-Value	Confidence Interval
Total Population_5000	**1.215**	**0.042**	**<0.001**	**1.134, 1.300**
Percent Female	**1.028**	**0.005**	**<0.001**	**1.018, 1.038**
Percent Over 65 years	0.998	0.004	0.689	0.991, 1.006
Percent Non-White	**1.003**	**0.001**	**0.012**	**1.001, 1.006**
Percent Unemployed	1.011	0.015	0.466	0.983, 1.039
Percent Uninsured	1.005	0.004	0.150	0.998, 1.012
Percent Disability	0.987	0.008	0.096	0.971, 1.002
Percent Medicaid	0.991	0.005	0.057	0.983, 1.000
Percent Bachelors	**1.015**	**0.002**	**<0.001**	**1.010, 1.020**
Percent Below Poverty	**1.008**	**0.003**	**0.017**	**1.001, 1.001**
Rurality	1.054	0.071	0.438	0.993, 1.204

Model 2 estimated factors affecting pharmacy availability, defined as the existence of at least one pharmacy within the census tract, among 5,299 census tracts in Texas (36 census tracts with no reported population were excluded from the analysis). The logistic regression results, shown in Table 9, indicated an estimate odds ratio of 1.19 ($p<0.001$ C.I. 1.079, 1.313) for a one unit (5000-person) increase in the population in the census tract, meaning that an increase in census tract population of 5000 was estimated to increase the likelihood for there to be a pharmacy in a census tract by 19%. Similarly, the estimated odds ratio was 1.036 ($p<0.001$, C.I. 1.023, 1.050) for a one percentage point increase in the percent female population in a census tract. The estimated odds ratio was 1.008 ($p<0.001$ C.I. 1.004, 1.011) for a one percentage point increase in the percent of non-white population in a census tract.

In terms of other area characteristics, the estimated odds ratio of having a pharmacy in a census tract was 0.988 ($p=0.048$, C.I. 0.977, 1.000) for a one percentage point increase in the percent of Medicaid population in the census tract, meaning that an increase of one percentage point in the percent of the census tract population covered by Medicaid was estimated to lead to a 2% decrease in the likelihood for there to be a pharmacy in the census tract. Recall that the sample mean percentage of census tract population covered by Medicaid was 17%, such that a one percentage point increase would correspond to about a 6% increase in Medicaid population on average. The estimated odds ratio was 1.025 ($p<0.001$ C.I. 1.019, 1.031) for a one percentage point increase in the percent of bachelor degree holders in the census tract, meaning that an increase in the percent of bachelor degree holders was estimated to lead to a 2.5%

increase in likelihood for there to be a pharmacy in the census tract. For census tracts classified as rural compared to urban, the estimated odds ratio of having a pharmacy was 1.221 (p=0.024, C.I. 1.026, 1.452), meaning census tracts classified as rural were 22% more likely to have at least one pharmacy in the census tract relative to urban census tracts, adjusted for census tract population and other census tract characteristics.

Table 9: Model 2 (Pharmacy availability) - Logistic regression for having a pharmacy or not (n=5,299)

Variable	OR	Standard Error	P-Value	Confidence Interval
Total Population_5000	**1.190**	**0.060**	**<0.001**	**1.079, 1.313**
Percent Female	**1.036**	**0.007**	**<0.001**	**1.023, 1.050**
Percent Over 65 years	0.990	0.005	0.061	0.980, 1.001
Percent Non-White	**1.008**	**0.002**	**<0.001**	**1.004, 1.011**
Percent Unemployed	1.006	0.019	0.752	0.970, 1.044
Percent Uninsured	1.008	0.005	0.079	0.999, 1.018
Percent Disability	0.999	0.010	0.940	0.980, 1.019
Percent Medicaid	**0.988**	**0.006**	**0.048**	**0.977, 1.000**

Table 9 (continued)

Variable	OR	Standard Error	P-Value	Confidence Interval
Percent Bachelors	**1.025**	**0.003**	**<0.001**	**1.019, 1.031**
Percent Below Poverty	1.007	0.004	0.092	0.999, 1.016
Rurality	**1.221**	**0.108**	**0.024**	**1.026, 1.452**

Model 3 estimated factors affecting pharmacy density, defined as the number of pharmacies per 10,000 population in census tracts with at least one pharmacy. The results for the ordinary least-squares regression (OLS) model for pharmacy density, reported in Table 10, showed that pharmacy density decreased by 1.15 (P<0.001 C.I. -1.559, -0.750) for every one unit (5000 person) increase in total population. Pharmacy density decreased in the census tract by 0.178 (p<0.001, C.I. -0.229, -0.126) for every one percentage point increase in the percent of females in the census tract. For every one percentage point increase in the percent of the uninsured population, the pharmacy density increased by 0.082 (p<0.001, C.I. 0.046, 0.121). For every one percentage point increase in the percent of disabled population, the pharmacy density increased by 0.139 (p< 0.001 C.I. 0.046, 0.121) in the census tract. One percentage point increase in the percent Medicaid population decreased the pharmacy density by 0.058 (p=0.025, C.I. -0.108, -0.007). Also, rural census tracts tended to have lower pharmacy density with an coefficient estimate of -0.755 (p=0.050, C.I. -1.510, 0.000), indicating the number of pharmacies per 10,000 population (a measure of pharmacy access) was on average about 0.75 lower in rural census tracts compared to urban census tracts. For every one percentage point increase in the percent bachelor's degree holder and the percent below poverty, pharmacy density increased by 0.064 (p<0.001 C.I. 0.037, 0.090) and 0.064 respectively (p<0.001 C.I. 0.028, 0.101).

Table 10: Model 3 (Pharmacy access) - Ordinary Least-Squares Regression for Pharmacy Density

Variable	**Coefficient**	**Standard Error**	**P-Value**	**Confidence Interval**
Total Population_5000	**-1.155**	**0.207**	**<0.001**	**-1.559, -0.750**
Percent Female	**-0.178**	**0.026**	**<0.001**	**-0.229, -0.126**
Percent Over 65 years	0.023	0.023	0.331	-0.023, 0.068
Percent Non-White	-0.003	0.019	0.708	-0.018, 0.012
Percent Unemployed	-0.153	0.082	0.063	-0.315, 0.008
Percent Uninsured	**0.082**	**0.020**	**<0.001**	**0.046, 0.121**
Percent Disability	**0.139**	**0.044**	**0.002**	**0.053, 0.224**
Percent Medicaid	**-0.058**	**0.026**	**0.025**	**-0.108, -0.007**

Table 10 (continued)

Variable	**Coefficient**	**Standard Error**	**P-Value**	**Confidence Interval**
Percent Bachelors	**0.064**	**0.014**	**<0.001**	**0.037, 0.090**
Percent Below Poverty	**0.064**	**0.019**	**<0.001**	**0.028, 0.101**
Rural Area	**-0.755**	**0.385**	**0.050**	**-1.510, 0.000**

The ordinal logistic regression results, shown in Table 11, indicate that for every one unit (5000-person) increase in the total population, the estimated odds ratio of being in a higher category of distance to the pharmacy, versus the less than 1 mile to the pharmacy category, was 1.421 ($p<0.001$ C.I. 1.296, 1.558). Meanwhile, for census tracts classified as being in rural areas, the estimated odds ratio of being in the higher categories of distance to the nearest pharmacy, versus less than 1 mile, was 2.551 ($p<0.001$, C.I. 2.160, 3.013), compared to census tracts classified as being in urban areas. Thus, residents of rural census tracts were much more likely to have to travel longer distances to access pharmacy services compared to residents of urban census tracts.

For every one percentage point increase in the percent female population, the estimated odds ratio of being in the higher categories of distance to the pharmacy was 0.952 ($p<0.001$ C.I. 0.940, 0.964), and for every one percentage point increase in the percent of the population over 65 years of age, the odds of being in the higher categories of distance to the pharmacy, versus less than 1 mile, was 1.044 (p<0.001 C.I. 1.033, 1.055). For every one percentage point increase in the percent non-white population, the estimated odds ratio of being in the higher categories of distance to the pharmacy, versus less than 1 mile, was 0.970 (p<0.001, C.I. 0.967, 0.974).

In terms of other area characteristics, for every one percentage point increase in the percent uninsured population, the estimated odds ratio of being in the higher categories of distance to the pharmacy, versus less than 1 mile, was 0.976 (p<0.001, C.I. 0.967, 0.985). Likewise, for every one percentage point increase in the percent of bachelor degree holders in the population, the estimated odds ratio of being in the higher categories of distance to the pharmacy, versus less than 1 mile, was 0.917 (p<0.001, C.I. 0.911, 0.924). For every one percentage point increase in the percent of the population living below poverty, the estimated odds ratio of being in the higher categories of distance to the pharmacy, versus less than 1 mile, was 0.987 (p=0.002, C.I. 0.978, 0.995).

Table 11: Model 4 (Pharmacy access) - Ordered Logistic Regression Results for Distance to Nearest Pharmacy (less than 1 mile, 1 to 2 miles, 2 to 5 miles, more than 5 miles)

Variable	**Odds ratio**	**Standard Error**	**P-Value**	**Confidence Interval**
Total Population_5000	**1.421**	**0.067**	**<0.001**	**1.296, 1.558**
Percent Female	**0.952**	**0.006**	**<0.001**	**0.940, 0.964**

Table 11 (continued)

Variable	Odds ratio	Standard Error	P-Value	Confidence Interval
Percent Over 65 years	**1.044**	**0.006**	**<0.001**	**1.033, 1.055**
Percent Non-White	**0.970**	**0.002**	**<0.001**	**0.967, 0.974**
Percent Unemployed	0.970	0.019	0.081	0.931, 1.004
Percent Uninsured	**0.976**	**0.005**	**<0.001**	**0.967, 0.985**
Percent Disability	1.001	0.010	0.952	0.981, 1.020
Percent Medicaid	1.000	0.006	0.950	0.989, 1.012
Percent Bachelors	**0.917**	**0.004**	**<0.001**	**0.911, 0.924**
Percent Below Poverty	**0.987**	**0.004**	**0.002**	**0.978, 0.995**
Rural Area	**2.551**	**0.217**	**<0.001**	**2.160, 3.013**
Cut* 1	-5.162	0.333	-	-5.815, -4.510
Cut* 2	-4.093	0.330	-	-4.739, -3.448
Cut* 3	-2.906	0.326	-	-3.545, -2.267

**Cut is the threshold for transition from each level to the next higher level of mileage*

Discussion

It is plausible for more populous census tracts to have a greater likelihood of pharmacy presence and more numerous pharmacies. This is reflected in the large effect size for total population estimates in most of the models. These areas also have low pharmacy density due to a large population relative to the number of pharmacies required to service the population. In other words, the number of pharmacies need not continue to increase proportionally as the population size increases, since a certain number and size or service capacity of pharmacies will be optimal to cover the pharmacy service needs in an area. Rural areas also had lower pharmacy density compared to urban areas; this is likely due to a lower number of pharmacies resulting from the lower population in these areas.

However, an unexpected result was that census tract areas with a greater total population were estimated to have greater travel distances to a pharmacy. The explanation for this finding is not clear, but it may relate to the imprecision in measurement of travel distance using the population-weighted centroid of a census tract as the proxy location for all residents of the census tract.

A higher percentage of Medicaid population was associated with both a lower likelihood of the presence of a pharmacy and a lower pharmacy density in an area. This is important for policy makers to review as the Medicaid population receiving assistance for their medication coverage may be experiencing issues with obtaining medications and other clinical pharmacy services. Also, pharmacy administrators should strive to align the services they provide to the needs of population that is predominant in their area. This may help with revenue generation for pharmacies and improve medication supply and access to pharmacy services for the Medicaid population.

A higher percentage of non-white population was surprisingly associated with a greater likelihood of the presence of a pharmacy and a greater number of pharmacies in a census tract. Areas with high minority populations also had shorter travel distances to the pharmacy. This may be due to the fact that the measure of minority population used in the model was all “non-white” population, which combined Asians and other non-Black minorities in a single category when compared to the white population.

Expectedly, areas with higher percentages of bachelor degree holders had a greater presence and a higher number of pharmacies, had higher pharmacy density and even traveled shorter distances to the pharmacy. Educational attainment serves as a general indicator of economic status. As such, this result underlines some potential economic disparities in pharmacy access and availability existing in Texas.

Census tracts with a high percent uninsured population experienced higher pharmacy density and residents in these tracts traveled shorter distances to the pharmacy. The shorter travel distances may help this population obtain medication and pharmacy services despite lack of insurance. Similarly, areas with a high percentage of population below the poverty level were likely to experience higher number of pharmacies with higher pharmacy density while also travelling shorter distance to the family. It is not clear why pharmacies areas accessibility seems to be greater in areas with a high percentage of uninsured or poverty population.

In line with other studies, living in rural areas led to about a twofold increase in the distance travelled to the pharmacy, compared to urban areas. However, there was no statistically significant difference in the number of pharmacies between rural or urban census tract areas. An unexpected finding was that the likelihood of having at least a pharmacy was greater in rural areas compared to urban areas. This result may be attributable to the adjustment for other census tract characteristics in the multivariable regression model, especially total population.

Recent legislation has been proposed in Texas to help the sustainability of pharmacy practice. This includes recognition of pharmacists as health care practitioners in the state, prevention of reimbursement discrimination to pharmacies for services provided within their scope of practice, clarifying and allowing collaborative practice agreements for community and long-term care pharmacies in the state, and legislation enhancing telepharmacy in federally qualified health centers, even in the presence of a class A or a class C pharmacy[20]. All these may need to be monitored and their effects assessed to make sure the intended goals are achieved, and necessary corrections are made in a timely manner.

Limitations

The actual locations of people relative to the locations of pharmacies was not available but was estimated using a geospatial analysis method, where the population-weighted centroid of the census tract represented the likely position where the majority of the census tract population were likely to live. The cross-sectional nature of the studies in this dissertation precludes making causal conclusions. We only assessed the distance to a pharmacy but not the travel time to the pharmacy or transportation options such as vehicle, bicycle and public transportation available to the population that may influence their access to pharmacy. Furthermore, pharmacy size and capacity (number of pharmacists working in one pharmacy) may vary across different pharmacies, and this may influence the types of pharmacy services available or how much of a population a pharmacy can cater for. Nonetheless, the combination of various models on different measures of pharmacy access and availability provides useful insights into the characteristics potentially affecting pharmacy availability and pharmacy access in Texas.

Conclusion

In conclusion, sociodemographic and economic factors that affect pharmacy access and availability in Texas include race, total population, educational status, poverty level, insurance status and rurality. Areas with a high percentage of Medicaid population may suffer reduced pharmacy access in Texas. Future studies should include pharmacy services or pharmacy capacity measures in their analysis. Also, future studies should use actual resident address, means of transportation and travel time in analyzing nearest distance to the pharmacy. Studies analyzing the impact of pharmacy access on medication adherence and health outcomes are also important for future research.

CHAPTER 4

SOCIO-DEMOGRAPHIC FACTORS ASSOCIATED WITH PHARMACY CLOSURES IN TEXAS

Introduction

Pharmacy closures have been a perennial issue of concern for healthcare access in the US. Even though hospital closures is the major health care challenge which gets more attention, pharmacy closures are critical to review, as closures of both pharmacies and hospitals ultimately impacts healthcare access[23,45,61–65]. Nationally, there were 9,600 pharmacy closures in the US between 2009 and 2017[5]. In rural communities, about 630 rural communities lost their only community pharmacies between 2003 and 2018, and 44 of these rural communities were in Texas, more than any other state[11]. It is purported that the implementation of Medicaid Part D has led to a reduction in reimbursement rates while increasing the size of the Medicare covered population. This has led to financial instability of pharmacies, especially independent pharmacies[66]. In addition, chain pharmacies are able to cope with tight regulations and change in reimbursement because of economies of scale[67]. Also, pharmacy benefit managers often owned by the chain pharmacies may also make it less favorable for out-of-network pharmacies to do business and obtain adequate and timely reimbursements, further reducing the chances of subsistence of these pharmacies[68].

In the US, the devastating effects of pharmacy closures can be felt in both rural and urban areas. In rural areas, the residents will need to travel farther for medication and pharmacy services when nearby pharmacies close[10]. Often, these pharmacies are the sole pharmacies or healthcare facility in the locality further complicating the issue of healthcare access[10]. Pharmacy closures in urban areas can also lead to reduced pharmacy access, as these areas may not be walkable given that many low-income families do not have access to vehicles or other means of transportation[23].

Many studies have reviewed hospital closures at the local, state and national level, particularly in relation to policies such as the Affordable Care Act[61,63–65,69,70]. However, comparatively few studies have examined pharmacy closures nationally or in relation to specific policies[5,10,71]. Klepser et al. assessed the trends in pharmacy closures due to the implementation of Medicare Part D between 2004 and 2009, and concluded that an unintended consequence of Part D was to increase the rate of pharmacy closures, especially rural and independent pharmacies[10]. Recently, Guadamuz et al. assessed the national pharmacy closure trend from 2009 to 2015 independent of any policy[5]. They reported a higher risk of closure for independent pharmacies in both urban and rural areas. They also found pharmacies serving low income, uninsured or publicly insured populations in urban areas were more likely to close[5].

The majority of published studies of pharmacy closures have been based on rural areas or rural pharmacy settings. The few studies that assessed pharmacy closures based on the type of pharmacy, i.e., comparing independent to chain pharmacies, mainly looked at rural settings[11,72]. Guadamuz et al. found that the risk of pharmacy closures was higher in urban areas compared to non-urban areas in the US[5].

Whenever a pharmacy closes particularly in rural areas, not only do the dispensing services disappear, but other non-dispensing services provided by the pharmacy may also be needed to be sourced elsewhere. These services may include, vaccination, medication therapy management, smoking cessation assistance, home service delivery, provider counselling, medication adherence councelling[49,73,74].

Prior research shows that pharmacy closures typically lead to medication nonadherence[9,57]. Specifically, pharmacy closures in Iowa were associated with reduced medication adherence in the state's Medicaid population[57]. Qato et al. found similar medication nonadherence issues nationally among elderly cardiovascular patients[9].

The study reported in this chapter assessed the extent of differences in pharmacy closures between rural and urban areas in Texas.

Aim

The aim of this study is to provide evidence about factors that affect pharmacy closures in the state of Texas.

Objectives

1. To identify the socioeconomic and demographic factors that affect pharmacy closures in Texas.
2. To understand the effect of rurality on pharmacy closures in Texas.

Methods

Data Sources

We used a combination of secondary datasets for our analysis. First, the list of closed pharmacies in Texas was obtained from the Texas State Board of Pharmacies. Second, the American Community Survey (ACS) data was used to derive the population characteristics of all census tracts in Texas. Due to small sample sizes within census tracts, only estimates for 5-year averages over the years 2014 to 2018 were used. Rural-urban commuting area (RUCA) 2010 codes, which range from 1 to 10, were used to classify the rurality designation of the census tracts. Specifically, census tracts with RUCA codes 1 to 3 were classified as Urban while those with RUCA codes 4 to 10 were classified as Rural.

Measures

Measures of pharmacy closure were operationalized using two measures below:

1. Closure1 (Presence of a closed pharmacy in the tract between 2014 and 2018)
2. Closure2 (Number of pharmacy closures in tracts that had closures between 2014 and 2018)

Analytical Approach

First, for all Texas tracts with closure of pharmacies at any time from 2014 to 2018, logistic regression was used to estimate if there was a closure or not within the census tract.

Second, for all Texas tracts with closure of pharmacies at any time from 2014 to 2018, negative binomial regression was be used to estimate the number of closures within this period.

Both of these models included as independent variables a number of local area characteristics, such as urban-rural category and a number of sociodemographic variables. Specifically, the number of existing pharmacies as of 2013 was included as an independent variable to determine its effect on closure in an area. Holding total population constant, more pharmacies in an area suggests greater market saturation, which may increase the potential for pharmacy closures. The percent of the census tract population age over 65 years was included as an independent variable, given this segment of the population tends to fill numerous prescriptions and may need other pharmacy services such as MTM. Variables indicating the percentage of uninsured population and the percentage covered by Medicaid were included in the model, because the financial sustainability of pharmacies may be adversely impacted in areas where these percentages are high, which in turn may increase the risk of closure. Population living with disability was obtained from the American Community Survey and it represents the percentage of the population in a census tract that marked yes to any of the six questions about disability when filling the survey. A rural-urban categorical variables was included in the model. Specifically, census tracts with RUCA codes 1 to 3 were classified as urban while those with RUCA codes 4 to 10 were classified as rural. A complete list of variables included in the statistical analysis is shown in Tables 12 and 13.

Table 12: List of Dependent Variables Used in the study

Dependent Variables	**Measurement**
At least one pharmacy closure in census tract from 2014 to 2018 (Closure1)	Binary
Number of pharmacies closures in census tract from 2014 to 2018 (Closure2)	Continuous (count)

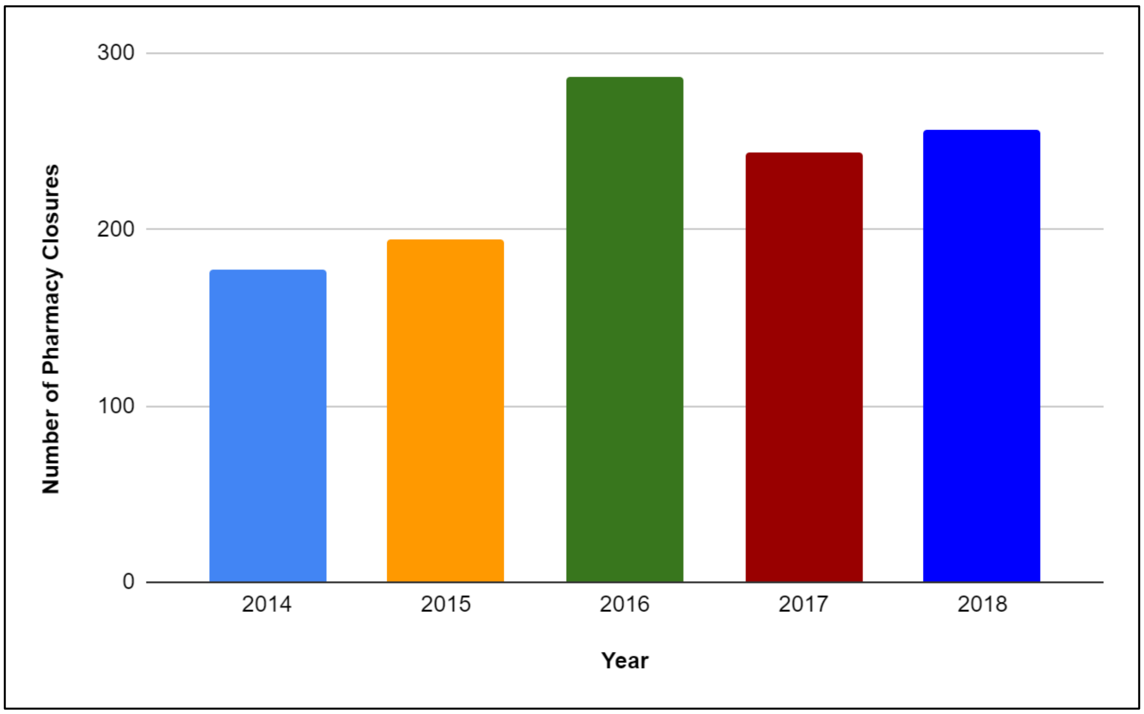
Table 13: List of Independent and Control Variables used in the Study

Independent Variables	**Measurement**
Total population	continuous
Rurality	0= urban, 1= rural
Sociodemographic	
Percent female	Continuous
Percent non-white	Continuous
Percent 65 years and over	Continuous
Percent without health insurance	Continuous
Percent unemployed	Continuous
Percent bachelor’s degree	Continuous
Percent Medicaid	Continuous
Percent disabled	Continuous
Percent below poverty	Continuous

Results

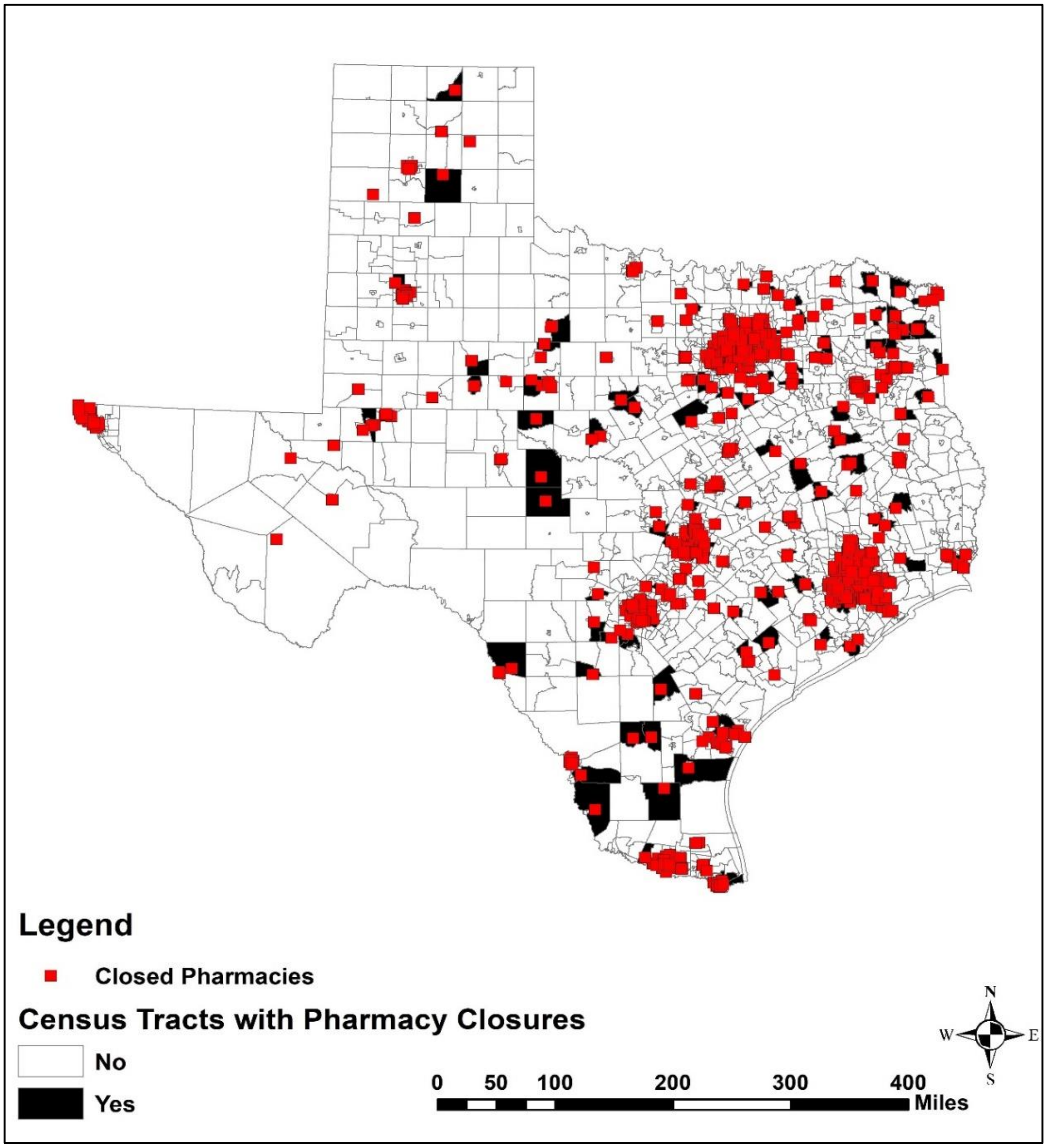
There was a total of 1,159 community pharmacy closures in Texas from 2014 to 2018. Closures occurred in 868 of the 5,299 census tracts in Texas with reported population. During this period, 2014 had the fewest annual pharmacy closures (177) while year 2016 had the largest number of annual pharmacy closures (287) (see Figure 5). Furthermore, there were 194 pharmacy closures in 2015, 244 closures in 2017 and 257 closures in 2018.

Figure 5: Number of Pharmacy Closures in Texas, 2014-2018



The map in Figure 6 shows the distribution of the pharmacies that closed in Texas from 2014 to 2018. Census tracts that experienced pharmacy closures are represented in black while those that did not have any closures were represented in white. The red squares represent a pharmacy that closed from 2014 to 2018. Majority of the pharmacy closures occurred in the densely populated areas in the Southeast, Northeast and Central part of the state**.**

Figure **6**: Map of Spatial Pattern of Pharmacy Closures in Texas, 2014-2018



Any Pharmacy Closure

Model 1 estimated the factors affecting the likelihood of having a pharmacy closure or not in all the census tracts in Texas. The logistic regression results, as shown in Table 14, indicate an estimated odds ratio of 1.266 ($p<0.001$ C.I 1.117, 1.433) for a unit (5000-person) increase in total population in the census tract, meaning an increase in the population of a census tract by 5000 persons was estimated to increase the likelihood of a pharmacy closure in a census tract by 27%. The number of existing pharmacies as of 2013 resulted in an estimated odds ratio of 1.525 ($p<0.001$ C.I. 1.437, 1.618) for each unit increase in an existing pharmacy in the tract in 2013, i.e., the likelihood of at least one pharmacy closure increased by about 53% for every additional existing pharmacy in the tract in 2013. Likewise, an estimated odds ratio of 1.019 ($p=0.004$ C.I 1.006, 1.032) was obtained for a one percentage point increase in the population of uninsured in the tract. This means a one percentage point increase in the uninsured population increases the likelihood of there to be a pharmacy closure in a census tract by about 2%. Similarly, the estimated odds ratio was 1.027 ($p<0.001$ C.I. 1.018, 1.035) for a one percentage point increase in the percent of people who hold a bachelor's degree.

Table 14: Model 1 - Logistic Regression Model for Any Pharmacy Closure (n=5,299)

Variable	Odds Ratio	Standard Error	P-Value	Confidence Interval
Total Population_5000	**1.266**	**0.080**	**<0.001**	**1.117, 1.433**
Number of Pharmacies in 2013	**1.525**	**0.046**	**<0.001**	**1.437, 1.618**
Percent Female	1.007	0.009	0.469	0.989, 1.025
Percent Over 65 years	1.006	0.007	0.425	0.992, 1.020
Percent Non-White	1.003	0.003	0.268	0.998, 1.008
Percent Unemployed	1.027	0.027	0.296	0.976, 1.082
Percent Uninsured	**1.019**	**0.007**	**0.004**	**1.006, 1.032**
Percent Disability	0.974	0.016	0.093	0.944, 1.005
Percent Medicaid	1.012	0.009	0.150	0.996, 1.029
Percent Bachelors	**1.027**	**0.004**	**<0.001**	**1.018, 1.035**
Percent Below Poverty	1.001	0.006	0.845	0.989, 1.013
Rural Area	1.160	0.146	0.239	0.906, 1.485

Number of Pharmacy Closures

Model 2 estimated factors affecting the number of pharmacy closures per tract in all the census tracts with population in Texas. The results for the negative binomial regression model are shown in Table 15. Total census tract population, measured in units of 5000 persons, had an estimated an incident rate ratio (IRR) of 1.199 ($p<0.001$ C.I. 1.087, 1.323), meaning an increase in census tract population of 5000 persons was estimated to increase the number of pharmacy closures within the census tract by 20% percent. An IRR of 1.413 ($p<0.001$ C.I. 1.367, 1.497) was estimated for a one unit increase in the number of existing pharmacies as of 2013, meaning that having an additional existing pharmacy in a census tract as of 2013 was associated with a 41% increase in the number of pharmacy closures in the tract. The model also estimated an IRR of 1.018 ($p=0.006$) associated with a one percentage point increase in the percent of uninsured in the population; and an IRR of 1.025 ($p<0.001$) associated with a one percentage point increase in the percent of bachelor degree holders in the census tract. Conversely, an estimated IRR of 0.969 ($p=0.033$) was associated with a one percentage point increase in the percent of disabled people in the census tract.

Table 15: Model 2 - Negative Binomial Regression Model for Number of Pharmacy Closures (n = 5,299)

Variable	Incidence Rate Ratio	Standard Error	P-Value	Confidence Interval
Total Population_5000	**1.199**	**0.060**	**0.001**	**1.087, 1.323**
Number of Pharmacies in 2013	**1.431**	**0.033**	**0.001**	**1.367, 1.497**
Percent Female	1.010	0.008	0.206	0.994, 1.028
Percent Over 65 years	1.010	0.007	0.127	1.997, 1.023
Percent Non-White	1.002	0.002	0.335	0.998, 1.007
Percent Unemployed	1.008	0.024	0.727	0.962, 1.057
Percent Uninsured	**1.018**	**0.006**	**0.002**	**1.007, 1.030**
Percent Disability	**0.969**	**0.014**	**0.033**	**0.942, 0.998**
Percent Medicaid	1.012	0.008	0.120	0.997, 1.027
Percent Bachelors	**1.025**	**0.004**	**0.001**	**1.018, 1.033**
Percent Below Poverty	1.001	0.006	0.833	0.990, 1.012
Rural Area	1.007	0.118	0.951	0.801, 1.268

Discussion

For our study, the higher likelihood of pharmacy closures and a higher number of pharmacy closures was associated with areas with higher population, a higher number of existing pharmacies in 2013, and areas with higher percentage of bachelor degree holders. This is a potentially mixed result. While highly populated areas might have led to more new pharmacy entrants leading to high concentration in the census tracts, the high concentration of pharmacies in such areas may result in having more closures. It is not very clear why areas with higher percentage of bachelor's degree holders may experience any pharmacy closures and higher closures. This may also be partly due to pharmacy concentration in such areas that led to higher market competition consequently resulting in higher number of closures.

Expectedly, census tracts with a high percentage of uninsured population were likely to experience pharmacy closures as well higher number of pharmacy closures. Since pharmacies rely on prescription volume and pharmacy services for revenue, areas with higher uninsured population may not be able to financially keep pharmacies viable and may result in pharmacy closures[60,73].

Similar to the Xiao study, we did not find a statistically significant difference between rural and urban areas in terms of the likelihood of any closures or a higher number of pharmacy closures[57]. This suggests that rural-urban differences in closures may be more directly related to differences in census tract population characteristics, such as total population, and that after using multivariable regression to adjust for these differences, categorical rural-urban status *per se* is not particularly pertinent.

Nonetheless, it is generally known that pharmacy closures in rural areas have a more pervasive and negative impact than closures in urban areas[10,11,49,56]. There are usually fewer number of existing pharmacies in rural areas compared to urban areas, so closures may add many miles to the distance rural residents may need to their nearest pharmacy.

Our study showed that some pharmacy services may be quite well aligned with the population or pharmacy. Areas with a higher percent disabled population had fewer pharmacy closures. While is important to ensure enhanced pharmacy access in these areas, it is important to note that our study did not specifically look at the kind of accessibility services provided by the available pharmacies. However, our previous analysis of the pharmacies in Texas reported in Chapter 3 showed that about 98% of the existing pharmacies in Texas indicated they offered disability services.

Limitations

Our study had several limitations. Due to non-availability of details in the pharmacy closures dataset, we did not examine the type or size of pharmacies that closed, nor did we examine the type of pharmacy services that the closed pharmacy provided. Also, we did not examine the impact of pharmacy closures on medication adherence or pharmacy services. Future studies should examine the impact of pharmacy closures on medication adherence and availability of pharmacy services, subject to data availability.

Conclusion

In our study, several sociodemographic and other factors in a census tract were associated with a higher risk of pharmacy closures in Texas, including more existing pharmacies, a larger total population, a higher percentage of bachelor degree holders, a higher elderly population, a higher percentage of minorities and a higher percentage of uninsured population. However, having a higher percentage of disabled population was associated with fewer pharmacy closures in census tracts in Texas.

CHAPTER 5

CONCLUSION

The final chapter of this dissertation provides an overview of the findings of the three studies reported in the previous chapters, the potential policy implications of the findings, and recommendations future for research.

This dissertation provided the first systematic review of literature on pharmacy availability and accessibility in the US and conducted an examination of the sociodemographic factors and other census tracts characteristics that affect pharmacy availability and accessibility, and pharmacy closures in Texas, a state with a large and diverse population.

The systematic review confirmed the common notion that pharmacies generally are widely available across the US, but that pharmacy access often is challenging in some local areas depending on area population characteristics. For instance, poor neighborhoods had the lowest pharmacy access. They also may not have broad range of services such as home delivery services offered by pharmacies in more affluent areas. Similarly, areas with high concentrations of minority populations generally have pharmacy access that is inferior to access in predominantly white areas. This has policy implications for health equity and disparities for these populations. Poor neighborhoods, especially those already designated medically underserved areas, may suffer more adverse consequences in the absence of pharmacies and other healthcare facilities. Policy makers should evaluate strategies that can help keep pharmacies viable in these areas. For instance, startup funds or interest free loans may facilitate the setup of new pharmacies or keep financially distressed pharmacies in these areas open. Also, policies that ensure timely (undelayed) and adequate reimbursements of pharmaceutical services and medications provided by pharmacies should be implemented in these areas.

The total population of a census tract was a crucial factor for having at least a pharmacy in a census tract, having higher number of pharmacies in a census tract and having a tendency for pharmacies to close. It appears population may be a major factor for siting pharmacies in densely populated areas, but this may portend challenges due to competition that may eventually lead to closures of pharmacies in densely populated areas.

While the majority of the pharmacies in Texas offered Medicaid services, the Medicaid population may be experiencing some challenges with both pharmacy availability and pharmacy access, given that a high percentage of Medicaid population was associated with lower likelihood of having a pharmacy and reduced pharmacy density. Furthermore, people over 65 years may also have some issues with pharmacy access, since a higher percentage of people over 65 years of age was associated with longer travel miles to the pharmacy, and were also likely to experience a higher number of pharmacy closures. Since people 65 and older are usually using more medications and in greater need of healthcare services than the younger population, it is crucial that pharmacy administrators in Texas align the pharmacy services that they provide with the population that they serve.

Living in rural areas was found to be associated with less pharmacy density and more than double the distance traveled to the pharmacy compared to living in urban areas in Texas. This is similar to results from previous literature in other states and it underscores the importance of keeping rural pharmacies open to support the health of the rural population. Staffing was also reported to be an issue with pharmacies in rural areas. Pharmacy schools in Texas may help by planning scheduled rotations to pharmacies in these areas and exposing pharmacy students to pharmacy practice in rural areas. This may encourage students to consider employment or setting up pharmacies in rural areas.

Our study of pharmacy closures revealed that a high percentage of uninsured population may increase the chances of pharmacy closures in a census tract. It was also related to having reduced pharmacy density but less distance traveled to the pharmacy in the census tract. It is important to further study this population so that they may be insured and have access to medications and pharmacy services. However, pharmacies in these areas should be reimbursed adequately to prevent results similar to initial implementation of Medicare Part D, which resulted in increased volume of prescriptions among newly covered population over 65 years of age, but reduced and delayed reimbursements, leading to financial distress and eventual closure of some pharmacies serving the elderly population[10]. Furthermore, the potential role of competition among existing pharmacies leading to pharmacy closures was explored. Further investigation into the optimum number of pharmacy required per population or the type of pharmacy mix (chain, independent) required to provide the broad array of pharmacy services required within the population may be warranted.

Future studies should empirically examine the impact of pharmacy access and pharmacy closure on medication adherence and on population health outcomes. In addition, future studies should examine the type of pharmacy services offered in closed pharmacies and compare to services offered in the nearest existing pharmacy in the same period.

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APPENDIX A

SUMMARY OF THE FINDINGS IN THE INCLUDED STUDIES

S/N	Author	Location	Type of Location	Summary of Findings
1	Adams DW et al	Virginia	State	Pharmacies were available and stable between 1994 and 1999. Number of pharmacies increased but pharmacy density remained the same in that period. Independent pharmacies decreased significantly as chain, mass merchandise or grocery increased. There was no observed rural urban difference. Low population areas had lower number of pharmacies
2	Adams EK et al	US	Country	Lower pharmacy availability in high poverty areas. Overall, Medicaid participation rates for both independent and chain pharmacies were the same. Higher percentage of independent pharmacies in these areas hence lower Medicaid participation rate.
3	Amstislavski et al.	New York	City	Lower pharmacy access and less pharmacy services were provided in poorest communities. Pharmacies in poor communities were likely to have medications out of stock.
4	Barber et al	Michigan	State	Young African American women tend to live closer to pharmacies. Pharmacies were available but less accessible using contraceptives as an indicator medication.
5	Batra et.al	California	State	About 5% of pharmacies provided pharmacist-prescribed hormonal contraceptives. There was no observed differences in the type of pharmacy or by rurality using contraceptives as an indicator.

S/N	Author	Location	Type of Location	Summary of Findings
6	Burrell et al	Allegheny, PA	County	Pharmacies were more available in urban areas. Pharmacy access was limited outside urban centers using naloxone as indicator medication despite the high number of deaths in the rural areas. Generally low availability of naloxone in the county.
7	Casey et al	North Dakota, South Dakota and Minnesota	State	Adequate pharmacy access and majority live within 20miles, hours of operation, call duty, home delivery. Closure resulted in losing sole pharmacies in some communities. Financial viability of the pharmacies and the rural residents is a bigger threat to survival of the pharmacies in the areas studied.
8	Chisholm-Burns et al.	Shelby	County	Higher minorities led to lower pharmacy access (density). Low employment and high personal crime risk lead to low home delivery service.
9	Gadkari	Wisconsin	State	Adequate pharmacy availability and accessibility. Pharmacies were available but more accessible in micropolitan areas. Pharmacy services such as Medication Therapy Management and Drug Therapy Services were more likely in non-core areas.
10	Guadamuz et al	US	Country	Closure rate increased from 7.8% (2009) to 12.8% (2015). Difference in closures of independent pharmacies compared to other types of pharmacies irrespective of rurality. Low income, uninsured or public insurance associated with closures/ reduced pharmacy access in urban areas.
11	Haag et al	Minnesota	State	No clear report on pharmacy availability. Rural pharmacies more likely provide Medication Therapy Management services.

S/N	Author	Location	Type of Location	Summary of Findings
				Both rural and urban pharmacies allocate similar time (30%) to non-dispensing services.
12	Klepser et al	United States	Country	Pharmacies were available and experienced increased availability within the study period. Pharmacy availability and accessibility reduced in rural areas. Also, more independent pharmacies were affected due to Medicare part D reimbursement rate despite utilization increase.
13	Olson et al	Minnesota	State	There was fluctuation in pharmacy availability. Independent pharmacies decreased by about 40% while chain pharmacies grew by about 50%. For chains, most growth were observed in urban areas. Pharmacy density affected independent and chain pharmacies differently.
14	Pednekar et al.	Pennsylvania	State	Pharmacy access was lower with higher females, married, white elderly. Rural and high white dominated areas had less pharmacy access and less 24-hr pharmacy services.
15	Qato et al	United States	Country	Pharmacy availability increased over the study period (2009 to 2015), but accessibility remained the same. Regional variation exists within the country. E-prescribing increased, while translation and home delivery services were stagnant. Services such as home delivery, 24hr operation, are required to be better aligned with the local population.
16	Qato et al	Chicago	City	Overall increase in pharmacy availability. There exist racial and socioeconomic difference in pharmacy availability. More availability of pharmacies in white communities compared to black communities, low-income communities and medically underserved communities. Further racial difference, low-income white communities had more pharmacies

S/N	Author	Location	Type of Location	Summary of Findings
				compared to low-income black communities. In the city, 259 (32%) of the 802 census tracts were classified as pharmacy deserts.
17	Samina et al	Chicago	City	Pharmacies were available and geographically accessible. Average euclidean distance to access a pharmacy was 1.35 and 1.39 miles for adherent and non-adherent enrollees respectively but was not statistical significant. Health Outcome: Number of pharmacies the patient visited, distance to the pharmacy, and distance to the prescriber were not associated with medication adherence. Of all races, Hispanics had shorter average distance compared to other racial/ethnic groups.
18	Schommer et al.	Minnesota	State	Changes in population density was a factor for chain pharmacy exit and entry of the market. There is a possibility that independent pharmacy might be closing due to chain competition in high population density growth areas. Overall, population density (and population decline) may be an important factor that determines closure of independent pharmacies.
19	Shannon et al	Northern Flint, Michigan	City	Pharmacies were available and geographically accessible. Majority of pharmacies provided home delivery services. Racial difference existed (white 0.4 miles vs blacks 0.5 miles to pharmacy) but was not statistically significant. Financial viability represented a bigger issue than distance for pharmacy access in the city. Respondents may not always use the nearest pharmacies and the concept of "activity area" may be looked at to assess distance traveled to pharmacies.

S/N	Author	Location	Type of Location	Summary of Findings
20	Stopka et al	Massachusetts	City	Pharmacies were geographically accessible. Naloxone was accessible across the state but there ware variation in accessibility based on non-prescription syringes. More syringes were sold in suburban and rural areas, but more syringe-selling pharmacies were located in urban areas. Independent pharmacies were more accessible by syringe than chain pharmacies.
21	Stopka et al.	Los Angeles	County	Low income led to less pharmacies. Higher elderly population (distant from poor communities) led to increased pharmacy access.
22	Swu-Jane	Illinois	State	Pharmacies were geographically accessible. Rural dwellers travel more, i.e., less access especially for the elderly.

APPENDIX B

QUALITY ASSESSMENT OF THE STUDIES INCLUDED IN THE SYSTEMATIC LITERATURE REVIEW

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Were the criteria for inclusion in the sample clearly defined	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Were the study subjects and the setting described in detail?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Was the exposure measured in a valid and reliable way?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Were objective, standard criteria used for measurement of the condition?	+	+	?	+	+	+	+	+	+	+	?	+	+	+	+	+	+	?	+	+	+	+
Were confounding factors identified?	n/a	+	?	n/a	n/a	n/a	n/a	?	+	+	-	+	+	n/a	+	+	+	n/a	-	n/a	+	n/a

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Were strategies to deal with confounding factors stated?	n/a	+	+	n/a	n/a	n/a	n/a	?	+	+	-	+	+	n/a	+	+	+	n/a	-	n/a	+	n/a
Were the outcomes measured in a valid and reliable way?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Was appropriate statistical analysis used?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Were recommendations for policy and/or practice supported by the reported data?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Were the specific directives for new research appropriate?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

KEY

Symbol	Term
+	Yes
-	No
?	Unclear
n/a	Not applicable

APPENDIX C

Maps Showing Pharmacies Providing Disability Access and 24 Hour Services by Population Characteristics