Equitable access and reimbursement for pharmacy-based services:

A case study of adult vaccinations

Rachel Wittenauer

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Reading Committee:

Andy Stergachis, Chair

Jennifer L. Bacci

Parth D. Shah

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University of Washington

Abstract

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Rachel Wittenauer

Chair of the Supervisory Committee:
Andy Stergachis
Department of Pharmacy

Community pharmacies are vital access points for healthcare in the United States. The COVID-19 pandemic highlighted the indispensable role of community pharmacists for patients and the healthcare system. However, not every neighborhood has good access to pharmacies, and pharmacies are facing increased financial and operational pressures which threaten their widespread availability. Despite the importance of community pharmacies, robust evidence at a national level is lacking on 1) the populations and locations which have low access to pharmacies, 2) whether this lack of access affects utilization of pharmacist-provided health services, and 3) whether any of the proposed policy solutions, such as provider status recognition for pharmacists at the federal level, provide a plausible path forward to bolster access to pharmacist-provided health services.

This investigation is structured as three aims. First, I defined, mapped, and characterized the locations of all "pharmacy deserts" in the U.S. at the census tract level. Pharmacy deserts are defined as areas that are both low-income (>20% of people living below the federal poverty line

or median income <80% of the nearest metro area) and have low access to a pharmacy (>1/3 of people living outside a 1, 5, or 10-mile radius of any pharmacy, depending on urbanicity). I found that 15.8 million (or 4.7% of) people in the U.S. live in neighborhoods classified as pharmacy deserts. Further, the populations living in these neighborhoods were associated with a higher proportion of many known social determinants of health such as lower educational attainment, racial/ethnic minority status, and lower health insurance coverage. These patterns were generally consistent across urban and rural areas and across all 50 states in the country.

Second, I evaluated whether these pharmacy desert neighborhoods were associated with lower utilization of a key pharmacy-based health service: shingles vaccination. I acquired census-tract-level vaccination data from seven different state Departments of Health and used propensity score matching to efficiently account for a variety of known confounding factors in the evaluation. The results from our primary analysis showed that pharmacy desert status was not associated with lower vaccination completion rates (0.4 fewer shingles vaccinations per 1000 population, $p = 0.83$). However, the results of our secondary analysis found that census tracts with low pharmacy access (as opposed to the two-part pharmacy desert definition that includes low-income levels) were associated with reduced shingles vaccination completion rates (2.4 fewer vaccinations per 1000 population, $p = 0.004$). This pattern indicates that lack of community pharmacy access may have direct health consequences for people living in these neighborhoods.

Lastly, I used a national claims database to explore the effects of state-level provider status legislation on reimbursements for shingles and seasonal influenza vaccination visits at pharmacies. We found that despite having the legal authority to do so, there are very few pharmacy claims being submitted to health insurance plans for vaccination services. Our dataset contained 2.3 million vaccination visits between 2021-2022, of which only 0.4% had any outpatient services claims billed during the visit, even in provider status states. This inhibits more robust evaluation of these policies' effects and may indicate important implementation barriers to address alongside these new authorities for pharmacists. In sum, this body of work provides evidence on the current state of access to pharmacies in the U.S., the negative effect of poor pharmacy access on shingles vaccination, and the potential utility of state-level provider status legislation in improving the financial profitability of vaccination services in community pharmacies.

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Finally, I could not have finished this degree without my family, friends, and partner. They kept me grounded throughout this degree by working in our garden, climbing mountains with me, making me laugh, exploring the world with me, and reminding me about what is really important in life. I love you all and am eternally grateful.

INTRODUCTION

Community pharmacies are a crucial component of healthcare infrastructure in the United States.[1,2] In addition to dispensing medications for acute and chronic illnesses, they provide routine vaccination, medications for opioid and other substance use disorders, contraception, patient counseling for medication side effects, diabetes education, and more. There is a long history of pharmacists providing important community health services, and the scope and breadth of these practices have expanded over time.[3–5] Communities that are both low-income and have low access to pharmacies are known as “pharmacy deserts” and lack access to the wide range of services provided at pharmacies.[6] Pharmacy deserts disproportionately exist in rural or historically marginalized neighborhoods, compounding already-existing health inequities experienced by these communities.[6–14] Information is lacking on the specific locations of these deserts nationwide, making it difficult to measure both the detrimental effects of poor access and the beneficial effects of pharmacy-based health interventions and services across geography.

These detrimental effects may include lower use of pharmacy-based patient care services,[15] including vaccinations. Low coverage of adult vaccinations in the U.S. is a persistent problem, consistently falling short of the Healthy People 2030 goals and causing substantial health and economic consequences.[16–19] While primary care providers (PCPs) are the main provider of childhood vaccinations, pharmacies are vital access points and providers for adult vaccinations.[3,20–33] Pharmacies provide 98% of shingles vaccines,[34] more seasonal influenza vaccines than PCPs,[35] and the majority of COVID-19 vaccines.[36,37] Medicare beneficiaries visit pharmacies twice as frequently as their primary care providers,[38] and low-income families have better geographic access to pharmacies than PCPs,[39] heightening the importance of service availability in pharmacies for these specific populations with a high need for accessible care.

The provision of patient services, such as vaccinations, in pharmacies is currently facing several converging new pressures. The largest pharmacy chains have announced closures of over 1,500 stores nationwide,[40] the healthcare workforce shortage across disciplines including pharmacists and primary care providers is not improving,[41–43] financial pressure from pharmacy benefit managers and insurers is contributing to a stressful, thin-margin operating environment in pharmacies,[44,45] and the country's ageing population is only going to increase the volume of medication dispensing and healthcare services sought at pharmacies in the coming years, to name just a few. One proposed mechanism to prevent pharmacy closures caused by these financial and operational pressures is to improve the financial sustainability of community pharmacies by diversifying their revenue and increasing reimbursements paid to them for important services they are providing for patients. This could be accomplished through a type of payment reform known as "provider status" recognition for community pharmacists.

Provider status in this case refers to the recognition of pharmacists as providers of patient health services regarding being reimbursed by health insurance companies for those services under the medical benefit. Unlike other allied health professionals (e.g., nurse practitioners, clinical psychologists),[46] as a general rule, pharmacists can currently only use billing codes under insurance plans' prescription drug benefit (ingredient costs and dispensing fees), but not the medical benefit (patient care services).[47] This creates a financial disincentive for pharmacists to provide these important services and constrains them to helping patients below the full scope of their licensed capabilities.[47] Recently, a bill was introduced in Congress to establish "provider status" at a national level, which would align insurance reimbursement with valuable patient care services that pharmacists are currently offering with little or no reimbursement.[48,49] Six states, including Washington, have already enacted provider status legislation[49–51] recognizing pharmacists as providers for commercial insurance plans. This creates a natural experiment to explore the real-world effects of these policies on payments to pharmacies, for which evidence is currently lacking. Vaccination for shingles and seasonal influenza is a patient service that is primarily provided in pharmacies (as opposed to PCPs) and is also provided to patients with commercial insurance (as opposed to solely Medicare) and thus potentially affected by state-level provider status payment regulations. These two characteristics make these vaccinations an ideal patient service to examine with respect to the effects of pharmacy reimbursement laws.

Specific research aims

This dissertation is organized into three chapters corresponding to three specific research aims. In Chapter 1, I identify and characterize the locations of all pharmacy deserts throughout the U.S. at the neighborhood level. I also describe the characteristics of populations living in these neighborhoods and characteristics of the pharmacies serving these areas, as compared to those in non-pharmacy-deserts. In Chapter 2, I evaluate whether the pharmacy desert status of a neighborhood is associated with lower rates of a key health service: shingles vaccination. I also conduct a secondary analysis using an alternate definition of pharmacy access to contribute to the field's ongoing efforts to operationalize an empirically based definition of "appropriate" pharmacy access. In Chapter 3, I explore evidence from the six states which have enacted provider status recognition for pharmacists with respect to commercial insurance billing for vaccinations. I use a national health insurance claims database to evaluate whether reimbursements to community pharmacists for provision of shingles and seasonal influenza vaccination visits are higher as compared to states without provider status recognition for pharmacists. The findings from all three of these studies may be important evidence to help shape the multiple state and national-level policies currently being considered to expand access and financing for community pharmacy-based health services.

Chapter 1. LOCATIONS AND CHARACTERISTICS OF PHARMACY DESERTS IN THE UNITED STATES: A GEOSPATIAL STUDY

Abstract

Pharmacies are important healthcare access points, but no national map currently exists of where pharmacy deserts are located. This cross-sectional study used pharmacy address data and Census Bureau surveys to define pharmacy deserts at the census tract level in all 50 U.S. States and DC. We also compared sociodemographic characteristics of pharmacy desert vs. non-pharmacy desert communities. Nationally, 15.8 million (4.7%) of all people in the U.S. live in pharmacy deserts, spanning urban and rural settings in all 50 states. On average, communities that are pharmacy deserts have a higher proportion of people who: have a high school education or less, have no health insurance, have low self-reported English ability, have an ambulatory disability, and identify as a racial or ethnic minority. While, on average, pharmacies are the most accessible healthcare setting in the U.S., many people still do not have access to them. Further, the people living in pharmacy deserts are often marginalized groups who have historically faced structural barriers to healthcare. This study demonstrates a need to improve access to pharmacies and pharmacy services to advance health equity.

1. Background

Community pharmacies are a crucial component of healthcare infrastructure in the U.S.[1,2] Nearly 7 in 10 adults between 40-79 years old take at least one prescription drug, and roughly 1 in 5 adults take 5 or more prescription drugs.[52] In addition to dispensing medications for acute and chronic illnesses, a wide variety of health services are offered at pharmacies including routine vaccination, opioid and addiction management therapy, contraception, and patient counseling on medications. There is a long history of pharmacists providing important community health services, and the scope and breadth of these practices have expanded over time.[3–5] Recently, the COVID-19 pandemic highlighted the importance of community pharmacists and pharmacies as points of access for providing essential health products and services, including administering half of all COVID-19 vaccines.[53]

Communities that are both low-income and have low access to pharmacies are known as "pharmacy deserts" and lack access to the wide range of services provided at pharmacies.[6] Pharmacy deserts disproportionately exist in rural or historically marginalized neighborhoods, compounding already-existing health inequities experienced by these communities.[6–14] However, information is lacking on the specific locations and characteristics of pharmacy deserts nationwide, making it difficult to measure both the detrimental effects of poor access and the beneficial effects of pharmacy-based health services across geography.

The term "pharmacy desert" was first coined in 2014 in Qato et al's analysis of pharmacy desert locations and characteristics in Chicago.[6] Since then, literature on this topic has grown to include identification of pharmacy deserts in Los Angeles County, the 30 largest metropolitan areas of the U.S., and all rural counties throughout the U.S..[6,8–11,14,54–57] Additional analyses examine characteristics of pharmacy closures[7] and several examine access to pharmacies but from an exclusively spatial lens (i.e., not considering income factors).[2,58] While these piecemeal analyses are beginning to create a cohesive evidence base, each map uses different methods and data sources and applies them to a small geographic area. To date, there is no comprehensive, systematically defined map of pharmacy desert locations in the United States. The objective of this study is to identify the locations of pharmacy desert neighborhoods using a standard methodology and characterize the population that lives in these areas and the pharmacies that serve them.

2. Methods

2.1 Approach

We applied the pharmacy desert definition[6] to classify the census tracts in all 50 U.S. states and the District of Columbia. We reported locations and population estimates of all pharmacy deserts and presented them visually on a choropleth map. We examined the tract-level social and demographic characteristics of populations (e.g., race/ethnicity, health insurance status) in pharmacy desert communities versus non-pharmacy desert communities, and the characteristics of pharmacies (e.g., services offered, independent vs. chain ownership) serving pharmacy desert communities vs. those serving non-pharmacy-desert communities.

2.2 Data Sources

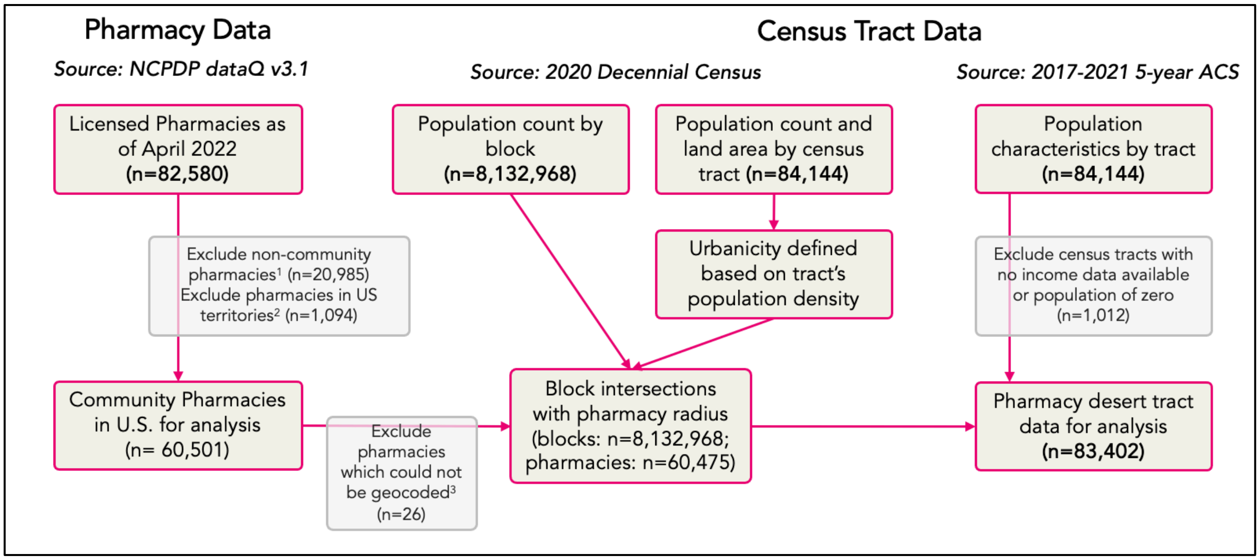
The locations and characteristics of all licensed pharmacies as of April 2022 were sourced from the National Council for Prescription Drug Programs (NCPDP).[59] Data to define pharmacy deserts and their associated characteristics were from multiple sources produced by the Census Bureau, including the 2020 Decennial Census and the 2017-2021 5-year American Community Survey.[60,61]

The NCPDP data contained the physical address of each pharmacy as well as characteristics of the pharmacy and services offered, such as vaccination services. We specifically used the Provider Information and the Services Information tables available in NCPDP's dataQ™ v3.1 product, which aggregates data self-reported by each included pharmacy. These data (n=82,520 licensed pharmacies) were restricted to contain community pharmacies open to the public in all

50 states and the District of Columbia (e.g., excluding military pharmacies, alternate dispensing sites, etc.) (n=60,501 licensed pharmacies). We then geocoded (i.e., assigned latitude and longitude to) each pharmacy based on its physical address using the Google Maps API. Of the 60,501 pharmacies, 34 were not able to be read by Google Maps and were geocoded manually. An additional 26 pharmacies were not able to be geocoded successfully and were excluded from analysis. We used the st_intersects function of the "sf" package in R to evaluate each pharmacy point location's intersection with a census tract polygon and thus assign each pharmacy to the census tract that it is located in.

To create the census-tract level dataset, we used the Census Bureau API and the tidycensus R package to extract a data table containing population counts, land area, geographic boundaries, and census tract GEOID for all 84,414 census tracts in the 50 U.S. states and the District of Columbia sourced from the 2020 Decennial Census. We merged this table with a second table of census tract-level estimates derived from the 2021 5-year American Community Survey, which contained estimates of population social and demographic characteristics including race/ethnicity, education level, health insurance status, language spoken, and more as listed in **Appendix A**. The tract-level datasets were merged using the 11-digit tract GEOID. The full data linkage process is summarized in **Figure 1**.

Figure 1. Data sources and dataset creation



Notes: [1] Pharmacy types that were excluded were: Non-pharmacy dispensing sites (n=8,833), Long-term care pharmacies (n=4,202), Closed Door Facilities (n=1,395), Institutional pharmacies (n=1,246), Clinic pharmacies (n=1,117), Home infusion therapy providers (n=771), Military pharmacies (n=697), Compounding pharmacies (n=662), Specialty pharmacies (n=628), Mail-order pharmacies (n=354), Indian Health Service pharmacies (n=305), Veterans Administration pharmacies (n=267), Alternate Dispensing Sites (n=163), Durable medical equipment pharmacy (n=161), Managed care organization pharmacies (n=141), Nuclear pharmacies (n=18), Parenteral nutrition (n=15), Nursing facility supplies (n=6), Oxygen equipment (n=2), Customized equipment (n=1), Dialysis equipment (n=1).
[2] Pharmacies excluded from U.S. territories were: Puerto Rico (n=1041), Guam (n=24), Virgin Islands (n=20), Northern Mariana Islands (n=9)
[3] Thirty-four observations were unable to be geocoded by Google Maps API and were added manually, an additional 26 could not be geocoded
Abbreviations: ACS: American Community Survey; API: Application Programming Interface; D.C.: District of Columbia; NCPDP: National Council for Prescription Drug Programs

2.3 Key Measures

We created binary indicators for the low-income and the low-access criteria of the pharmacy desert definition. A census tract meeting both indicators was then designated as a pharmacy desert. The specific measures are defined as follows: 1) *Low income:* Tract has either A) 20% or more of its population living below the federal poverty line, or B) a median household income that was less than 80% of the median income of the nearest metropolitan area. 2) *Low access:* Tract has at least 33% of its population living 1 mile or more from the pharmacy for urban tracts, >5 miles for suburban tracts, >10 miles for rural tracts, and >0.5 miles for tracts with less than 100 individuals owning a car. Census tracts were classified as urban, suburban, and rural using population density,[58] based on thresholds defined in previous analyses [62] and consistent with survey research on living environments.[63]

We used areal interpolation at the block level to calculate the proportion of a tract's population living within the accessibility radius of a pharmacy.[64] For each urbanicity level's acceptable pharmacy radius (0.5, 1, 5, or 10 miles), we evaluated whether the centroid of every census block in the U.S. was inside or outside of a pharmacy's radius. Then, for every tract, we summed the population of the blocks which were inside any pharmacy radius based on tract urbanicity. If more than one-third of the population was not in the radius, the tract was designated as meeting the "low access" component of the pharmacy desert definition. Additional details on this process are available in **Appendix A**.

2.4 Statistical Analyses

We compared characteristics of populations and pharmacies in pharmacy desert versus non-pharmacy desert communities. For continuous variables we tested statistical significance with a two-sample *t*-test and for categorical variables a chi-squared test of independence. All *p*-values were corrected for multiple comparisons using the Benjamini-Hochberg correction.[65–67] All analyses were conducted using R version 4.2.2. Maps were created using Tableau Desktop version 2023.2 (see **Appendix A** for additional details [i]).[68,69]

3. Results

3.1 Locating and quantifying pharmacy deserts

Nationally, 15.82 million (4.7%) of all people in the U.S. live in pharmacy desert communities. Of the 84,414 census tracts, 4,679 (5.5%) were identified to be pharmacy deserts, 78,723 (93.3%) were designated as not pharmacy deserts, and 1,012 could not be classified due to no available income data (*n*=446, 0.5%) or having a population of zero (*n*=566, 0.7%). Among the census tracts that are pharmacy deserts, the majority have zero pharmacies (*n*=4,421, 94.5%) (**Table 1**). Of the 60,475 community pharmacies nationwide, only 294 (0.5%) are serving pharmacy desert communities (**Table 2**).

The states with the highest proportion of their adult population living in pharmacy deserts are New Mexico (14.9%), Alaska (14.8%), and Arizona (8.6%). The states with the lowest proportion were New Hampshire (0.86%), New Jersey (1.05%), and New York (1.74%). The states with the highest number of adults living in pharmacy deserts are California (2.53 million), Texas (1.68 million), and Florida (749,103), reflecting the size of those states' large populations. These data by state are summarized in **Appendix C.2**.

The locations of all pharmacy desert tracts and all tracts with low access (but which did not meet the low-income criteria and thus are not considered full "pharmacy deserts" in our main analysis) are visualized on a choropleth map in Figure 2. An interactive version of the map is available via Tableau Public <*https://tinyurl.com/PharmacyDesertsMap2022*>. Map inset views of five example urban areas in the U.S., locations of each individual pharmacy and the number of pharmacies per population are also available in **Appendix C.3**.

If the low-income component of the pharmacy desert definition was not accounted for, as is the case in some pharmacy access research,[2,58,70,71] then a higher number of census tracts would be designated as pharmacy deserts. In this case, beyond the 4,679 pharmacy desert tracts, an additional 7,536 tracts were identified as having low access to pharmacies. This total of 12,215 tracts represents approximately 34 million adults (13.2% of all adults) in the country living in areas with low access to pharmacies.

3.2 Characteristics of pharmacy deserts

Pharmacy deserts are most often located in urban and rural areas as opposed to suburban areas ($p<0.001$). Communities that are pharmacy deserts, as compared to non-pharmacy desert communities, have a higher proportion of people who: have a high school education or less (33.2% vs. 27.6%, $p<0.001$), have no health insurance (15.2% vs. 9.9%, $p<0.001$), have public health insurance (41.9% vs. 35.4%, $p<0.001$), speak English "not well" or "not at all" (5.7% vs. 3.1%, $p<0.001$), have an ambulatory disability (10.4% vs. 8.3%, $p<0.001$), identify as non-Hispanic Black race (19.1% vs. 12.6%, $p<0.001$), identify as American Indian or Alaskan Native (3.5% vs. 0.5%, $p<0.001$), and identify as Hispanic White race (12.0% vs. 8.0%, $p<0.001$). Pharmacy desert communities have a lower proportion of people who: are under the age of 65 (15% vs. 16.9%, $p<0.001$), identify as non-Hispanic White race (45.5% vs. 61.2%, $p<0.001$), and identify as non-Hispanic Asian race (3.3% vs. 5.3%, $p<0.001$). These results are summarized in Table 1. Most patterns seen at the national level persist when stratified by urbanicity, e.g., pharmacy deserts still have a higher proportion of people with lower education, non-White race, and no health insurance across urban, suburban, and rural areas. However, among rural pharmacy deserts versus rural non-pharmacy deserts, there is a slightly higher proportion of individuals aged 65 and older. **Appendix C.4** presents these data stratified by urbanicity level and **Appendix C.5** presents these data for tracts that have low spatial access to pharmacies but did not meet the low-income criteria of the pharmacy desert definition.

We also examined the characteristics of pharmacies that are located in pharmacy desert tracts versus non-desert tracts (**Table 2**). Pharmacies serving pharmacy deserts are more often in urban and rural areas rather than suburban areas. Pharmacies located in pharmacy deserts versus non-pharmacy desert areas have different distributions of ownership: those in pharmacy deserts are more often independently owned pharmacies (41.2% vs 36.6%, $p<0.001$). Pharmacies in pharmacy deserts also have varying levels of service offerings: for example, they more often have walk-in clinics available as compared to non-pharmacy desert pharmacies (13.6% vs. 6.5%, $p<0.001$). Additional detail is available in **Appendix C.6**.

Table 1. Characteristics of populations living in pharmacy deserts

	Pharmacy Desert (N=4,679)	Not Pharmacy Desert (N=78,723)
Urbanicity and access (n (%))		
Urbanicity of census tract[a]		
Urban	2692 (57.5%)	19972 (25.4%)
Suburban	204 (4.4%)	30264 (38.4%)
Rural	1783 (38.1%)	28487 (36.2%)
Pharmacies per census tract[a]		
Zero pharmacies in the tract	4,421 (94.5%)	43,249 (54.9%)
One pharmacy in the tract	34 (0.7%)	14,852 (18.9%)
Two or more pharmacies	224 (4.8%)	20,622 (26.2%)
Social characteristics (mean (SD))		
Prop. Below FPL[a]	24.6% (14.3)	13.0% (10.8)
Median Household Income[a]	$46,400 ($14,900)	$76,000 ($37,000)
Prop. With High School Education or Less[a]	33.2% (10.4)	27.6% (11.4)
Prop. With No Health Insurance[a]	15.2% (11.2)	9.89% (8.56)
Prop. With Public Health Insurance[a]	41.9% (15.8)	35.4% (12.9)
Prop. Do Not Speak English[a]	5.73% (9.53)	3.07% (6.78)
Demographic Characteristics (mean (SD))		
Prop. With Ambulatory Disability[a]	10.4% (6.37)	8.34% (4.97)

	Pharmacy Desert (N=4,679)	Not Pharmacy Desert (N=78,723)
Prop. Older Adult (Age 65+)[a]	15.0% (10.1)	16.9% (8.80)
Race and ethnicity		
Prop. NH, White[a]	45.5% (32.1)	61.2% (29.3)
Prop. NH, Black[a]	19.1% (26.1)	12.6% (20.4)
Prop. NH, Asian[a]	3.29% (7.03)	5.25% (9.80)
Prop. NH, AIAN[a]	3.50% (1.49)	0.51% (2.78)
Prop. NH, 2 or More Races[a]	3.02% (3.31)	3.16 (3.16)
Prop. NH, Other Race	0.33% (1.02)	0.36% (1.10)
Prop. Hispanic, White Race[a]	12.0% (16.1)	7.97% (11.6)
Prop. Hispanic, Black Race[a]	0.39% (1.11)	0.35% (1.15)
Prop. Hispanic, Asian Race	0.06% (0.29)	0.07% (0.37)
Prop. Hispanic, AIAN Race[a]	0.42% (1.28)	0.22% (0.80)
Prop. Hispanic, 2 or More Races[a]	4.74% (6.85)	3.47% (5.37)
Prop. Hispanic, Other Race[a]	7.32% (11.5)	4.70% (8.80)

Notes: [a] Denotes statistically significant difference of characteristic in pharmacy desert versus non-pharmacy desert tracts at $p<0.01$. All p-values are from a t-test for continuous variables or a chi-squared test for categorical variables, all adjusted for multiple comparisons using the Benjamini-Hochberg correction. Abbreviations: AIAN: American Indian or Alaskan Native; FPL: Federal Poverty Line; NH: Non-Hispanic; Prop.: Proportion of tract population; SD: standard deviation.

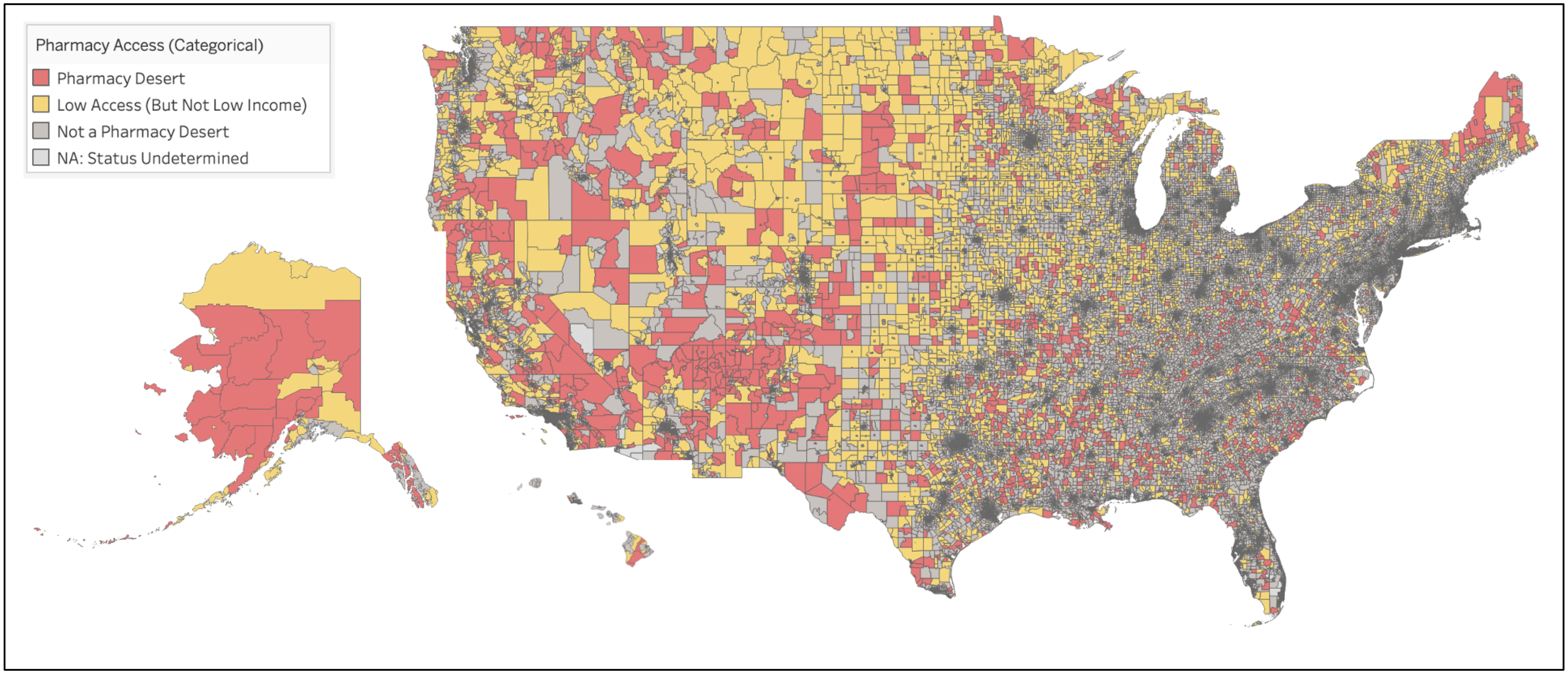
Table 2. Characteristics of pharmacies located in pharmacy deserts

	Pharmacy Desert (N=294)	Not Pharmacy Desert (N=60,175)	*p*-value[a]
Urbanicity of Pharmacy Location			
Urban	179 (60.9%)	15986 (26.6%)	<0.001
Suburban	8 (2.7%)	26922 (44.7%)	
Rural	107 (36.4%)	17206 (28.6%)	
NA: No Population	0 (0%)	61 (0.1%)	
Pharmacy Ownership			
Independent	121 (41.2%)	22,010 (36.6%)	<0.001
Chain	165 (56.1%)	37,371 (62.1%)	
Franchise	3 (1.0%)	659 (1.1%)	

	Pharmacy Desert (N=294)	Not Pharmacy Desert (N=60,175)	*p*-value[a]
Government	5 (1.7%)	135 (0.2%)	
Immunization Services Available	221 (75.2%)	48,510 (80.6%)	0.051
ADA Accessible	290 (98.6%)	59,429 (98.8%)	1.000
Multidose Packaging Available	73 (24.8%)	12,056 (20.0%)	0.087
Emergency Services 24 Hours	82 (27.9%)	17,841 (29.6%)	0.621
Walk-in Clinic Available	40 (13.6%)	3,923 (6.5%)	<0.001
Compounding Pharmacy	172 (58.5%)	37,230 (61.9%)	0.335
DME Available	219 (74.5%)	46,742 (77.7%)	0.323

Notes: [a] All *p*-values result from a *t*-test for continuous variables and a chi-squared test for categorical variables, all adjusted for multiple comparisons using the Benjamini-Hochberg correction. Abbreviations: ADA: Americans with Disabilities Act; DME: Durable Medical Equipment

Figure 2. Choropleth map of pharmacy desert locations in the United States in 2022



Notes: Maps of select urban areas are available in Appendix C.3. For more detail, an interactive Tableau version of this map is available at < *https://tinyurl.com/PharmacyDesertsMap2022* >.

Table 3. Implications of study results for patient and population health, policy solutions, and future research

	Key findings	Implications
Application to patient and population health	• Nearly 16 million adults in the U.S. live in pharmacy deserts • People living in pharmacy deserts already face many known barriers to accessing healthcare including lower education level, lower self-reported English-speaking ability, and lower insurance coverage • Pharmacy desert communities have a higher population of racial and ethnic minorities as compared to non-pharmacy deserts	• Many adults in the U.S. do not have adequate access to pharmacies, which 1) signals gaps in access to important routine healthcare, 2) weakens emergency and pandemic preparedness infrastructure, and 3) raises health equity concerns. • Left unaddressed, pharmacy deserts may contribute to widening health disparities for individuals living in these areas
Policies to improve access to pharmacies	• Nearly 95% of pharmacy deserts have no pharmacies in them at all • Pharmacy desert communities have a higher proportion of their population with no insurance and with public insurance compared to non-pharmacy desert communities • Pharmacy deserts were overwhelmingly in lower-income areas and in urban or rural areas (rather than wealthier or suburban areas); evidence shows pharmacies in these areas are more likely to close • Populations living in pharmacy deserts were more likely to have public health insurance and be under the age of 65—two characteristics which point to the inability of state-level laws to adequately act through commercial insurance plans to improve pharmacy access for patients and reimbursements for pharmacy services	• State and federal policies can halt the growth of pharmacy deserts and address patient care in existing ones by 1) preventing closures of existing pharmacies especially in underserved areas, possibly including PBM regulation and provider status recognition by CMS- two issues which impact pharmacy revenue and viability, 2) establishing or incentivizing new services access points for patients similar to the HPSA incentives for primary care, and 3) leveraging new technology and care models such as telepharmacy, mobile clinics, and expanded scopes of practice. • New medicines, technologies, or policies which are intended to be delivered or act through pharmacies to improve patient health will have minimal effect in pharmacy desert neighborhoods. Thus, it is essential to prioritize these areas in any policies which aim to improve access to healthcare via pharmacy-based services
Future research on pharmacy access	• Inclusion of an income component in the pharmacy definition substantially reduces the population who are considered to be living in "pharmacy deserts," as opposed to if only geographic access was considered • Study has many limitations which could be improved upon with more robust methods and data in future research	• The field of pharmacy-based services research would benefit from a carefully considered consensus definition on what a "pharmacy desert" is and how to parameterize their locations for analysis, particularly including the inclusion of an income component and role of urbanicity and access radius definitions • The causes of pharmacy deserts and individual-level health effects on patients should be explored in future research

4. Discussion

Our study provides estimates of the number of adults living in pharmacy deserts in the U.S.; nearly 16 million people. The proportion and number of adults living in pharmacy deserts vary by state, from less than 1% of adults in New Hampshire to nearly 15% of adults in New Mexico. Nationally, our results indicate pharmacy desert neighborhoods are associated with many social and political determinants of health including lower educational attainment, lower income, lower health insurance coverage, and higher proportion of people identifying as racial or ethnic minorities. These patterns did not vary substantially by urbanicity of the neighborhood. Of the tracts that are pharmacy deserts, nearly 95% contained zero pharmacies. In examining characteristics of pharmacies, we find that the few that are serving pharmacy desert communities are more often independently-owned rather than chain-owned, and more often have walk-in clinic services available as compared to pharmacies serving non-pharmacy deserts.

Compared to other studies of pharmacy deserts with similar operational definitions, our results indicate a smaller proportion of population in pharmacy deserts. This is potentially due to our paper's inclusion of a "suburban" category rather than an urban/rural binary, which we believe to be an important distinction but is not often included. An analysis of pharmacy deserts in Washington State with a similar approach (but using only urban and rural categories) found 8% of the adult population living in pharmacy deserts versus our analysis found 7.62% of Washington adults were in pharmacy deserts.[56] An analysis of pharmacy deserts in the thirty largest metropolitan areas in the U.S. found 32% of tracts were pharmacy deserts, while our study found 11.8% of urban tracts were pharmacy deserts.[55] We believe that using a 5-mile radius for tracts with less than 5000 people per square mile (suburban definition) is a key contributor to this discrepancy, as is our study's limitation of using linear distance rather than road distance.

The magnitude of population living in pharmacy deserts in our study is comparable to that of people living in food deserts (similar in both concept and definition): roughly 18.8 million people (6.1% of the U.S. population) live in census tracts that are food deserts.[72]

In terms of population characteristics, other published studies of pharmacy deserts in smaller geographies have found similar associations.[57] For example, studies of pharmacy access in Shelby County TN, Chicago IL, and the 30 most populous U.S. cities, found that neighborhoods with worse pharmacy access were associated with higher proportions of racial and ethnic minority groups.[6,10,55] In Los Angeles County, a clustering analysis identified two statistically distinct types of pharmacy deserts: one type with higher population density, younger population, and higher proportion of racial/ethnic minorities, and a second type with lower population density and higher proportion non-Hispanic White.[8] The results of this national analysis align with those findings from L.A. county.

4.1 Implications

These findings have implications for patient and population health, policy solutions, and future research to understand and address patient access to medications and pharmacy services. We note that while many insurance plans provide their enrollees with access to prescriptions via mail order, the focus of this analysis is access to physical pharmacy locations which provide many important health services including and beyond dispensing medications. Implications of this study's findings regarding lack of access to pharmacy-based services are summarized in Table 3. Implications of study results for patient and population health, policy solutions, and future research and further described below.

4.1.1 Implications for patient and population health

At a broad level, these results highlight that many adults in the U.S. do not have adequate access to pharmacies. This lack of access 1) signals important barriers in routine healthcare, 2) weakens emergency and pandemic preparedness infrastructure, and 3) raises health equity concerns.

Access to pharmacies and the variety of services pharmacists provide is an important means to protect and promote one's health. One cohort study found that when neighborhood pharmacies closed, patients who had previously been filling their cardiovascular medication prescriptions in those stores had a clinically and statistically significant decline in medication adherence.[15] Our results found that the most common structure of a pharmacy desert is to have no pharmacies in that neighborhood as opposed to inadequate access driven by per capita pharmacy to population ratio —a dynamic that poses a clear barrier for patients to access their medications and pharmacy services. Our results further found that, in communities which do have pharmacies, a smaller proportion of pharmacies in pharmacy deserts (compared to non-deserts) offered health services such as administering immunizations, selling DME, and offering 24-hour emergency services. Though these differences were not statistically significant in our study, past analyses have identified statistically different service offerings in areas that are pharmacy deserts compared to non-deserts.[70,73] Lack of access to pharmacies puts pharmacy desert communities-- and their nearly 16 million residents-- at a disadvantage for staying healthy.

Nationwide gaps in pharmacy accessibility are also noteworthy for emergency preparedness and response. The COVID-19 pandemic is the most recent example of the importance of pharmacy infrastructure—not only for testing, vaccinations, and treatment access to mitigate health and economic consequences of the pandemic—but to enable continuity of care for peoples' prescription medications.[53] In climate-related and natural disasters, pharmacists remain trusted health providers who are perceived as responsible for continuity of medication supply chains by both patients and other healthcare providers,[74,75] and may be well-suited to take on roles such as triaging evacuees, assessing vaccination needs, and providing over-the-counter and prescription medications.[76] People living in pharmacy desert communities may be left behind in accessing important emergency services.

If left unaddressed, pharmacy deserts may contribute to widening health disparities for populations living in these areas. Our results indicate that, on average, pharmacy desert residents already face many known barriers to accessing healthcare including lower income, lower education level, lower English-speaking ability, and lower health insurance coverage. All of these barriers may layer on each other to further limit patients' abilities to reach accessible, appropriate, affordable healthcare.[77] Pharmacy desert communities also have a higher population of racial and ethnic minorities as compared to non-pharmacy deserts. For example, the proportion of population identifying as AIAN is seven times higher in pharmacy deserts compared to non-pharmacy-deserts (3.5% vs 0.5%), and the proportion of Black population is higher as well (19.1% vs 12.6%). The association between pharmacy locations today and race-based exclusionary policies from decades ago, such as redlining, has been established empirically,[78] and the propagation of health disparities for historically minoritized groups will continue to propagate through the legacies of structural racism and colonialism if deliberate steps are not taken to close access gaps in these specific communities.[79,80]

4.1.2 Implications for policy

State and federal policies can halt the growth of pharmacy deserts and address patient care in existing ones by 1) preventing closures of existing pharmacies especially in underserved areas,[7] 2) establishing or incentivizing new service access points for patients,[49,81] and 3) leveraging new technology and care models to reach all patients (including adoption of tele-pharmacy, addressing staff shortages, using mobile clinics, and expanding scopes of practice).[22,70,82–84] One important factor in pharmacy closures is lack of a sufficient level of revenue. Pharmacies serving primarily low-income, publicly insured, and uninsured populations are at increased risk of closure, and independent pharmacies are more likely to close than chain pharmacies.[7] Legislative efforts to acknowledge pharmacists as healthcare providers in Medicare,[47,49,85] regulate pharmacy benefit managers,[44,86] and provide HPSA-like financial incentives for pharmacies operating in underserved areas, could all help alleviate this financial pressure particularly on pharmacies serving medically under-resourced communities. The most effective policy solutions may take different forms for pharmacies in urban areas versus rural areas and regionally, as the logistics of reaching people in these areas differ greatly. Federal-level legislation is likely to have a more meaningful impact than state-level changes: the results of our study found that populations in pharmacy deserts were more likely to have public health insurance and be under the age of 65—two characteristics which point to the inability of state-level laws to adequately act through only commercial insurance plan regulations to improve pharmacy access for patients.

We also found that the most common type of pharmacy desert were tracts with no pharmacies in them at all (94.5% of pharmacy deserts). New medicines, technologies, or policies which are intended to be delivered through pharmacies to improve patient health will undoubtedly have minimal availability and effect in pharmacy desert neighborhoods. Thus, it is essential to consider the differential impact in these communities of any policies which aim to improve access to healthcare via pharmacy-based services.[87]

4.1.3 Implications for future research

Beyond addressing this study's conceptual and methodological limitations, there are several ways that future research can extend this work. To inform ongoing policy discussions such as provider status legislation, the relationship between HPSAs and pharmacy deserts should be better defined. One study found that within urban areas in the U.S., the prevalence of pharmacy deserts was similar in Medically Underserved Areas (MUAs) vs non-MUAs, indicating that national measures of primary care access should not be presumed to correlate directly with pharmacy access.[55] If a better understanding of these differences is to be accomplished, consensus in the field about an appropriate definition for low pharmacy access must first be achieved, including inclusion of any income components and delineating access radii that are based on empirical evidence relating geographic accessibility to real-world patterns of pharmacy use and acceptability to patients.

Once pharmacy deserts are defined, evaluations of interventions and of patient health implications can take place. For example, an evaluation of any negative effects at the individual patient level of accessing medications in pharmacy deserts versus non-pharmacy deserts could help policymakers understand the magnitude and implications of these access concerns, and evaluations of the effects of varying state-level pharmacy policies (e.g., regulation of PBMs, provider status, telemedicine, etc.) can be contextualized. More robust statistical and causal inference methodologies can be applied to determine root causes of pharmacy deserts and may reveal potential solutions to prevent or reduce the loss of community pharmacies, and the vital services they provide, in the future.

4.2 Limitations

The data underlying this analysis have several limitations. These pharmacy locations are as of April 2022 and may soon be outdated. In 2022 and 2023, the three largest pharmacy chains (CVS, Walgreens, and Rite Aid) all announced significant planned store closures numbering over 1,500 total stores.[40] Previous research has indicated that pharmacy closures are more likely to happen in low-income areas in both urban and rural settings,[7] which the results from this analysis suggest already face higher likelihoods of being a pharmacy desert. These trends suggest a need to update this map in the coming years. The results presented here should thus be considered an underestimate of the gaps in pharmacy access.

These results are also limited by several assumptions in parameterizing pharmacy deserts, particularly in defining urbanicity and selecting access thresholds. Our use of population density as a proxy for urban status presents several challenges, we apply linear distance rather than travel time, and empirical data justifying the specific mileage of the access radii is limited. However, we note that minimum pharmacy benefit requirements from CMS also use population density to define urban, suburban, and rural areas and corresponding acceptable radii.[58,88]Further limitations to this study can be found in **Appendix B**.

Finally, there are contextual limitations to consider when interpreting these results. This analysis assumes that any patient can go to any pharmacy, but in reality, insurance networks determine a select list of pharmacies for their enrollees. For any given individual, a map of pharmacies which accept their specific insurance would be much sparser. For example, in Washington, pharmacies in rural areas were less likely to contract with Medicaid, heightening the existing access disparities there.[54] In addition to insurance coverage, a long list of non-spatial factors feed into the concept of "access," including language spoken, financial accessibility, hours and appointments, ADA accessibility, quality of care, and more. These factors are well-summarized by Levesque et al in their description of the interface of health systems and populations.[77,89] The results of our study indicate that populations in pharmacy deserts have a higher proportion of individuals who speak English "not well" or "not at all," have lower median incomes, and have more of their community living below the FPL. While describing access barriers comprehensively is outside the scope of this analysis, a spectrum of challenges must be considered by policymakers seeking to improve patient access to pharmacies.

4.2.1 Strengths of the study

This analysis also has several strengths. To our knowledge, this study represents the first published estimates of locations and characteristics of pharmacy desert locations at the local level throughout the U.S. applying the most widely-used definition of "pharmacy desert." We use the precise location of all licensed community pharmacies and population count data from the 2020 Decennial Census—the most comprehensive population estimate available. We also derive proportion of population living inside vs. outside the radius of a pharmacy using areal interpolation with the most granular geographic unit possible—all 8.1 million census blocks—and incorporate suburban locations as a category beyond an urban/rural binary. Lastly, we include an interactive map of results and all source code alongside our publication to facilitate further inquiry on the definition and characteristics of pharmacy deserts. Despite the limitations described above, these results summarize a comprehensive national estimate of pharmacy desert locations and characteristics.

5. Conclusion

In this first national estimate of pharmacy desert locations and characteristics, 15.8 million people in the U.S. are living in areas without adequate access to pharmacies. These communities span all 50 States and the District of Columbia and occur in urban, suburban, and rural areas. Populations residing in pharmacy deserts are more likely to face multiple known social, political, and demographic barriers to accessing health, including lower education level, lower health insurance coverage, higher proportion identifying as racial or ethnic minorities, higher proportion with difficulty speaking English, and higher proportion with ambulatory disabilities. These findings raise important concerns about pharmacy services and medication access in these specific communities throughout the U.S. Future research and policy solutions should consider pharmacy desert locations in evaluating pharmacy-based health services and improvements to medication access.

Chapter 2. PHARMACY ACCESS AND SHINGLES VACCINATIONS IN THE U.S.: A PROPENSITY SCORE MATCHING ANALYSIS

Abstract

Community pharmacists provide many important healthcare services, including routine adult vaccinations. However, an estimated 15.8 million people in the United States live in pharmacy deserts and may lack access to these services. While many U.S. residents have good geographic access to pharmacies, the relationship between pharmacy deserts and adult vaccine coverage has yet to be thoroughly explored empirically. We evaluated the relationship between census tract-level pharmacy access and shingles vaccination receipt. This propensity score matched analysis used 2022 vaccination data from seven collaborating State Departments of Health: Colorado, Louisiana, Nevada, Massachusetts, Oklahoma, Washington, and Wisconsin. Census tracts in those states were classified based on their access to community pharmacies in April 2022. The dataset for analysis contained 9,652 census tracts representing 13.7 million adults aged 50+ years. Our primary exposure was whether a census tract was a pharmacy desert, defined as being both low-income and having low geographic access to pharmacies. Our secondary exposure was whether a tract had low geographic access to pharmacies regardless of income status of that tract. The primary outcome was completed shingles vaccinations per 1000 population age 50+ years in 2022. We found that pharmacy deserts had 0.4 fewer shingles vaccinations per 1000 population ($p = 0.83$; 95% CI -3.8, 3.6) compared to matched non-pharmacy-desert tracts. Our secondary analysis indicated that low-access tracts had 2.4 fewer vaccinations per 1000 population (p=0.004, 95% CI: -3.9, -0.7). Low pharmacy access is

associated with lower rates of shingles vaccination. Efforts at the state and national levels to prevent pharmacy closures and support pharmacists in delivering care may improve access to important pharmacy services such as vaccination.

1. Background

Vaccination coverage is below target for nearly every recommended vaccine on the U.S. Centers for Disease Control and Prevention (CDC)'s adult schedule.[16,90] Despite being some of the most safe and cost-effective health interventions, coverage of influenza, pneumococcal, shingles, and other routine vaccinations are consistently low and, in some cases, declining.[91] There are approximately 18.5 million cases of vaccine-preventable illnesses among adults in the U.S. every year.[19] Beyond the health consequences of missed vaccinations, the economic burden of un- and under-vaccinated adults has been estimated to be $8.3 billion from inpatient and outpatient treatment costs in a single year. [17,19]

Community pharmacies play an important role in adult vaccinations, and this role has expanded recently.[4,23,92,93] Today, community pharmacies provide more seasonal influenza vaccines than any other medical settings, have administered about half of all COVID-19 vaccines, and provide approximately 90% of shingles vaccinations.[34,35,53] Pharmacists and, in some states, pharmacy technicians, are authorized to provide vaccinations, are trusted by members of their communities, have convenient hours and appointment scheduling, and often are more geographically accessible than primary care providers (PCPs).[21,39]

However, the relationship between pharmacies and vaccinations is facing new pressures: new routine vaccinations for adults such as RSV and COVID-19 have been added to the recommended schedule,[94] vaccine hesitancy is on the rise in the U.S.,[95,96] and the largest pharmacy chains have closures planned for a significant number of stores nationwide.[40] In this context of shrinking pharmacy access and increasing importance of facilitating access to routine vaccinations, understanding the role that pharmacies play in vaccination is urgent.[71,97–99] Real-world evidence on the relationship between pharmacy accessibility and receipt of routine vaccinations is sparse: one study among a group of breast cancer patients demonstrated that higher driving distance from pharmacies was associated with lower odds of influenza vaccination, and a national survey found that vaccination receipt was significantly associated with reported proximity to a pharmacy.[13,100] More research is needed to define the relationship between poor pharmacy access and low vaccination coverage.

Communities that are both low-income and have low geographic access to pharmacies are designated as "pharmacy deserts."[6] A 2022 study found that 15.8 million people (4.7%) in the U.S. are living in pharmacy desert neighborhoods, and an additional 28.7 million people (for a total of 44.6 million, or 13.5% of the overall U.S.) are living in tracts with low geographic access to pharmacies (regardless of income status).[101] Pharmacy deserts are disproportionately rural or historically marginalized neighborhoods and have less access to the range of services provided in pharmacies, such as vaccinations.

The shingles, or herpes zoster, vaccine is well-suited for analysis of pharmacy-based vaccination services because most are given in pharmacies, pharmacists in all states have the authority to prescribe and administer it, and it is recommended to all adults aged 50 years and older.[21,22,90,102,103] It also has a substantial health and economic burden; the U.S. has approximately 1.1 million cases of shingles per year, costing $782 million in direct costs and productivity losses in 2015.[19] The current recommended shingles vaccine is a two-dose recombinant vaccine that is over 90% effective, however only 29.4% of adults age 50 years and older have received it.[91] As the U.S. population ages, the economic and human burden of shingles will likely continue to increase if vaccination rates remain low. The burden of shingles can be alleviated by improving population coverage of this effective intervention, such as through delivery in pharmacies. The objective of this study was to evaluate the relationship between community pharmacy access and shingles vaccination receipt.

2. Methods

We conducted a cross-sectional study to assess the association of a census tract's pharmacy desert status with its shingles vaccinations per population. We hypothesized that shingles vaccination series completions per 1000 adults aged 50 years and older would be lower in census tracts that have worse access to pharmacies as compared to census tracts with good access to pharmacies.

2.1 Key measures and data sources

2.1.1 Predictor

The **predictor** for our primary analysis was a binary indicator for whether that tract was a "pharmacy desert". As a secondary analysis, we defined our predictor variable as tracts that had low geographic access to pharmacies ("low access tracts"), including those which did not meet the low-income criterion of the standard pharmacy desert definition (Figure 3). This comparison may inform the evolving research efforts towards a consensus parameterization of adequate pharmacy access.

We classified census tracts in our selected states as pharmacy deserts and low-pharmacy-access tracts using pharmacy location data from the National Council for Prescription Drug Programs (NCPDP; April 2022), population data from the 2020 Decennial Census,[60] and sociodemographic data from the 2021 5-year American Community Survey (ACS)[61] (**Figure 1).** Details on the algorithm used to identify these tracts have been described previously[6] and are available in **Chapter 1**.

2.1.2 Outcome

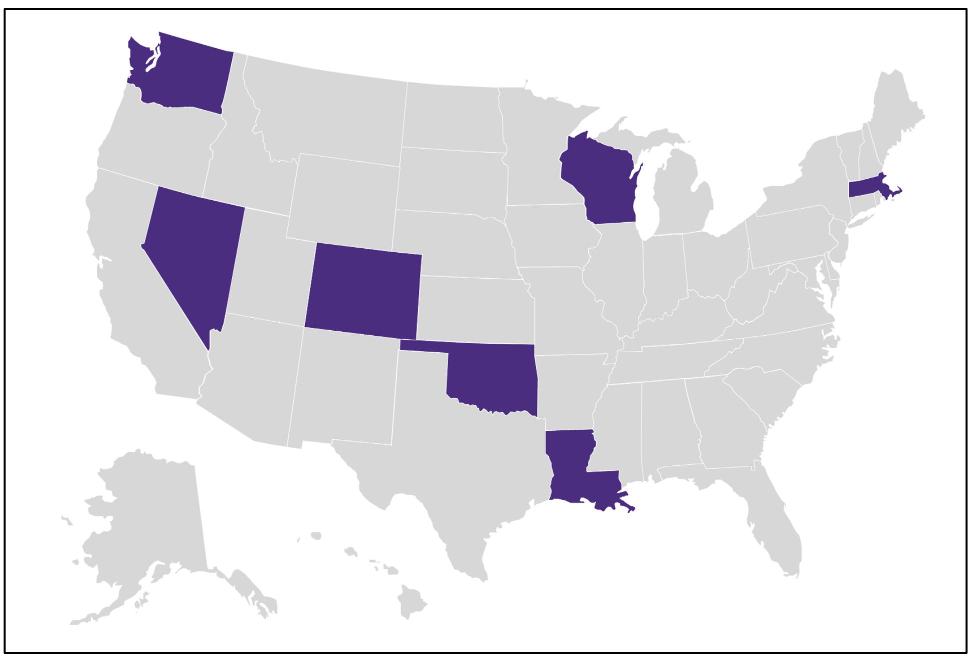
Our outcome of interest was yearly completed shingles vaccination series per 1000 adults aged 50 years and older in 2022. Specifically, we defined this measure as the number of adults age 50+ years who were up-to-date (i.e., completed 2-dose vaccine series) with recombinant zoster vaccination (RZV) between Jan 1 2022 – Dec 31 2022 in each tract, divided by the number of adults age 50 years and older in the tract. This provided a standardized rate of completed shingles vaccinations per population in the age group eligible to be vaccinated. While this is not a measure of population-wide shingles vaccination coverage, it provides a relative comparator of vaccination receipt in each census tract in the same year for which pharmacy access status was calculated.

We obtained vaccination data from a convenience sample of seven participating state DOH's Immunization Information System (IIS): Colorado, Louisiana, Massachusetts, Nevada, Oklahoma, Washington, and Wisconsin (**Figure 4**). To obtain that sample, we visited the DOH websites of all 50 states, identified and contacted the 24 that allowed vaccination data requests for research, and received datasets that were compatible with the needs of this analysis from the seven states listed. These states are geographically distributed throughout the country, reflect a wide variety of sociodemographic patterns, and have a range of low (Massachusetts, 43rd-highest state) to high (Colorado, 4th-highest state) proportions of their population living in pharmacy deserts.[101] Each participating state Department of Health (DOH) provided several notes and limitations to the reported IIS data (**Appendix D**), including lack of mandatory reporting of shingles vaccinations for all providers and suppression of census tracts with counts <10 individuals.

Figure 3. Graphic depiction of "pharmacy desert" (main analysis) versus "low-pharmacy-access" (secondary analysis) definitions

Notes: The main analysis evaluated the impact of pharmacy desert status. The secondary analysis evaluated the impact of low pharmacy access, regardless of income status. This broader category of "low access" tracts includes the tracts that are pharmacy deserts.

Figure 4. Participating state Immunization Information Systems



Notes: States in purple indicate inclusion in the dataset for analysis

2.1.3 Covariates

We selected covariates associated with shingles vaccination for inclusion in our propensity score creation based on previous published literature **(Table 4).**[21,34,104–107] These covariates were primarily calculated as proportions within the census tract population, with exceptions of population-to-primary-care-provider ratio, political party, and self-reported health status of "fair" or "poor," which were each calculated at the county level and applied to all tracts within that county. When data on a covariate was missing for a particular census tract, the median value of that covariate in the state was used.[108] Data for these covariates were primarily sourced from the 2017-2021 5-year ACS.[61]

Table 4. Covariates included for propensity score generation and matching

Characteristic (*Reference*)	**Tract-level covariate**	**Covariate data source**
Older age (*Lu 2017*)	Prop. population 65+ yrs.	2021 5-year ACS
	Prop. population 50-65 yrs.	2021 5-year ACS
State (*Lu 2017, Patterson 2022, Tak 2019*)	State (state-level)	state IIS data (not publicly available)
Marital status (*Lu 2017*)	Prop. population married	2021 5-year ACS
Gender (*Zhang 2016, Lu 2017, Harpaz 2008*)	Prop. female	2021 5-year ACS
Race/ethnicity (*Lu 2017*)	Prop. by race/ethnicity (various)	2021 5-year ACS
Poverty status, employment (*Lu 2017, Harpaz 2008*)	Median household income	2021 5-year ACS
	Prop. receiving public assistance income	2021 5-year ACS
	GINI Index	2021 5-year ACS
Healthcare use (*Lu 2017, Harpaz 2008, Shuvo 2021, Zhang 2016, Patterson 2022*)	Prop. no health insurance	2021 5-year ACS
	Prop. public insurance	2021 5-year ACS
	Population-to-PCP ratio (county-level)	Health Resources and Services Administration, HHS
	Prop. self-reported perceived health status "fair" or "poor" (county)	Behavioral Risk Factor Surveillance System, US CDC
	Prop. high school degree or less	2021 5-year ACS

Education & health literacy (Lu 2017, Harpaz 2008, Shuvo 2021, Uscher-Pines 2023)	Prop. grad or professional degree	2021 5-year ACS
	Prop. with household internet access	2021 5-year ACS
	Prop. don't speak English well, self-reported	2021 5-year ACS
Political Party (Shuvo 2021)	Voted Democrat in 2020 presidential election (county-level)	state Boards of Election

2.2 Dataset creation

We linked the previously described data sources to create the analytic dataset. Across the seven states in this study, this linked dataset contained 9,765 total census tracts. Of these, 106 were removed for having undetermined pharmacy desert status (31 had no income data and 75 had a total population of zero). Seven tracts were removed based on assumed mis-recording of patient addresses: five for having reported shingles vaccinations despite having a population of 0, and two tracts for having shingles vaccination completions of greater than 1000 per 1000 population. The two tracts were manually checked and confirmed to be tracts containing medical facilities, and the reported shingles vaccinations for these individuals were likely due to using the facility address in the patient records rather than the patients' residential addresses, and thus were not suitable for this analysis.

The final dataset for analysis contained 9,652 census tracts containing 13,677,410 adult residents aged 50 years and older. Of the 9,652 tracts, 646 (6.7%) were pharmacy deserts (main analysis), and 1,798 (18.6%) were low-access census tracts (secondary analysis). An unadjusted *t*-test of mean shingles vaccination completions per 1000 population between the pharmacy desert and non-pharmacy-desert groups showed vaccination completion rates were lower in pharmacy desert tracts (38.2 vs 48.5, $p<0.001$). The unadjusted *t*-test of means in the low-access and non-low-access tracts also indicated fewer shingles vaccination completions in the low access tracts (42.1 vs. 49.1, *p*<0.001). The two exposure groups were different across most covariates prior to matching (**Table 5**).

Table 5. Distribution of sample covariates pre-matching

Covariate Mean (SD)	Pharmacy Desert (N=646)	Not Pharmacy Desert (N=9,006)	Overall (N=9,652)
Shingles per 1000 pop.	38.2 (47.6)	48.5 (24.3)	47.8 (26.6)
State			
Colorado	140 (21.7%)	1292 (14.3%)	1432 (14.8%)
Louisiana	84 (13.0%)	1282 (14.2%)	1366 (14.2%)
Massachusetts	54 (8.4%)	1540 (17.1%)	1594 (16.5%)
Nevada	56 (8.7%)	715 (7.9%)	771 (8.0%)
Oklahoma	73 (11.3%)	1123 (12.5%)	1196 (12.4%)
Washington	147 (22.8%)	1622 (18.0%)	1769 (18.3%)
Wisconsin	92 (14.2%)	1432 (15.9%)	1524 (15.8%)
Demographics			
Prop. Age 65+ years	0.153 (0.0984)	0.165 (0.0770)	0.164 (0.0786)
Prop Age 50+ years	0.333 (0.137)	0.368 (0.100)	0.365 (0.104)
Prop. Married	0.412 (0.149)	0.497 (0.137)	0.492 (0.139)
Prop. Female	0.494 (0.0698)	0.502 (0.0478)	0.501 (0.0496)
Income and education			
Median Income	49100 (14100)	78300 (36200)	76300 (35900)
GINI Index	0.435 (0.0707)	0.419 (0.0674)	0.420 (0.0678)
Prop Receiving Income Asst.	0.202 (0.125)	0.127 (0.111)	0.132 (0.113)
Prop. HS Education or less	0.326 (0.104)	0.271 (0.112)	0.274 (0.112)
Prop. Grad or Prof. Degree	0.0590 (0.0503)	0.122 (0.101)	0.117 (0.0995)
Prop. Access to Internet	0.818 (0.112)	0.874 (0.0951)	0.870 (0.0973)
Prop. Low English-speaking	0.0387 (0.0641)	0.0199 (0.0484)	0.0212 (0.0498)
Healthcare and insurance			
Prop. No Insurance	0.131 (0.0910)	0.0850 (0.0746)	0.0880 (0.0766)
Prop. Public Insurance	0.420 (0.149)	0.356 (0.123)	0.361 (0.125)
Pop to PCP Ratio	1970 (2440)	1640 (1510)	1660 (1590)

Covariate Mean (SD)	Pharmacy Desert (N=646)	Not Pharmacy Desert (N=9,006)	Overall (N=9,652)
Prop. Poor Health Status	0.147 (0.0399)	0.136 (0.0395)	0.137 (0.0396)
Race and ethnicity			
Prop. Race NH White	0.533 (0.261)	0.668 (0.235)	0.659 (0.239)
Prop. Race NH Black	0.131 (0.208)	0.0970 (0.181)	0.0993 (0.183)
Prop. Race NH AIAN	0.0310 (0.102)	0.0137 (0.0394)	0.0148 (0.0465)
Prop. Race NH Asian	0.0384 (0.0640)	0.0467 (0.0732)	0.0461 (0.0727)
Prop. Race Hisp. White	0.0980 (0.115)	0.0567 (0.0739)	0.0595 (0.0781)
Voted Dem. In 2020	0.536 (0.499)	0.568 (0.495)	0.565 (0.496)

2.3 Statistical approach

2.3.1 Rationale for approach

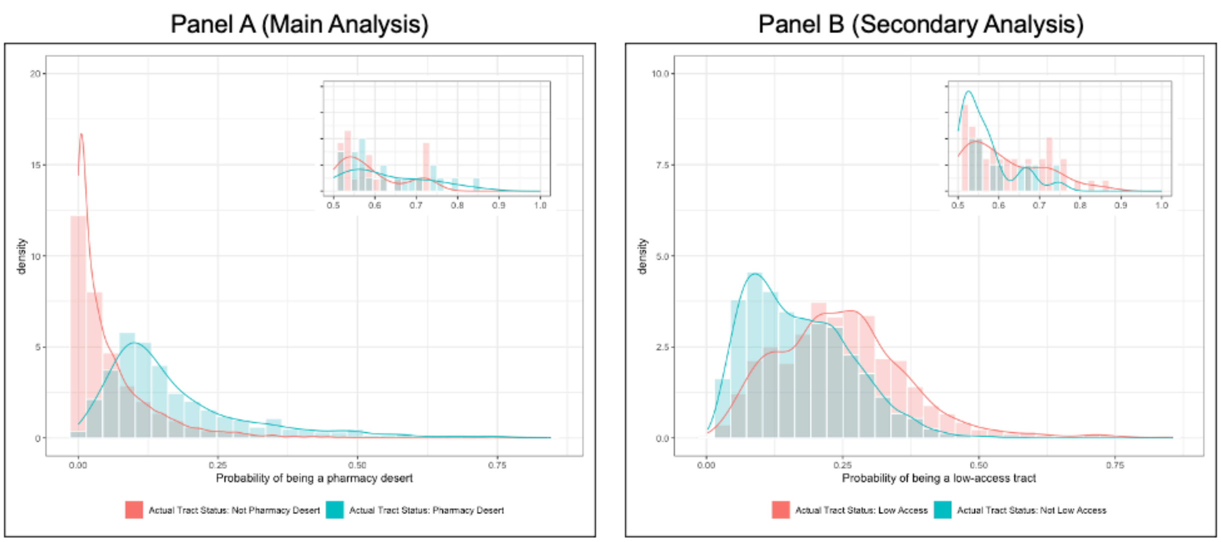
To evaluate our hypothesis, we designed a propensity score analysis. This approach is well-suited to address residential selection bias—a key concern with evaluating the effects of neighborhood-level variation, such as access to pharmacies. Propensity score matching generates a propensity score for each observation, then creates a matched set of "exposed" and "unexposed" groups —in this case pharmacy deserts and non-pharmacy-deserts—with which to conduct the final analysis.[109] This approach typically reduces bias more successfully than stratification or covariate adjustment alone.[110,111]

2.3.2 Propensity score generation and matching

We generated propensity scores using a logistic regression model. Before proceeding with the analysis, we visually checked the region of common support to confirm qualitatively that there was adequate overlap for evaluation (**Figure 5**). We also divided the generated scores into quintiles and used a *t*-test to confirm that the mean scores comparing exposure vs. nonexposure groups in each quintile were not statistically different. We then created a matched dataset, iterating on the matching algorithm until a pre-specified covariate balance of |SMD| <0.01 was achieved for all covariates (**Figure 6**). To achieve this balance, we used nearest-neighbor matching within a caliper of 0.05 and a ratio of 2 non-pharmacy-desert to 1 pharmacy desert tract, without replacement.

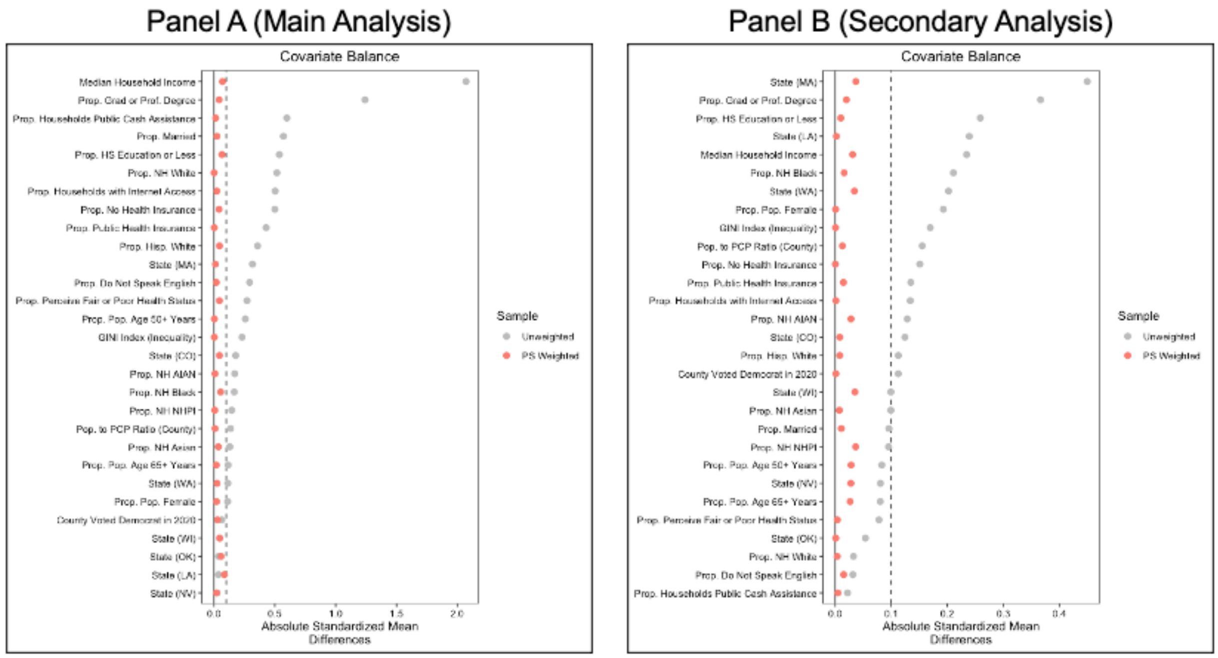
The matched sample for the main analysis included 628 pharmacy desert and 1,230 non-pharmacy desert tracts. There remained 18 and 7,776 unmatched pharmacy desert tracts and non-pharmacy-desert tracts, respectively. For the secondary analysis, the matched dataset contained 1,743 low-access tracts and 3,295 non-low-access tracts (leaving 45 and 4,569 unmatched low-access and not-low-access tracts, respectively).

Figure 5. Region of common support of generated propensity scores pre-matching for main analysis (panel a) and secondary analysis (panel b)



Notes: Distribution of propensity scores in pharmacy desert and non-pharmacy-desert tracts. The inset plot shows a zoomed-in view of the upper tail of the distribution to visually check region of common support of these values. Panel (a) corresponds to the main analysis (evaluation of pharmacy desert tracts) and panel (b) corresponds to the secondary analysis (evaluation of all low-pharmacy-access tracts).

Figure 6. Standardized mean differences between treated versus untreated groups, pre- and post-matching for main analysis (panel a) and secondary analysis (panel b)



Notes: Covariate balance before and after matching on propensity scores. Panel (a) corresponds to the main analysis (evaluation of pharmacy desert tracts) and panel (b) corresponds to the secondary analysis (evaluation of all low-pharmacy-access tracts).

2.3.3 Statistical analysis plan

We used a linear regression model to evaluate our outcome using the matched dataset and corresponding sample observation weights. This final model included shingles vaccination completions per 1000 population as the outcome, pharmacy desert status as the exposure, and all balancing covariates to further account for any remaining imbalances (the “doubly robust” approach).[109,112] We used cluster-robust standard errors to account for the uncertainty in the propensity score generation process.[113] Model output from propensity score matched analyses are interpretable as the average effect of treatment among the treated (ATT); that is, we estimated the average effect of living in a pharmacy desert on completed shingles vaccinations per 1000 people, as compared what the rate would have been if that neighborhood was not a pharmacy desert. The same matching and evaluation approach was applied for the secondary analysis on low-access tracts. Statistical significance was evaluated with two-sided tests at a critical-$\alpha = 0.05$. All analyses were conducted using R version 4.3.2,[69] and utilized the tidycensus and MatchIt packages.

3. Results

Primary analysis: Association between pharmacy deserts and shingles vaccination rates. Census tracts classified as pharmacy deserts had 0.4 fewer shingles vaccination completions per 1000 population as compared to tracts that were non-pharmacy-deserts, though this main effect was not statistically significant ($p = 0.83$; 95% CI -3.8, 3.6) (**Table 6**).

Secondary analysis: Association between low pharmacy access areas and shingles vaccination rates. Census tracts that were classified as low pharmacy access had an ATT of 2.4 fewer vaccinations per 1000 population compared to tracts that were classified as having adequate pharmacy access (p=0.004, 95% CI: -3.9, -0.7) (**Table 6**).

Table 6. Analysis results for primary and secondary analyses

	Primary Analysis: Pharmacy Desert Tracts			Secondary Analysis: Low-Access Tracts		
Predictors	Estimates	Std. Error	p	Estimates	Std. Error	p
Intercept	33.26	20.81	0.110	31.32	15.58	0.044
Pharmacy Desert (primary analysis) | Low Access Tract (secondary)	-0.37	1.74	0.830	-2.35	0.80	0.003
State						
State: Louisiana	14.83	2.50	<0.001	9.78	1.50	<0.001
State: Massachusetts	20.41	7.33	0.005	24.55	3.31	<0.001
State: Nevada	-4.40	2.06	0.032	-6.30	1.32	<0.001
State: Oklahoma	42.27	3.35	<0.001	33.57	2.36	<0.001
State: Washington	18.22	1.93	<0.001	18.81	1.16	<0.001
State: Wisconsin	29.12	2.17	<0.001	32.64	0.99	<0.001

Demographics						
Proportion of Pop. 65+	-5.31	12.09	0.660	17.46	10.01	0.081
Proportion of Pop. 50+	-9.18	13.57	0.499	-22.74	10.22	0.026
Prop. Married	-33.48	13.34	0.012	-17.49	7.65	0.022
Prop. Female	47.94	13.82	0.001	25.24	15.63	0.106
Income and Education						
Median Income	0.00	0.00	0.050	0.00	0.00	0.007
GINI Index	28.88	16.99	0.089	4.30	12.05	0.721
Prop. Income Assistance	-21.85	18.50	0.238	-10.53	11.57	0.363
Prop. HS Education or Less	-31.13	20.92	0.137	-30.01	12.98	0.021
Prop. Grad or Prof Degree	-54.12	48.22	0.262	20.55	31.71	0.517
Prop. Access to Internet	-9.43	18.79	0.616	3.12	11.57	0.788
Prop. Low English Proficiency	11.50	18.20	0.528	17.51	12.48	0.160
Healthcare and insurance						
Prop. No Health Insurance	-27.95	11.39	0.014	-29.49	8.31	<0.001
Prop. Public Health Insurance	-6.76	8.95	0.450	-20.41	6.10	0.001
Pop to PCP Ratio	0.00	0.00	0.920	0.00	0.00	0.411
Prop. Low Health Status	-126.61	24.15	<0.001	-68.96	17.64	<0.001
Race and Ethnicity						
Race: NH White	1.07	7.45	0.886	7.93	5.06	0.117
Race: NH Black	-1.12	7.35	0.879	10.20	4.86	0.036
Race: NH AIAN	46.32	17.17	0.007	80.90	25.13	0.001
Race: NH Asian	41.09	19.00	0.031	28.08	9.56	0.003
Race: NH NHPI	-50.03	32.83	0.128	-41.03	21.94	0.061
Race: Hisp. White	25.44	7.51	0.001	30.15	6.02	<0.001
Voted Dem. in 2020 Election	3.22	1.27	0.011	4.91	0.72	<0.001
Observations	1858			5038		
R^2 / R^2 adjusted	0.269 / 0.257			0.406 / 0.403		

4. Discussion

To our knowledge, this is the first analysis to evaluate the correlation between pharmacy access and utilization of a vaccination in the general population.[13] Our primary analysis revealed no significance difference in vaccination completions between census tracts classified as pharmacy deserts and non-deserts. However, we found that vaccination rates were lower in tracts with low spatial access to pharmacies (secondary analysis, a broader classification), accounting for differences in demographics, education level, healthcare access, race/ethnicity, and other sociodemographic factors. To contextualize the magnitude of this effect derived from our secondary analysis, if our estimate was applied to the 15.6 million adults age 50+ who are living in low-pharmacy-access tracts nationally,[101] this disparity translates to a deficit of 36,738 (95% CI: 12,031 – 61,447) shingles vaccinations in 2022. Previous research has shown that even a modest increase in shingles vaccination coverage can have a clinically and economically significant impact on the health of unvaccinated adults.[114]

Community pharmacies are important access points for healthcare, and consequences of poor geographic access can impact population health such as lower vaccine coverage. This conclusion aligns with a similar study that found that the patients living in the lowest pharmacy access quintile were associated with lower odds of obtaining influenza vaccinations.[13] Similarly, a study of pharmacy closures found that patients experienced a clinically significant decline in adherence to their cardiovascular medications when their local pharmacy closed.[15] Beyond the pharmacy access literature, the association between low geographic access to other provider types (such as primary care physicians) and poor patient health outcomes is well-documented.[115–118]

4.1 Implications for policy, practice, and research

There are multiple policy mechanisms being considered at the state and federal levels that may slow pharmacy closures and improve the ability of pharmacists to provide services in low-access areas. These include granting "provider status" to pharmacists to bill and be compensated for patient care services, enhancing federal support for pharmacies located in medically underserved areas, regulating pharmacy benefit managers contracting and reimbursement practices, and expanding telehealth capabilities.[44,49,70,85,101] Beyond community pharmacies, pilot programs linking hospital patients with hospital-pharmacy-based shingles vaccinations can increase vaccine access,[119] and non-pharmacy-based vaccination services such as mobile vans and workplace drives can also fill spatial gaps in access.

Lastly, these results have implications for future research on pharmacy deserts. The results of this study suggest that the income component of the pharmacy desert definition may not add a useful level of precision to identify communities with low pharmacy access. However, more research is needed to validate a standardized pharmacy desert definition that includes neighborhood income levels as a component before ruling out its importance, as 1) it is possible that poor pharmacy access renders a vaccination more difficult but not impossible, and may still have important patient health consequences such as delayed vaccinations,[34,105] and 2) our small pharmacy deserts sample may not have been powered to detect a statistically significant difference of small magnitude. Additionally, the role of pharmacy access should be further explored by creating more granular definitions of acceptable travel distances, frequencies of pharmacy use, and pharmacy capacity for patient volume[120,121] in order to identify the presence of any gradient or threshold effects. Those data will be crucial to inform an empirical foundation for defining "appropriate" levels of pharmacy access for use in future policies and programs.[13,120]

Looking ahead, the three largest pharmacy chains have announced planned closures of over 1,500 stores,[40] and the number of neighborhoods that are classified as pharmacy deserts is likely to grow.[7,101] Existing inequities in pharmacy access and consequent disparities in access to services such as vaccinations may be expected to increase accordingly. We hypothesize that the effect size on vaccination completions seen in this study will continue to increase with closures of pharmacies.

4.2 Strengths and limitations

Our study design has notable strengths. This is one of a very limited number of studies to examine the effects of pharmacy deserts and low pharmacy access on real-world vaccinations, and the first to evaluate these effects for shingles vaccinations.[13] We use census tract-level data to define both our exposure and our outcome, which is an essential level of detail to understand neighborhood-level effects and yet patient data at this granularity are only rarely available. Propensity score matching is a well-established statistical approach that efficiently adjusts for confounding across many covariates, for which we followed all best practices.

There are limitations to our study to consider. Our dataset was based on a convenience sample of only seven states, and the statistical analysis results revealed significant differences by state even after matching on propensity score, which may indicate the limited generalizability of these results to other U.S. states. The state IIS datasets present multiple limitations in defining both the exposure and the outcome variables for analysis. For instance, shingles vaccination reporting is not mandatory in most states (though survey and implementation research indicate that IIS use and reporting in pharmacies is high[98,122]), and for this analysis we had to assume that this under-reporting was non-differential across our exposure groups. Further, shingles vaccination was selected for this study because published evidence indicates it is primarily delivered in pharmacies, however data from these sampled states indicate there are exceptions to this: according to the data from Wisconsin's IIS, only 43% of shingles vaccinations were provided in pharmacies there. This likely attenuates any effect of pharmacy desert residence on shingles vaccination completions in that state. Further, our measure of series completions per population in a single year presents challenges in measuring the denominator: the relative proportion of individuals who are age 50 in the year of the analysis relative to those who are already 51+ leaves a variable pool of eligible people in the single year of analysis. Additional data caveats are listed by state in **Appendix D**.

In addition to these data limitations, propensity score methods do not account for any unmeasured confounding. In other words, any factors driving shingles vaccinations that were not explicitly accounted for as covariates in our analysis may influence the result. In particular, since our unit of analysis was census tract, we do not account for individual-level variables that are known to be important such as health plan type, perceived individual risk, and recommendation from a primary care provider.[34,106,123,124] These and many other factors all affect access as defined in the broad sense, which can encompass transportation, language spoken, affordability, appropriateness of care, and much more that is not captured in our study's approach to defining access (primarily geographically).[77]

5. Conclusion

The results of this propensity score matching analysis in seven U.S. states demonstrated that worse spatial access to pharmacies is associated with fewer completions of shingles vaccination per population. This indicates negative consequences for patient utilization of pharmacy-based health services and ultimately patient health outcomes due to poor access to pharmacies. Pharmacy-centered vaccination programs supported by state and national policies to bolster community pharmacy practices may alleviate these access challenges and improve patient access to important health services.

Chapter 3. VACCINATION PAYMENTS IN STATES WITH PROVIDER STATUS RECOGNITION FOR PHARMACISTS: A COMMERCIAL CLAIMS ANALYSIS

Abstract

Federal-level legislation to formally recognize pharmacists as providers and thus allow insurance reimbursement for health services claims, not just prescription drug claims (known as "provider status"), has been advocated for within the profession for many years but is yet to be passed into federal law. In the meantime, several state governments have enacted provider status recognition for commercial insurance and/or Medicaid plans. However, the impact of these laws on reimbursement and patient access to health services has yet to be explored empirically. Our objective was to compare reimbursements for influenza and herpes zoster vaccinations for adults in provider status vs non-provider-status states to explore whether these laws have had the intended effect of increasing reimbursement to pharmacists for services they provide. We used pharmaceutical claims and outpatient services claims data housed in Marketscan, a national commercial claims database, to examine payments made to pharmacies for all codes billed during a single vaccination visit. We then used a multivariable logistic regression model to compare the profitability of vaccination visits in provider status states versus non-provider-status states. Our dataset contained 2.3 million vaccination visits during 2021-2022. We found that the odds of a vaccination visit being profitable were slightly higher in provider status states (shingles vaccination OR: 1.013, $p<0.001$; influenza vaccination OR 1.007:, $p<0.001$). These findings are limited by the stark lack of health services claims by pharmacies in our dataset; only 0.4% of

visits included any outpatient services claims, even among provider status states. This indicates that pharmacists are not submitting claims for reimbursement to payors for services they are providing. This absence could be due to a number of reasons. In any case, limits the ability to generate evidence about the effect of these laws on health and economic outcomes for patients and health systems.

1. Background

Community pharmacies are important access points for healthcare. In addition to dispensing medications for acute and chronic health conditions, pharmacists provide a variety of healthcare services including tobacco cessation counseling, opioid management services, medication therapy management, medication counseling, testing for certain illnesses, and vaccinations.[1,3,4,125] Despite their importance, community pharmacies throughout the United States are closing.[126] In recent years, three of the largest pharmacy chains have announced the upcoming closures of over 1,500 stores.[40] One reason commonly cited for these pharmacy closures is financial pressures and inability to sustain a profitable business.[7]

The sustainable financing of community pharmacies has been the focus of a number of state and national-level reform efforts including addressing pharmacy benefit managers (PBMs) transparency and reimbursement practices,[44,86] addressing staffing challenges,[84] leveraging telepharmacy and other innovative care delivery models,[70] and broadening sources of revenue through expanded clinical services and retail offerings.[83] One of these strategies is a type of payment reform to establish provider status for pharmacists, which refers to the formal recognition pharmacists as providers of healthcare services to patients and thus eligibility for reimbursement by health insurers.[47,49] Despite their importance on the patient care team, pharmacists are not officially recognized with respect to health insurance coverage as "healthcare providers" at the federal level.[46,127] This means that, unlike other healthcare professionals (e.g., physicians, nurse practitioners, clinical psychologists),[46] pharmacists can typically only use billing codes under insurance plans' prescription drug benefit (ingredient costs and dispensing fees), but not the medical benefit (patient care services).[47] This disconnect is a key area where the pharmacy profession is seeking reforms to update their business model and improve financial viability of providing health services.[48,85]

Allowing pharmacists to be reimbursed for services under the health insurance medical benefit rather than only the prescription drug category may result in re-alignment of financial incentives with patient and population health outcomes by increasing the revenue pharmacies receive for providing patient services.[47,128] Under the current system, these services are typically not reimbursed by health insurance plans.[47,49] The economic rationale for pharmacy payment reform, as in other healthcare disciplines, is straightforward: pharmacy providers will be incentivized to offer services that bring in higher revenue (or, at minimum, those which do not incur a net financial loss). While there is extensive empirical evidence of this relationship for primary care services,[129] and a theoretical basis for the same pattern in pharmacist-provided services,[130,131] empiric evidence documenting this relationship for community pharmacies is sparse.[128,132–134]

The most impactful level of provider status implementation for pharmacists would be recognition at the federal level. This is especially important because the scope of federal-level changes includes Medicare—the largest insurance payor in the nation—and commercial payors often adapt following Medicare's lead. However, in lieu of federal-level recognition, incremental steps have been taken at the state level.[127] Several states have implemented reimbursement regulations specifying that pharmacists are recognized as healthcare providers and as such are subject to similar reimbursements as other healthcare providers for certain services by commercial and Medicaid payors.[49–51] The implementation in these select states provides a natural experiment in which to compare reimbursements for pharmacist-provided health services in commercial insurance claims.

Routine adult immunizations such as for herpes zoster (shingles) and seasonal influenza (flu) provide a useful case study for evaluation of health services reimbursement for a few reasons. Firstly, they are commonly provided in pharmacies: more seasonal influenza vaccinations are provided in pharmacies than other healthcare locations,[35] and the majority of shingles vaccinations are provided in pharmacies.[34] Secondly, they are recommended for patients of ages who typically have commercial insurance (starting at age 50 for shingles and annually after age 18 for influenza). Lastly, vaccinations have multiple health services billing codes associated with their provision, administration, and patient counseling (**Appendix F.1**). As such, pharmacy-based vaccinations are a good proxy to answer two research questions: 1) whether pharmacies are being reimbursed for health services in provider status states at all (i.e., is the law being implemented); and 2) whether the reimbursements for patient services are higher in provider status states compared to non-provider-status states (i.e., is it having the intended financial effect).

The objective of this study was to evaluate the effect of provider status laws on reimbursement to pharmacies for vaccination services. We hypothesized that pharmacist-provided vaccination visits in states with provider status laws would have higher odds of being profitable as compared to vaccination visits in states without those laws, among commercial insurance claims.

2. Methods

2.1 Approach

This was a cross-sectional retrospective study to investigate reimbursements to community pharmacies in states with versus without "provider status" recognition for pharmacists. We adhered to the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) guidelines for reporting on cross-sectional studies.[135]

2.2 Key Measures

Unit of analysis. Our unit of analysis was a patient vaccination visit. This comprised any claims for vaccination-related drugs or services delivered by a pharmacist in a pharmacy on a specific day, including the vaccine itself, administration, and patient counseling services.

Outcome. We selected two vaccinations to evaluate which are both frequently administered in community pharmacies: seasonal influenza and herpes zoster (shingles).[34,35,136] Our outcome measure for each vaccination was a binary indicator of profitability of vaccination visit. We defined profitability as whether the total payment to a pharmacy for a vaccination visit was greater than the private sector list price for the vaccine product that was administered.[137] We calculated the total payment to a pharmacy for a vaccination visit by summing the paid claim for a vaccination along with any vaccine administration or counseling service that also occurred on that day. All product and service codes used are listed in **Appendix F.1**.

Predictor. Our independent variable was whether that state recognized pharmacists as healthcare providers with respect to billing insurance for vaccination services. We limited this to include only states which allow for commercial insurance billing, rather than provisions for state Medicaid programs, primarily because our data source (described next) only included commercial claims. To be included, the state's provider status law must have been in effect for commercial insurers beginning January 2021. Lastly, we excluded states who have universal vaccine purchase programs which purchase and distribute adult vaccines to participating providers (Alaska, Hawaii, Rhode Island, and Vermont).[123] The six states which meet all of these inclusion criteria are: New Mexico, Ohio, Tennessee, Texas, Washington, and West Virginia.

Covariates. Covariates in the model for each vaccine dataset (influenza and shingles vaccination visits) to adjust for possible confounding were patient age, patient sex, year of vaccination, health plan type, and whether the patient lived in an urban or rural area. Further details on these key measures are available in **Appendix F.2.**

2.3 Data source and sample creation

Our data was sourced from the Merative MarketScan® Commercial Claims and Encounters (CCAE) Databases of Outpatient Services and Pharmaceutical Claims. These files contained de-identified, individual-level healthcare claims for individuals who are members of employer-sponsored health plans nationally. We evaluated patient claims between January 1, 2021, and December 31, 2022, which were the two most recent years available and are after the effective date of the selected states' provider status laws. The private sector list price for each vaccination throughout the time period was sourced from the U.S. Centers for Disease Control and Prevention's Vaccine Price List by NDC code. Archived versions of the page approximately each month between January 2021 and December 31, 2022, were examined to track changes in NDC codes and list prices for influenza and shingles vaccinations throughout the study period.

We used two tables within MarketScan to create our datasets for influenza and shingles vaccinations: pharmacy claims data and outpatient services claims data. The pharmacy claims data contained the National Drug Code (NDC) number for each vaccination, payments from insurance claims, patient contributions (copay, coinsurance, deductible), service date, and patient age and sex. The outpatient services claims contained the Current Procedural Terminology (CPT) code for each service, patient and plan payments, provider type (e.g., nurse, pharmacists), care location (e.g., pharmacy, clinic, inpatient hospital), service date, and patient age and sex.

For shingles vaccinations, we first limited the pharmacy and services claims data to adults aged 50+ years who had received a shingles vaccination in 2021 or 2022 (defined using CPT codes in the services table and NDC codes in the pharmacy table). Within the outpatient services table, we restricted the data to include only vaccination services provided by a pharmacist (provider type) in a pharmacy (care location), removed claims from capitated payment and HMO insurance plans, and limited outpatient services claims to enrollees whose plans contributed both services and pharmacy claims data to MarketScan to verify completeness of billing for each vaccination visit. Claims in any table with no enrollee ID, missing payment fields, or no billing code were also excluded, as were any payments with totals that were more than five standard deviations away from the mean.

Within these restricted pharmacy and services claims tables, we then created a unique visit identification number by combing the patient's enrollee ID and the service date in each the outpatient services claims table and the pharmacy claims table, and merged the two tables to thus create a single dataset with each row corresponding to a pharmacist-provided vaccination visit and columns for any services claims and drug claims that were billed during that visit. The total amount paid to the pharmacy, including both patient and plan contributions, was summed and compared to the private sector list price (**Appendix F.1**) for the vaccine to calculate our outcome variable: profitability of vaccination visit. We classified states as "provider states" or not, creating the binary variable for our predictor of interest as described in section 2.2 above.

We repeated this same process for influenza vaccinations, this time including all adults aged 18+ years. To capture influenza vaccination, we used the 30 NDC codes (pharmacy claims) and six CPT codes (services claims) corresponding with influenza vaccination delivery at various time points throughout the study period. The total pharmacy payment for a visit was compared to the private sector price for each specific NDC/CPT code in each influenza season.

2.4 Statistical analysis plan

Characterization of study population and vaccination visits. We first descriptively analyzed the characteristics of the patients and each vaccination visit within our sample. We summarized the mean patient age, patient sex, patient health plan types, urbanicity, and year of vaccinations. We also evaluated the proportion of visits that had a pharmacy claim or service claim (or both), mean reimbursement paid to the pharmacy for the visit, and proportion of vaccination visits that were profitable or not. These are summarized both overall and by provider status states versus non-provider-status states.

Correlates of profitability of vaccine administration. We used a multiple logistic regression model to evaluate the association between vaccination visit profitability and state provider status laws, adjusting for known confounders of age, sex, year, and health plan type. Our model is shown in **Equation 1** (below). Significance was evaluated using a two-sided test with critical-$\alpha = 0.05$. We applied the same regression model to shingles vaccination visits and influenza vaccination visits separately.

Equation 1. Regression model specification for main outcome

$$logit(p_{profit}) = \beta_0 + \beta_1 x_{PS} + \beta_2 x_{age} + \beta_3 x_{sex} + \beta_4 x_{year} + \beta_5 x_{plan} + \beta_6 x_{urban} + \varepsilon$$

Where p_{profit} = proportion of vaccination visits that were profitable (outcome); x_{PS} = binary variable indicating whether that pharmacy is in a "provider status" state (exposure); x_{age} is the patient age category (covariate); and x_{sex} is the sex of the patient (covariate), x_{year} is the year of vaccination, x_{plan} is the patient's health plan type, and x_{urban} is the patient's urban/rural location.

Missed reimbursement opportunities. Post-hoc, we calculated the magnitude of potential missed payments to pharmacists who were reimbursed for only the drug and not the administration service. We calculated this as the hypothetical sum of if the pharmacist *had* billed an administration code for every vaccine visit, as allowed under provider status regulation. The purpose of this analysis was to contextualize the potential financial loss to pharmacists of not receiving reimbursements up to the full extent of regulations in their state. We added this analysis based on the observed results in the aforementioned two planned analyses.

3. Results

3.1 Characterization of study population and descriptive analysis

Our final dataset comprised 360,740 shingles vaccination visits and 1,928,154 seasonal influenza vaccination visits between 2021 – 2022. For both vaccines, there were slightly more vaccination visits in 2022 than 2021 (approximately 48% of included visits were in 2021 vs 52% in 2022), and more females than males (56% vs 44%). More than two-thirds (69%) of shingles vaccinations were in adults aged 55 years and older. The median age of influenza vaccine recipients was 46 (range: 18 – 65) years old. For both vaccines, the majority of visits were in non-provider-status states (83% influenza and 82% for shingles visits). Additional characteristics of the patients who had vaccine visits are listed in **Table 7**. Most claims were drug claims (NDC codes) rather than the services claims (CPT codes), and a very small number of patients (2 shingles, 5 influenza) had both an NDC code and a CPT code billed during their visit.

The average payment to a pharmacy was $176 for a shingles vaccination visit and $34 for an influenza vaccination visit. The private sector list price in 2022 for shingles was $171.57 and ranged between $17.67 - $28.44 for influenza vaccines depending on the specific product. Examining the unadjusted one-way associations, shingles vaccination visits were slightly more often profitable in provider status states (88.6% vs. 88.3%), while influenza vaccination visits were slightly less often profitable in provider status states (90.7% vs 91%). Notably, there was an extremely limited number of claims in the services table (less than half of a percent for both shingles and influenza vaccination visits), even in provider status states. Additional characteristics of the costs and claims of the vaccine visits are listed in **Table 8**. Vaccination visits and profitability by claim type is available in **Appendix F.3.**

Table 7. Characteristics of vaccination visits in sample

	Influenza (N=1,928,154)	Shingles (N=360,740)	Overall (N=2,288,894)
Year of Vaccination			
2021	930132 (48.2%)	172212 (47.7%)	1102344 (48.2%)
2022	998022 (51.8%)	188528 (52.3%)	1186550 (51.8%)
Age Category			
Age 18-26	250776 (13.0%)	-	250776 (11.0%)
Age 27-39	464198 (24.1%)	-	464198 (20.3%)
Age 40-49	404096 (21.0%)	-	404096 (17.7%)
Age 50-54	233797 (12.1%)	111812 (31.0%)	345609 (15.1%)
Age 55-59	273090 (14.2%)	117984 (32.7%)	391074 (17.1%)
Age 60-65	302197 (15.7%)	130944 (36.3%)	433141 (18.9%)
Sex			
Male	853757 (44.3%)	162748 (45.1%)	1016505 (44.4%)
Female	1074397 (55.7%)	197992 (54.9%)	1272389 (55.6%)
Urbanicity			
Rural	95086 (4.9%)	27267 (7.6%)	122353 (5.3%)
Urban	1685243 (87.4%)	302987 (84.0%)	1988230 (86.9%)
Missing	147825 (7.7%)	30486 (8.5%)	178311 (7.8%)
Health Plan Type			

	Influenza (N=1,928,154)	Shingles (N=360,740)	Overall (N=2,288,894)
Basic/major medical	34 (0.0%)	4 (0.0%)	38 (0.0%)
Comprehensive	68875 (3.6%)	19018 (5.3%)	87893 (3.8%)
EPO	13988 (0.7%)	3935 (1.1%)	17923 (0.8%)
POS	346491 (18.0%)	47872 (13.3%)	394363 (17.2%)
PPO	873093 (45.3%)	173710 (48.2%)	1046803 (45.7%)
CDHP	219683 (11.4%)	45276 (12.6%)	264959 (11.6%)
HDHP	405990 (21.1%)	70925 (19.7%)	476915 (20.8%)
Provider Status State			
Not PS State	1598115 (82.9%)	296587 (82.2%)	1894702 (82.8%)
Provider Status State	330039 (17.1%)	64153 (17.8%)	394192 (17.2%)

Note. Abbreviations used stand for EPO: Exclusive Provider Organization, POS: non-capitated Point of Service, PPO: Preferred Provider Organization, CDHP: Consumer-driven Health Plan, HDHP: High Deductible Health Plan.

Table 8. Costs and claims by provider status laws

	Influenza		Shingles		Overall	
	Not PS State (N=1,598,115)	Provider Status State (N=330,039)	Not PS State (N=296,587)	Provider Status State (N=64,153)	Not PS State (N=1,894,702)	Provider Status State (N=394,192)
Total Payment ($)	$34.0 (8.62)	$33.2 (8.28)	$176 (9.92)	$176 (10.4)	$56.2 (52.3)	$56.4 (53.3)
Patient Contribution	$0.09 (1.32)	$0.14 (1.63)	$0.95 (9.17)	$0.87 (8.37)	$0.22 (3.84)	$0.26 (3.70)
Plan Contribution	$33.9 (8.74)	$33.1 (8.44)	$175 (13.8)	$175 (13.5)	$56.0 (52.2)	$56.1 (53.2)
Profitability (%)	91.0% (0.286)	90.7% (0.290)	88.3% (0.322)	88.6% (0.317)	90.6% (0.292)	90.4% (0.295)
Claim Type						
Both	1 (0.0%)	4 (0.0%)	2 (0.0%)	0 (0%)	3 (0.0%)	4 (0.0%)
Drug Claim	1,591,036 (99.6%)	328,650 (99.6%)	295,640 (99.7%)	63,916 (99.6%)	1,886,676 (99.6%)	392,566 (99.6%)
Service Claim	7078 (0.4%)	1385 (0.4%)	945 (0.3%)	237 (0.4%)	8023 (0.4%)	1622 (0.4%)

3.2 Correlates of profitability of vaccination visit.

The odds of a shingles vaccination visit being profitable were higher in provider status states compared to non-provider status states, adjusting for year, age, sex, plan type, and urbanicity (OR: 1.013, *p*<0.001 ; 95% CI: 1.010 – 1.016). The odds of a seasonal influenza vaccination visit being profitable were higher in provider status states compared to non-provider status states (OR 1.007:, *p*<0.001 ; 95% CI: 1.006 – 1.008). For both shingles and influenza vaccination visits, age group and urbanicity of patient's residence were statistically significant covariates. Results of the analyses are listed in **Table 9**.

Table 9. Correlates of profitability of vaccination visit

	Shingles Vaccination Visits			Influenza Vaccination Visits		
Predictors	Estimates	Conf. Int. (95%)	p	Estimates	Conf. Int. (95%)	p
Provider Status State	1.01	1.01 – 1.02	<0.001	1.01	1.01 – 1.01	<0.001
Year (2022)	1.04	1.03 – 1.04	<0.001	0.97	0.97 – 0.97	<0.001
Age: 27-39	NA	NA	NA	1.00	0.99 – 1.00	<0.001
Age: 40-49	NA	NA	NA	0.99	0.99 – 0.99	<0.001
Age: 50-54	NA	NA	NA	0.99	0.99 – 0.99	<0.001
Age: 55-59	1.00	1.00 – 1.01	0.001	0.99	0.98 – 0.99	<0.001
Age: 60-65	1.01	1.01 – 1.01	<0.001	0.98	0.98 – 0.98	<0.001
Sex (Female)	1.00	1.00 – 1.00	0.702	1.00	1.00 – 1.00	0.717
Plan Type: Comprehensive	0.99	0.53 – 1.84	0.977	1.00	0.89 – 1.12	0.995
Plan Type: EPO	1.00	0.54 – 1.85	0.995	1.01	0.90 – 1.13	0.910

Plan Type: POS	0.99	0.53 – 1.84	0.981	0.89	0.80 – 1.00	0.048
Plan Type: PPO	0.85	0.46 – 1.58	0.614	0.93	0.83 – 1.05	0.234
Plan Type: CDHP	0.95	0.51 – 1.77	0.882	0.96	0.86 – 1.08	0.504
Plan Type: HDHP	0.96	0.52 – 1.78	0.899	1.00	0.89 – 1.12	0.985
Urbanicity: Urban	1.01	1.01 – 1.01	<0.001	0.99	0.99 – 1.00	<0.001
Observations	330254			1779812		
R^2	0.045			0.021		

3.3 Missed reimbursement opportunities

In 99.7% of the shingles vaccination visits and 99.6% of influenza vaccination visits, pharmacists billed a CPT or NDC code for the vaccine product but no code for the administration of the vaccine or patient counseling time. Among the outpatient services claims that were billed (0.04% of the sample), the majority (93%) of vaccination visits had an administration claim alongside the primary vaccine code claim. The mean payment for the most common vaccine administration CPT code (90471) was $12.90 for shingles (sd: 0.71) and $12.90 for influenza (sd: 1.05). We applied this amount to the number of vaccinations where the drug product code was reimbursed but no administration code. Within the sample of shingles and influenza vaccination visits in the six provider status states, this amounts to $412,658 per year in missed reimbursements for shingles vaccine administrations (63,978 visits over 2 years with no administration code billed) and $2.12 million per year in missed reimbursements for influenza vaccine administrations (328,670 visits over 2 years). Applying this to all shingles and influenza vaccination visits in Marketscan nationally with no administration code billed, if pharmacists in all states were able to bill for services in addition to drugs, this would equal $2.32 million per year in missed administration reimbursements for shingles vaccinations (359,630 visits over 2 years) and $12.38 million per year in missed administration reimbursements for influenza vaccinations (1,919,864 visits over 2 years). These calculations are summarized in **Appendix F.3**.

4. Discussion

4.1 Summary of findings

Our statistical results indicate that provider status laws were associated with slightly higher yet statistically significant higher odds of a vaccination visit being profitable. Despite the statistical significance, the magnitude of the effect is small and likely has no practical impact on a pharmacy's likelihood of being profitable. One important reason for this is the near-total lack of health service claims billed by pharmacists in provider status states. These data highlight that despite having the legal and regulatory authority to be reimbursed by commercial insurance plans for provision of certain health services, there are very few services claims being billed for adult vaccinations by pharmacists. Since an intended effect of provider status policies is to facilitate this mechanism, the observation that only a fraction of a percent of vaccination visits in provider status states were from services claims—a low proportion and the same as in non-provider-status states—was surprising. This precludes a more rigorous evaluation of the health and economic effects of increased pharmacy revenue from provision of health services.

We also calculated the hypothetical sum of reimbursements if pharmacists in provider status states *had* been paid for administration services (approximately $13 per vaccination visit) alongside payment for dispensing the vaccine products. The total amounts were $412,658 per year for shingles vaccinations and $2.12 million per year for influenza vaccinations for visits, just in the Marketscan sample in the six provider status states included in the study. These amounts are funds that, according to existing provider status laws, could have been paid for pharmacists' services provided.

There are several possible barriers to payments for pharmacy claims which may explain the results of our study. In examining these payment barriers, we also highlight possible consequences for patient health and health system operations and describe some possible takeaways for future provider status implementation.

4.2 What explains this pattern? Barriers to services claims for pharmacies in current provider status states.

A commonly cited barrier from the pharmacist perspective is that health insurance plans (payors) are not readily partnering with pharmacists to implement services reimbursements. Survey research of community pharmacists indicate high confidence in pharmacist readiness to implement provider status but low confidence in the preparedness of payors to support provider status.[138] Examples of barriers to readiness of payors/plans include onerous credentialing processes, overly complex claims submission processes, and insufficient reimbursements for services provided even upon successful credentialing and claims submission.[139,140] For example, when Washington State's provider status law was established, the State Insurance Commissioner, with the help of a private sector committee, established a set of credentialing processes which mirrored that for other healthcare provider types.[51]

Another key barrier is the fragmentation of provider status laws even within states where the laws are enacted. In several provider status states, the landscape of which patients are covered for health services by a pharmacist is inconsistent. This can be because not every insurance plan will choose to enroll pharmacists (except in states where it is legally required to do so), or because each individual pharmacist is required by each health plan to be credentialed separately. This fragmentation adds to pharmacist visit time as they determine eligibility on a patient-by-patient basis depending on their health plan[141] and makes it difficult to scale up broad trainings and system changes. This hinders the fully realized benefits of reimbursable services.

Several other barriers to implementing existing provider status laws include reliable connectivity to patient electronic health records to facilitate billing and communication with care teams,[51] lack of pharmacist time to train and adopt new systems, and physician opposition to expansion of Medicare payments to pharmacists and reticence to allow pharmacists to provide care within their scope-of-practice.[142] All of these factors likely contribute in some part to the lack of services claims seen in our data from this study.

4.3 What is at stake? Implications for patient health and healthcare systems.

Failure to fully implement existing provider status laws may ultimately affect patient health in multiple ways. Most directly, there is a wide array of evidence that pharmacist-provided health services improve patient health outcomes and decrease hospital admission rates.[30,141,143,144] Without compensation for these services and under increasing financial pressure, pharmacies may soon be unable to provide these valuable services to their patients and may even close.[145] Provider status is anticipated to be an important means to diversify pharmacy revenue beyond increasingly narrow dispensing profit margins (or even losses), and thereby help sustain financial solvency of community pharmacies.[47,49] The post-hoc analysis results of our study quantifies a small sample of services for which pharmacists could be receiving more reimbursement for services than they currently are: about $2.53 million per year just for this sample of vaccination visits in six states. If paid to pharmacies, these funds could in theory be used to relieve financial pressure on pharmacists, provide more patient care services, and help sustain the presence of community pharmacies in underserved areas.

From a healthcare system perspective, the economic value of pharmacists is also well-documented.[146] For example, one study estimated that pharmacists could prevent more than 15 million heart attacks and nearly 8 million strokes, and save $1.1 trillion over 30 years if they were allowed to help provide care management for patients living with hypertension.[147] Further, pharmacists are well-positioned to absorb several health services currently provided by physicians, and could contribute to easing the ongoing primary care provider shortage in the U.S..[41,145]

4.4 What is the path forward? Lessons for future provider status legislation implementation.

The claims data seen in this study demonstrate that having legislation signed into law, while a necessary step, is not sufficient for widespread effective uptake of the law. Looking ahead, there are system, organization, and practice-level barriers to implementing provider status laws effectively at the practice level. Some noteworthy steps include pharmacists and payors pursuing a standardized protocol for credentialing & privileging requirements in a mutually beneficial approach,[140] harmonization of patient health records for smooth communication with the whole care team, and connectivity with standard billing pathways.[51]

4.5 Strengths and limitations of this analysis

This analysis has several strengths. To our knowledge, this is the first analysis to investigate the effects of pharmacist provider status laws using real-world insurance claims. We used a large national database comprising health insurance claims from millions of people in all 50 U.S. States to construct our analysis, which adds to the reliability of our findings. We also selected a health service which a broad swath of the population is eligible for—routine vaccinations—to provide a large sample of pharmacy visits to evaluate. We selected states whose *provider status* laws are scheduled to be fully in effect as of the start of the analysis.

There are also several limitations to this analysis. Firstly, there are important nuances between every state's provider status law. For example, Washington State requires mandatory compensation from payors to pharmacists for healthcare services, while in other states such as Ohio, pharmacists have the option to enroll but it is not universally mandatory. This may attenuate the statistical effect we see in our analysis if not all pharmacies in a state can bill health services. Second, vaccinations in particular can have more complex payment schemes than other health services, and it is possible that payors compensated pharmacies by using capitated payments or other lump sums not captured with CPT codes.[5] This payment structure would make it difficult to track reimbursements and counts of these services, and we argue has long-term detrimental effects both financially and for patient healthcare teams. Third, the threshold we used for profitability of each vaccination visit does not truly reflect the net revenue received by the pharmacy, as it ignores many cost aspects including staff, facilities, and other incident or overhead costs. We used this approach to provide a standardized means of evaluating reimbursements for over two dozen vaccination products with limited data on true purchase price or ancillary costs. Lastly, our statistical analysis can only be interpreted as associations (not causal) and many covariates that are known to be associated with receipt of vaccinations are not included in our dataset, meaning several sources of confounding are likely not accounted for in the statistical conclusions.

Future research would benefit from including Medicaid claims in the evaluation, as several more states have implemented provider status recognition for pharmacists for those insurance schemes but not commercial plans, as captured in this analysis. Additionally, some states, such as Washington, implemented provider status in waves beginning with hospital-based pharmacists before requiring enrollment of community pharmacists. This earlier stage of law implementation could merit evaluation as well. Investigation of other common pharmacist-provided services apart from vaccinations, such as MTM or diabetes counseling, could also contribute evidence quantifying the impact of provider status laws on reimbursements. Qualitative or implementation science-based approaches would also be highly valuable in understanding the specific barriers that pharmacists, plans, and other stakeholders face in implementing these laws.

5. Conclusion

We found very few claims for pharmacist-provided health services and no difference in proportion of health services billed comparing provider status states and non-provider status states. Our results indicate that pharmacists in provider status states are not billing for the full extent of health services they provide, despite having the scope-of-practice and legal authority to do so, and this may have consequences for patient health and healthcare systems. In a post-hoc analysis, we calculated the hypothetical total payments that pharmacies in provider status states would have received had they included the CPT code accounting for administration not just the vaccine itself: $2.53 million dollars per year for this sample of shingles and influenza vaccines in provider status states. More research is needed to define and address implementation barriers if provider status is intended to be a meaningful policy solution to improve access to pharmacist-provided health services at a national level.

CONCLUSION

Summary of findings

Pharmacies are important access points for health, and, on average, are widely geographically distributed. However, at the local level, there is heterogeneity in pharmacy access. This study revealed that nearly 16 million people throughout the United States do not have good access to a community pharmacy, and that people living in these neighborhoods differ systematically from those who do not. Though its operational definition is still evolving, pharmacy access has many implications for patient and population health. One of these implications is differential access to pharmacy-based health services, such as routine vaccinations. Our second study explored this relationship using local-level health data from seven states throughout the country and found that the rate of shingles vaccination completions is lower in neighborhoods that have low pharmacy access compared to neighborhoods that do not have low pharmacy access. With more pharmacy closures announced by the biggest pharmacy chains over the coming years, bolstering the remaining pharmacies to continue their role as local access points for healthcare is urgent.

One mechanism to accomplish this is improving financial sustainability of community pharmacies by addressing a key weakness in their existing business model—a near-exclusive focus on dispensing medications. The recognition of provider status for pharmacist-provided health services is one such strategy and has been implemented in several states already. We evaluated the relatively early effect of these laws on profitability of vaccination visits using a national commercial insurance claims database. Though we did find that provider status states were associated with more profitable vaccination visits, these findings were limited by the stark lack of services claims by pharmacists even in states which allow for this type of billing. Additional research on implementation barriers for provider status and associated medical billing is needed if these laws are to successfully address long-term financial sustainability of community pharmacies and, ultimately, close the gaps in patient access to these vital services.

Implications for policy and research

The findings from this body of research can inform several dimensions of state and federal-level policies to improve access to pharmacy-based health services. The locations of census tracts that are classified as having low access to pharmacies may be leveraged as geographic priorities for policy-based interventions to 1) reach patients in these areas through alternative health services access points and 2) provide additional support to pharmacies serving patients in these areas. Many policy parallels can be drawn from physician payment incentives and HPSA-related policies to attract and retain pharmacy services in the underserved areas identified in Chapter 1. Chapter 2 provided evidence that without proactive efforts to improve access to pharmacy-based services, there are consequences for patient health, such as lower rates of shingles vaccination completions. Lastly, Chapter 3 illuminated the gap that exists between signing provider status legislation into law versus real-world implementation of those laws. Despite having been enacted (in some cases) many years previously, very few health services claims are being billed by pharmacists for providing vaccination administration and counseling services. In the near term, this means pharmacists are leaving revenue on the table. In the long term, this could lead to closures of pharmacies and negative impacts on patient accessibility for key pharmacy-based services.

The results of all three of these studies also point towards multiple important unknowns for pharmacy services researchers to focus on as an extension of this work. Chapter 1 provided a baseline national map at the census tract level using a standard definition from which to compare future research efforts in the area of pharmacy access and its impacts on patient health. The operational definition of acceptable levels of pharmacy access continues to evolve, including whether an income component should be included in the definition. While the results of Chapter 2 indicated that the income component may not ultimately add additional precision to this definition, several more studies are needed to validate these findings for other types of pharmacy services and in populations outside of older adults. Lastly, in Chapter 3, we found that provider status policies for commercial insurance at the state level have yet to be fully implemented even, in some cases, after many years since the law took effect. Researchers can support full implementation of these laws at the state level and at the federal level by pursuing an implementation science-based agenda that could shed actionable light on barriers to implementation such that all stakeholders can work together to implement these important changes.

Ultimately, the pharmacy profession and patient health can be positively impacted from continued research and policy advancements in the areas of equitable access to pharmacy-based services.

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SUPPLEMENTAL APPENDIX

APPENDIX A: Pharmacy desert calculation details

A.1 Variable creation

The low-income component of a pharmacy desert definition is partially based on if a tract has a median household income that was less than 80% of the median income of the nearest metropolitan area. If a tract was located in a census-defined Metropolitan Statistical Area (MSA), the median income of that MSA was used as the threshold. If the tract was not located in an MSA, the median income of the state was used as the threshold. To describe characteristics of census tracts, we calculated the proportion of population with each characteristic by dividing the census estimate by the denominator of total population that was asked that question. For example, the proportion of adults with no health insurance was calculated by summing the number of adults with no health insurance by the denominator of adult population asked that census question. Binary and categorical versions were created of all pharmacy service characteristics from the NCPDP data using definitions provided by NCPDP.

Table S-A-1. Data sources and variables used in this analysis

Variable Name	Geography	Source (Variable ID)
Components of pharmacy desert definition		
Population count (total and by age)	Census tract, block group	Decennial 2020 (P12_001N - P12_049N)
Median household income in 2021 dollars	Census tract, MSA, state	ACS 2021 (B19013_001E)
Number of individuals below the federal poverty line	Census tract	ACS 2021 (B17001_002E)
Number of individuals at or above the poverty line	Census tract	ACS 2021 (B17001_031E)
Number of individuals who do not own a vehicle	Census tract	ACS 2021 (B08201_001E)
Land area (used to calculated population density and urbanicity)	Census tract	Decennial 2020 (ALAND)
Characteristics of census tracts and pharmacies		
Education: adults >25 with high school education or less	Census tract	ACS 2021 (B15001_001E)

Race/Ethnicity: Proportion of adults by self-described racial and ethnic identity	Census tract	ACS 2021 (B02001_001E – 009E)
Socioeconomic status: Proportion of individuals living below the FPL	Census tract	ACS 2021 (B17001_002E)
Elderly age: Proportion of adults age 65 or older	Census tract	ACS 2021 (B01001_001E-B01001_049E)
Health insurance (any): Proportion of adults with health insurance	Census tract	ACS 2021 (B27001)
Health insurance (public): Proportion of adults with public health insurance	Census tract	ACS 2021 (B27003)
English-speaking: Proportion of adults whose English-speaking ability is "not well" or "not at all"	Census tract	ACS 2021 (B16004_024E – 67E)
Physical disability status: Proportion of adults with an ambulatory difficulty	Census tract	ACS 2021 (B18105_006E – 032E))
Inequality: Gini index by after-tax income	Census tract	ACS 2021 (B19083_001E)
Pharmacy ownership (independent, chain, franchise, government)	Point	NCPDP (Dispenser Class Code 01, 02, 05, 06)
Durable medical equipment offered	Point	NCPDP (DME Code 13, 14, 15, 16, 17, 18)
Walk-in clinic services offered	Point	NCPDP (Walk-in Clinic Code 19, 20, 21, 22)
Emergency services offered	Point	NCPDP (24h Emergency Service Code 23, 24, 25, 26, 27)
Immunizations offered	Point	NCPDP (Immunizations Provided Code 31, 32, 33)
Handicap accessibility offered	Point	NCPDP (Handicapped Accessible Indicator)
340b relationships offered	Point	NCPDP (340B Status Code 36, 37, 38, 39)

A.2 Coordinate reference systems

Pharmacy street addresses were geocoded (i.e., converted to latitude and longitude) using the R package ggmap and the Google Maps Application Programming Interface (API) which uses the World Geodetic System 1984 (WGS84) coordinate reference system (CRS) (EPSG: 4326).[148] All polygons from the U.S. Census Bureau for state, county, MSA, tract, and block level data use the North American Datum of 1983 (NAD 83) CRS (EPSG: 4269). All geographic data were converted to the WGS84 CRS for mapping and analysis using the "st_crs" function in the R package "sf". The mileage buffers around each pharmacy were calculated by converting to the Web Mercator projection (EPSG: 3857), which measures in meters. Distances of 804.672m, 1609.34m, 8046.720m, 16093.440m, respectively, were used to create the 0.5, 1, 5, and 10-mile radius buffers around pharmacies.

A.3 Urbanicity determination

Urbanicity was determined by dividing the total population count of a census tract by land area of the tract (both fields as provided in the 2020 Decennial Census). This population density was then used to create a categorical variable for urbanicity: density >5,000 people per square mile to indicate urban area, density between 1,000-5,000 people per square mile for suburban, and <1,000 people per square mile as indicative of rural area. Urbanicity was used to determine what the acceptable radius of a pharmacy is for the population in that tract. An example visualization of the urban, suburban, and rural tracts along with varying pharmacy radii as examples can be seen in Figure A1-2. In the figure, light green denotes urban tracts, dark blue denotes suburban, and light blue denotes rural tracts as calculated based on population density. Black dots represent pharmacies and the orange circles around them represent the 0.5, 1, 5, or 10-mile radius around that pharmacy based on the urbanicity status of the tract the pharmacy is located in.

A.4 Population within pharmacy radius

To calculate the proportion of the population living within the acceptable radius of a pharmacy, we used areal interpolation at the block level. First, we identified the geographic centroid of every block in the U.S.. Then, we created a binary variable whether that block was within a 1-mile linear distance (as opposed to street travel distance) radius of any pharmacy using the "st_within" function of the "sf" R package. If the block centroid was inside, then the population of the block was counted as living within the pharmacy radius. We repeated this step for 0.5-mile, 5-, and 10-mile radius distances for all centroids and all pharmacies in the U.S. To calculate the proportion of a tract's population living within the acceptable radius of a pharmacy for a given urbanicity of the tract, we summed the population of all the blocks that were inside the acceptable radius and divided that by the total population of the tract. For example, for a suburban census tract, we summed all the census blocks with centroids that were within the 5-mile radius of any pharmacy and divided it by the total population of that tract. In this way, the calculation allowed for access to pharmacies in other tracts, while preserving the acceptable access distance based on urbanicity of that specific tract.

APPENDIX B: Pharmacy desert analysis limitations

In addition to those listed in the main chapter, we note several additional limitations and considerations for the reader in interpreting this analysis.

Design limitations: There is a need for a standardized technical definition of a "pharmacy desert" —nearly every study of pharmacy access uses a slightly different methodology, data, and definition.[57] One key decision is the inclusion of an income-based component versus pure geographic access to pharmacies. As with the definitions of food deserts[149] and HPSAs,[49,150] the primary definition of *pharmacy desert* used in this analysis includes income in addition to spatial factors. We present results with and without the income-based component to enable comparison with other studies, though believe the inclusion of income and resource access on top of geography is important to consider and has theoretical foundations in Link and Phelan's *fundamental cause* theory of health disparities.[151] Determining a definition for the field is out of the scope of this analysis, though these results will be a useful input to the discussion.

Data limitations: Further, the characteristics of populations residing in pharmacy deserts are presented at the group level and thus preclude any inference about individual-level characteristics or risks. The NCPDP data is self-reported by pharmacies and may be less accurate than other objective measures of service availability. However, this was the most current data available to the research team, has been used in other studies,[2,7,152] and aligns with findings from studies using alternative pharmacy data sources.

Analysis limitations: Our use of population density as a proxy for urban status presents several challenges. For example, tracts which contain schools or parks will have relatively lower average population density, and thus would be classified as suburban or rural even if they were surrounded by dense urban tracts. Other approaches to define urbanicity of a place include commuter patterns, inclusion in a designated metro or micropolitan area, urban/rural designation by the Census Bureau, and more.[153] One alternative to using population density that was considered was using the U.S. Department of Agriculture's rural-urban commuter area (RUCA) codes, which are calculated at the census tract level and summarize a complex array of factors to create levels of urbanicity and which are used in a wide variety of analyses, including previous pharmacy desert analyses.[56,154] However, the most recent RUCA codes at the time of this analysis were based on 2010 population levels, which is not current enough to be relevant for this analysis (2020 RUCA codes are expected to be available in Winter 2024). For this analysis, we chose population density because we needed a method that was available at the census tract level, able to indicate urban, suburban, and rural categories, and reflective of current population levels.[58]

Once urbanicity is defined, the corresponding acceptable threshold for distance (e.g., 1, 5, or 10 miles) and the definition of "appropriate" pharmacy-to-population relationships are inconsistently defined in the literature. Some studies have applied a binary 1-mile (urban) vs 10-

mile (rural) access radius classification,[6] others use 10 miles regardless of urbanicity,[70] others use 2-, 5-, or 10-miles[2] as based on the CMS requirements for minimum pharmacy insurance benefits[88], while still others use pharmacy-to-population ratios instead. We chose 1-, 5-, and 10-mile radii to merge the most common pharmacy desert definition (1- and 10-mile) with the CMS pharmacy requirement of 2, 5, and 10-mile because we wanted results to be based in policy though agree with other analyses that 2 miles is not a reasonable radius in urban areas.

Lastly, due to computing resource constraints, in this analysis we do not calculate road travel distance or time in transit in evaluating distance to pharmacies. Instead, we used linear distance, which likely underestimates the true distance and effort required to access a pharmacy.[89]

Statistical limitations: In this analysis we are examining bivariate associations at the population level, which has important limitations. One, without any individual data on inhabitants in each tract we can only make inferences about tract-level average characteristics, not characteristics of individuals who live in pharmacy deserts. Two, these are associations rather than causal links, and do not reveal any information about why these patterns exist. Three, while many of the average characteristic differences are *statistically* significant between pharmacy deserts and non-pharmacy deserts, the magnitude of those differences may not be "significant" in their scientific implications. For example, the proportion of individuals with a high school education or less is 33% in pharmacy deserts versus 28% in non-pharmacy deserts. While statistically distinct, even when adjusting our tests for multiple comparisons, there may not be a practical difference in, say, designing policy solutions based on the fact that 5% more of the population has lower educational background in pharmacy deserts compared to non-deserts

APPENDIX C: Extended results of pharmacy desert analysis

C.1 Accessing source data and analysis code

The R code and a file of the processed data at the census tract level is available on the project GitHub page at this link <https://github.com/rwitten1/Pharmacy-Deserts-Analysis>. A public Tableau version of the pharmacy desert map is available here <https://tinyurl.com/PharmacyDesertsMap2022>. The NCPDP pharmacy address data is proprietary thus is not included in this public repository. The full R code used in dataset creation and analysis is available on this site as well. Researchers are welcome to contact the corresponding author with questions.

C.2 Population living in pharmacy deserts by state

Figure S-C-1. Proportion of adult population living in pharmacy deserts in each state

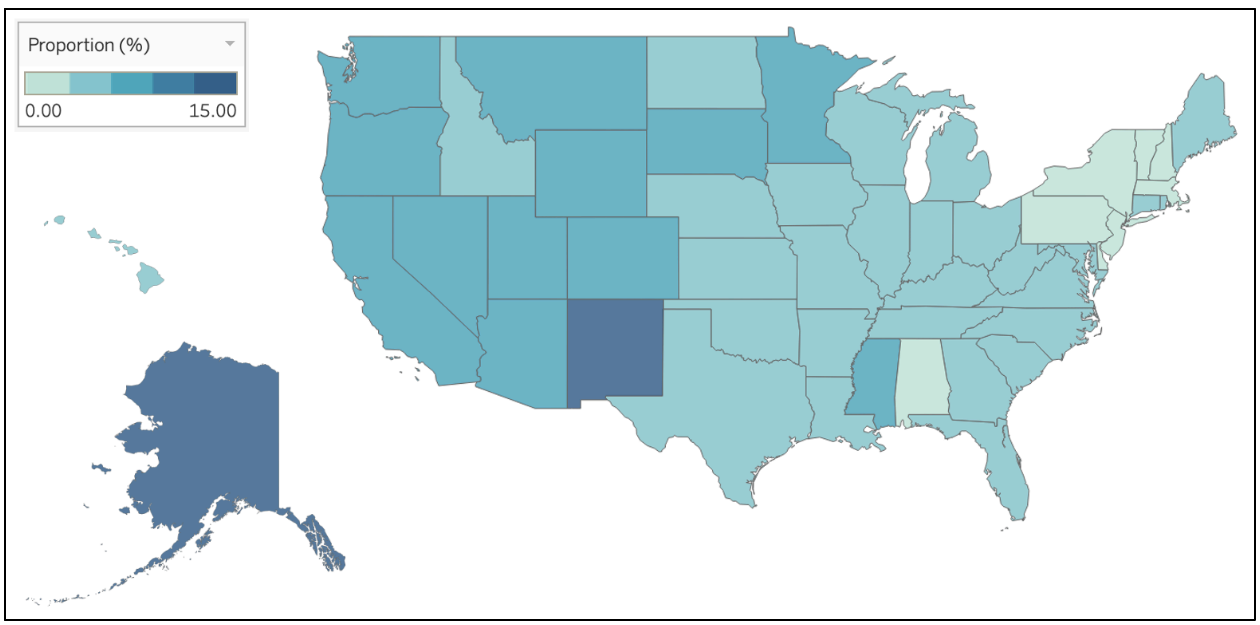


Table S-C-1. Population living in pharmacy deserts by state

State	Proportion of the Adult Population Living in Pharmacy Desert (%)	Proportion of the Total Population Living in Pharmacy Desert (%)	Total Number of People Living in a Pharmacy Desert (N)
New Mexico	14.89	15.18	320,932
Alaska	14.77	15.47	113,488
Arizona	8.64	8.99	640,797
Colorado	8.60	8.60	495,596
South Dakota	8.28	8.90	78,899
Montana	8.17	8.38	90,817
Oregon	7.92	8.04	340,621
Washington	7.62	7.72	594,498
Mississippi	7.56	7.40	219,252
Minnesota	7.09	7.17	409,101
Utah	6.82	6.44	210,351
Nevada	6.33	6.59	204,434
Wyoming	6.22	5.95	34,348
California	6.17	6.43	2,535,219
Texas	5.74	5.79	1,683,909
North Dakota	5.47	5.40	42,070
Oklahoma	5.37	5.35	211,562
Maine	5.26	5.21	70,955
Connecticut	5.24	5.36	192,996
Louisiana	5.16	5.07	235,950
Missouri	5.07	5.08	312,678
Ohio	4.96	5.01	590,536
Virginia	4.89	4.85	417,496
Idaho	4.87	4.62	85,030
Maryland	4.86	5.01	308,608
West Virginia	4.81	4.69	84,134
Kentucky	4.63	4.59	206,389
Kansas	4.47	4.40	129,344
Wisconsin	4.47	4.52	266,395
Illinois	4.43	4.46	571,740
Indiana	4.20	4.23	286,337
Michigan	4.14	4.22	423,339
Nebraska	4.03	4.19	82,053
Hawaii	3.87	4.11	59,847
Arkansas	3.84	3.70	111,396
Iowa	3.44	3.35	106,671
Florida	3.42	3.48	749,103
Georgia	3.41	3.47	371,241
South Carolina	3.38	3.26	166,586
Tennessee	3.33	3.42	235,886
Rhode Island	3.25	3.32	36,479
North Carolina	3.02	2.94	306,247
Massachusetts	2.93	2.93	205,691
Delaware	2.60	2.61	25,868
Alabama	2.52	2.40	120,601
Pennsylvania	2.51	2.52	327,033
District of Columbia	1.98	1.91	13,179
Vermont	1.80	1.77	11,406
New York	1.74	1.83	369,336
New Jersey	1.05	1.15	106,706
New Hampshire	0.86	0.86	11,778

C.3 Pharmacy accessibility results

Figure S-C-2. Pharmacy desert locations in the United States

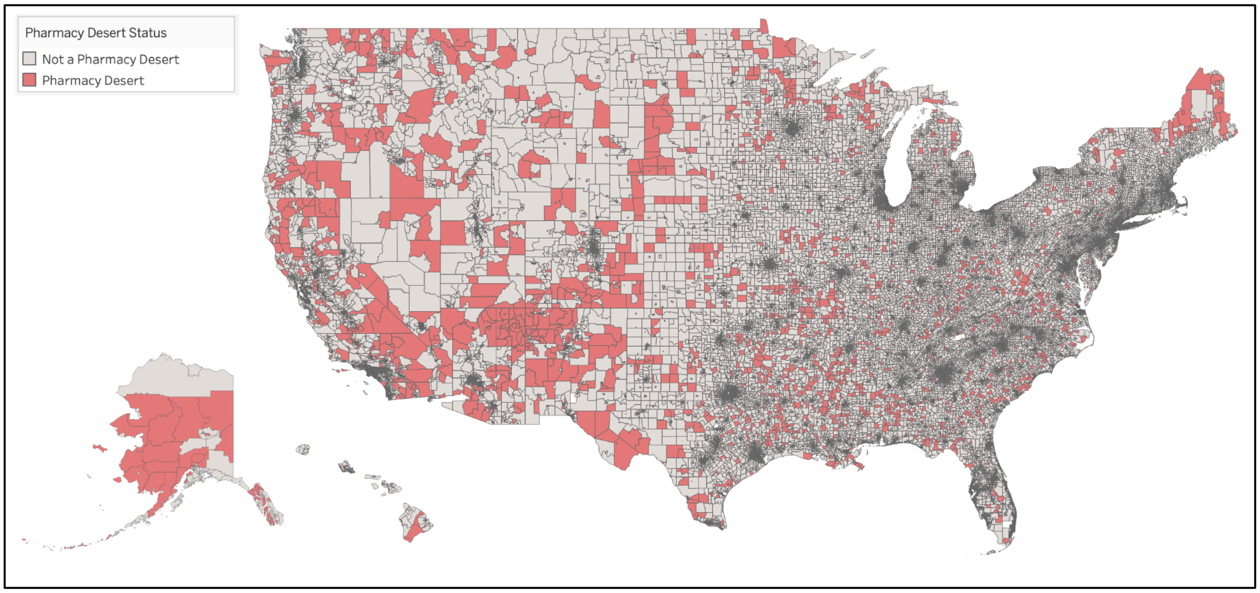


Figure S-C-3. Pharmacy desert locations in select urban cities throughout the U.S.

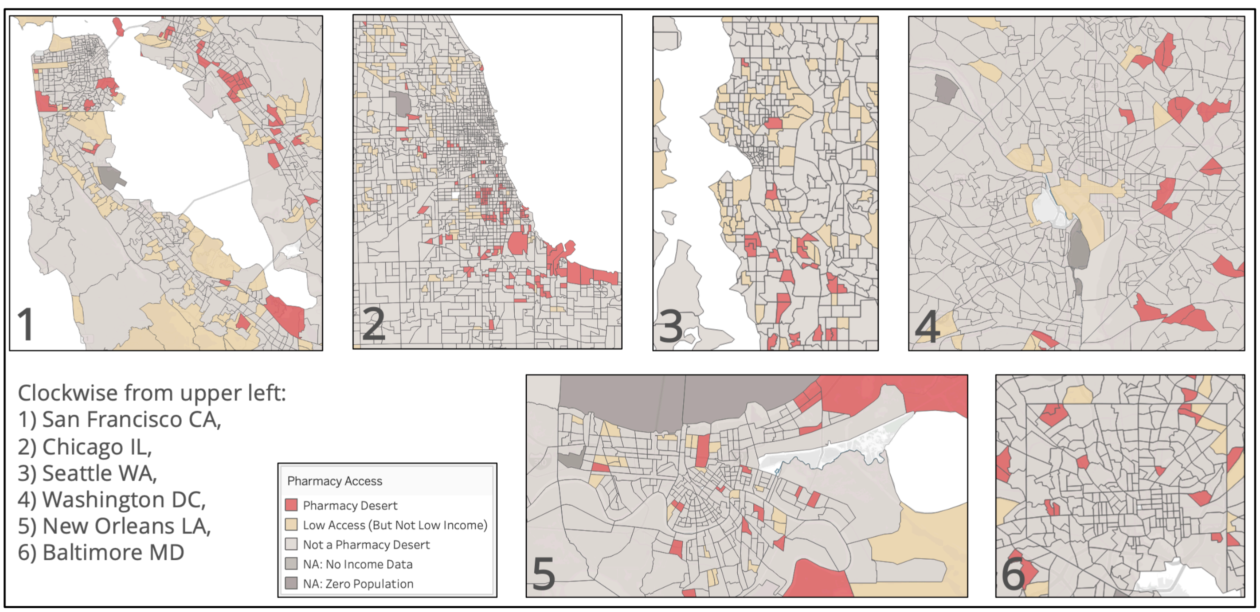


Figure S-C-4. Pharmacy locations in the U.S..

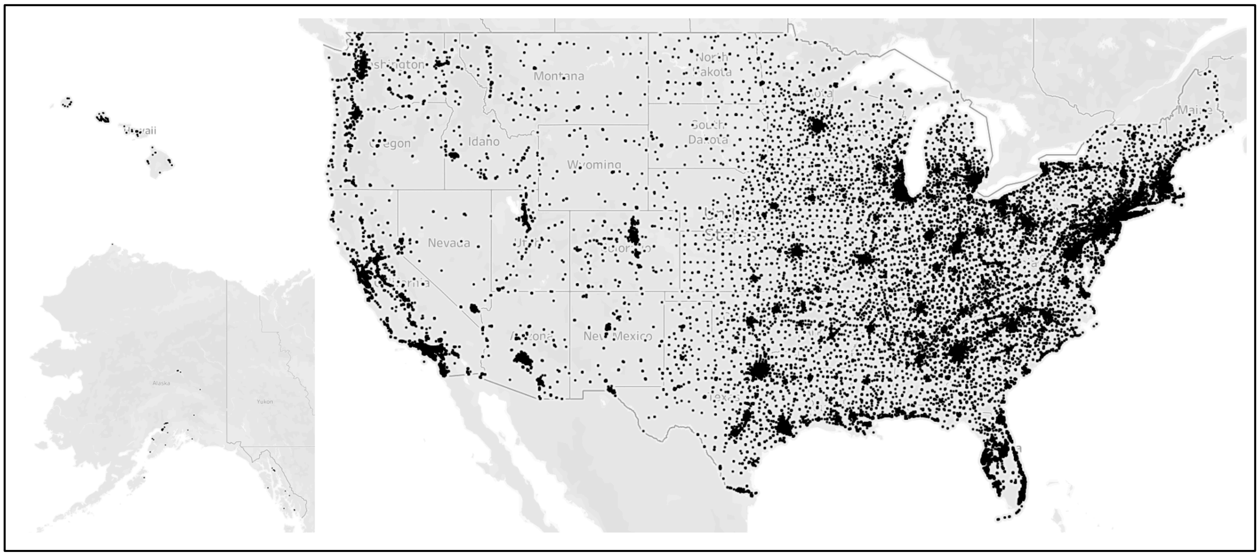
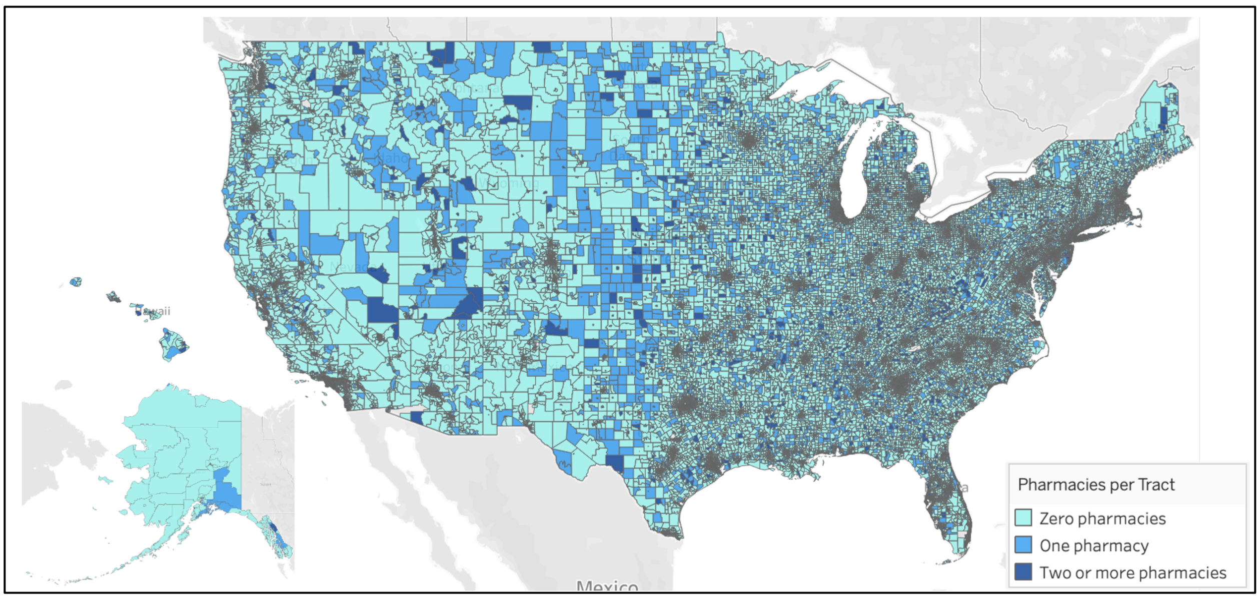


Figure S-C-5. Pharmacy counts by census tract



C.4 Characteristics of populations and pharmacies in pharmacy deserts

Table S4. Pharmacy desert characteristics stratified by urbanicity.

	Urban		Suburban		Rural	
Mean (SD)	Pharmacy Desert (N=2,692)	Not Pharmacy Desert (N=19,972)	Pharmacy Desert (N=204)	Not Pharmacy Desert (N=30,264)	Pharmacy Desert (N=1,783)	Not Pharmacy Desert (N=28,487)
Prop. Below FPL	25.3% (13.9)	15.4% (12.1)	31.9% (22.2)	12.7% (11.4)	22.7% (13.4)	11.7% (8.63)
Median Income	$47,100 ($16,100)	$76,800 ($37,700)	$44,700 ($21,500)	$79,100 ($40,700)	$45,500 ($11,700)	$72,000 ($31,500)
Prop. High School Education or Less	30.5% (9.69)	24.0% (10.9)	32.3% (12.0)	25.6% (0.11.0)	37.4% (0.09.78)	32.3% (10.6)
Prop. With No Health Insurance	16.3% (11.9)	11.0% (09.62)	12.0% (12.6)	9.69% (8.69)	13.9% (9.79)	9.33% (7.48)
Prop. With Public Health Insurance	38.2% (15.6)	33.7% (14.0)	42.2% (22.4)	34.1% (13.0)	47.5% (13.3)	38.0% (11.4)
Pharmacies per Tract (N (%))						
Zero pharmacies	2,537 (94.2%)	10,266 (51.4%)	198 (97.1%)	15,065 (49.8%)	1,686 (94.6%)	17,918 (62.9%)
One pharmacy	132 (4.9%)	5,912 (29.6%)	5 (2.5%)	8,238 (27.2%)	87 (4.9%)	6,472 (22.7%)
Two or more pharmacies	23 (0.9%)	3,794 (19.0%)	1 (0.5%)	6,961 (23.0%)	10 (0.6%)	4,097 (14.4%)
Prop. Do Not Speak English	7.91% (10.4)	6.64% (9.99)	4.39% (10.2)	2.40% (5.30)	2.58% (6.87)	1.30% (3.85)
Prop. Ambulatory Disability	9.07% (5.57)	7.21% (4.66)	10.4% (8.21)	8.05% (4.87)	12.5% (6.70)	9.45% (5.06)
Prop. Older Adult (65+)	11.3% (7.84)	13.4% (7.11)	15.3% (13.3)	16.9% (9.42)	20.7% (10.0)	19.5% (8.29)
Prop. NH, White	32.8% (26.4)	39.2% (27.6)	54.4% (29.2)	60.2% (26.8)	63.8% (31.2)	77.5% (21.7)
Prop. NH, Black	25.3% (28.6)	16.0% (22.7)	17.0% (22.7)	14.9% (22.1)	9.88% (18.9)	7.79% (15.1)
Prop. NH, Asian	4.88% (8.03)	10.5% (14.3)	2.67% (5.55)	5.11% (8.20)	0.962% (4.40)	1.72% (4.43)
Prop. NH, AIAN	0.45% (1.61)	0.26% (0.86)	1.33% (7.52)	0.362% (1.46)	8.33% (23.1)	0.84% (4.29)
Prop. NH, 2 or More Races	3.24% (3.33)	3.42% (3.38)	2.93% (2.95)	3.37% (3.11)	2.69% (3.30)	2.75% (3.00)
Prop. NH, Other Race	0.41% (1.13)	0.54% (1.49)	0.20% (0.71)	0.36% (1.03)	0.23% (0.85)	0.23% (0.78)
Prop. Hispanic, White Race	15.3% (16.9)	12.7% (13.7)	10.9% (15.5)	7.94% (11.3)	7.23% (13.5)	4.70% (8.82)
Prop. Hispanic, Black Race	0.56% (1.24)	0.71% (1.69)	0.52% (2.00)	0.31% (0.96)	0.12% (0.59)	0.13% (0.73)
Prop. Hispanic, AIAN Race	0.46% (1.27)	0.37% (1.04)	0.25% (0.76)	0.20% (0.76)	0.38% (1.35)	0.13% (0.61)

	Urban		Suburban		Rural	
Mean (SD)	Pharmacy Desert (N=2,692)	Not Pharmacy Desert (N=19,972)	Pharmacy Desert (N=204)	Not Pharmacy Desert (N=30,264)	Pharmacy Desert (N=1,783)	Not Pharmacy Desert (N=28,487)
Prop. Hispanic, 2 or More Races	6.09% (7.28)	5.77% (6.63)	3.86% (6.66)	3.36% (5.06)	2.80% (5.61)	1.97% (3.97)
Prop. Hispanic, Other Race	10.0% (0.12.5)	10.1% (13.0)	5.71% (11.3)	3.64% (6.34)	3.40% (8.20)	2.06% (4.95)

C.5 Characteristics of populations living in low-access tracts

Table S5. Characteristics of populations in low-access tracts

	Low Access (N=12,646)	Not Low Access (N=71,202)	*p*-value
Urbanicity and access (n (%))			
Urbanicity of census tract			
Urban	5,790 (45.8%)	16,947 (23.8%)	<0.001
Suburban	652 (5.2%)	29,887 (42.0%)	
Rural	5,959 (47.1%)	24,360 (34.2%)	
NA: No Population	245 (1.9%)	8 (0.0%)	
Pharmacies per census tract			
Zero pharmacies in the tract	721 (5.7%)	20,149 (28.3%)	<0.001
One pharmacy in the tract	116 (0.9%)	14,786 (20.8%)	
Two or more pharmacies	11,809 (93.4%)	36,267 (50.9%)	
Social characteristics (mean (SD))			
Prop. Below FPL	14.7 (0.12.4)	13.5 (0.11.1)	<0.001
Median Household Income	$69,100 ($32,000)	$75,200 ($37,400)	<0.001
Prop. With HS Educ. Or Less	30.6 (0.11.5)	27.5 (0.11.4)	<0.001
Prop. With No Health Insurance	11.0 (0.09.40)	10.0 (0.08.70)	<0.001
Prop. With Public Health Insurance	37.0 (0.14.2)	35.5 (0.12.9)	<0.001
Prop. Do Not Speak English	3.48 (0.07.26)	3.18 (0.06.95)	<0.001
Demographic characteristics (mean (SD))			
Prop. With Ambulatory Disability	8.62 (5.57)	8.43 (5.00)	<0.001
Prop. Older Adult (Age 65+)	16.3 (9.49)	16.9 (8.80)	<0.001
Race and ethnicity			
Prop. NH, White	59.7 (31.3)	60.3 (29.4)	0.045
Prop. NH, Black	11.2 (19.8)	13.3 (21.0)	<0.001
Prop. NH, Asian	4.42 (9.44)	5.27 (9.71)	<0.001
Prop. NH, AIAN	1.88 (9.82)	0.470 (2.58)	<0.001
Prop. NH, 2 or More Races	3.15 (3.41)	3.15 (3.12)	0.978
Prop. NH, Other Race	0.299 (0.88)	0.369 (1.12)	<0.001
Prop. Hispanic, White Race	9.19 (13.3)	8.03 (11.7)	<0.001
Prop. Hispanic, Black Race	0.281 (1.15)	0.362 (1.15)	<0.001
Prop. Hispanic, AIAN Race	0.288 (0.954)	0.220 (0.82)	<0.001
Prop. Hispanic, 2 or More Races	3.93 (5.99)	3.47 (5.37)	<0.001

	Low Access (N=12,646)	Not Low Access (N=71,202)	*p*-value
Prop. Hispanic, Other Race	5.31 (9.54)	4.77 (8.89)	<0.001

C.6 Pharmacy services details

Table S6 summarizes characteristics of pharmacies in pharmacy desert communities versus not in pharmacy desert communities with more granular service categories than Table 2 in the main manuscript.

Table S6. Characteristics of pharmacies located in pharmacy deserts

	Pharmacy Desert (N=294)	Not Pharmacy Desert (N=60175)	*p*-value*
Urbanicity			
Urban	179 (60.9%)	15,986 (26.6%)	<0.001
Suburban	8 (2.7%)	26,922 (44.7%)	
Rural	107 (36.4%)	17,206 (28.6%)	
NA: No Population	0 (0%)	61 (0.1%)	
Pharmacy Ownership			
Independent	121 (41.2%)	22,010 (36.6%)	<0.001
Chain	165 (56.1%)	37,371 (62.1%)	
Franchise	3 (1.0%)	659 (1.1%)	
Government	5 (1.7%)	135 (0.2%)	
Immunization Services Availability			
No on-site immunizations	73 (24.8%)	11,665 (19.4%)	<0.001
Immunization services at select dates and times	34 (11.6%)	3,266 (5.4%)	
Immunization services during business hours	187 (63.6%)	45,244 (75.2%)	
ADA Accessibility			
Not ADA accessible	4 (1.4%)	746 (1.2%)	1.000
340b Status Category			
No 340B relationships	219 (74.5%)	50,943 (84.7%)	<0.001
Not owned by 340B entity but contracts to covered entities	53 (18.0%)	7,417 (12.3%)	
Owned by 340B entity but also serves non-eligible patients	21 (7.1%)	1,692 (2.8%)	

	Pharmacy Desert (N=294)	Not Pharmacy Desert (N=60175)	*p*-value*
Owned by 340B entity and only serves eligible patients	1 (0.3%)	123 (0.2%)	
Multidose Packaging Availability			
No multidose compliance packaging	221 (75.2%)	48,119 (80.0%)	<0.001
Multidose compliance packaging to assisted living facilities only	31 (10.5%)	2,841 (4.7%)	
Multidose compliance packaging to all	42 (14.3%)	9,215 (15.3%)	
Emergency Services 24 Hours Availability			
No 24h emergency service	212 (72.1%)	42,334 (70.4%)	<0.001
24h emergency remote pharmacist (call center)	38 (12.9%)	10,706 (17.8%)	
24h emergency remote pharmacist (local)	24 (8.2%)	5,431 (9.0%)	
24h emergency pharmacist with in-person access	19 (6.5%)	1551 (2.6%)	
24h in-person emergency pharmacist service	1 (0.3%)	153 (0.3%)	
Walk-in Clinic Available			
No walk-in clinic	254 (86.4%)	56,252 (93.5%)	<0.001
Walk-in clinic with limited services, mid-level professional	21 (7.1%)	2,053 (3.4%)	
Walk-in clinic with limited services, licensed physician	12 (4.1%)	1,489 (2.5%)	
Onsite emergency room	7 (2.4%)	381 (0.6%)	
Compounding Pharmacy Category			
No compounding services	122 (41.5%)	22,945 (38.1%)	0.070
Basic non-sterile compounding	160 (54.4%)	35,591 (59.1%)	
Complex non-sterile compounding	7 (2.4%)	1,263 (2.1%)	
Low complexity sterile compounding	4 (1.4%)	241 (0.4%)	
High complexity sterile compounding	1 (0.3%)	135 (0.2%)	
DME Availability			
No DME offered	75 (25.5%)	13,433 (22.3%)	0.034
DME off-the-shelf, non-custom, unaccredited	43 (14.6%)	7,609 (12.6%)	
DME full range and custom, unaccredited	4 (1.4%)	1,656 (2.8%)	
DME for pharmaceuticals and diabetic testing, accredited	98 (33.3%)	17,283 (28.7%)	
DME off-the-shelf, non-custom, accredited	37 (12.6%)	9,785 (16.3%)	
DME full range and custom, accredited	37 (12.6%)	10409 (17.3%)	

Footnotes: * *p*-value is from a t-test for continuous variables and a chi-squared test for categorical variables, all adjusted for multiple comparisons using the Benjamini-Hochberg correction.

APPENDIX D: State Department of Health IIS Data Notes

Table S-D-1. Notes on state IIS Data

State Department of Health	Accompanying Data Notes
Colorado Department of Public Health & Environment (CDPHE)	• **Immunization Information System:** "Colorado Immunization Information System (CIIS)" • Mandatory reporting for shingles vaccinations: No • Proportion of shingles vaccinations delivered in pharmacies: Not reported • **Additional state DOH notes:** Includes individuals with a jurisdictional-level status of "Active" in the Colorado IIS at the time of the data pull and excludes individuals with a residential address outside of Colorado. Between 2019-2022, 11,431 individuals were categorized as census tract "Unknown" which corresponds to individuals who had no address info on record in CIIS. It's possible that this group includes individuals who do not live in Colorado.
Louisiana Department of Health (LDH)	• **Immunization Information System:** "Louisiana Immunization Network (LINKS)" • **Mandatory reporting for shingles vaccinations:** Yes • **Proportion of shingles vaccinations delivered in pharmacies:** Not reported • **Additional state DOH notes:** Prior to the COVID-19 pandemic response, vaccinations administered to adults in Louisiana were not required to be reported to LINKS. Since then, Louisiana continues to expand its adult provider enrollment into LINKS. Nonetheless, it is possible that shingles vaccination coverage, as derived from LINKS, may be an underestimation of the true coverage rate due to incomplete reporting.
Massachusetts Department of Health (MDPH)	• **Immunization Information System:** "Massachusetts Immunization Information System (MIIS)" • Mandatory reporting for shingles vaccinations: Yes • **Proportion of shingles vaccinations delivered in pharmacies:** Not reported overall, however the dataset used for this analysis were restricted to patients who received a vaccine in a commercial pharmacy. The authors note that this data restriction to only pharmacy-based vaccinations rather than all vaccinations may overestimate the relationship between pharmacy access and rate of shingles vaccinations in this state. • **Additional state DOH notes:** Addresses of any individual age 50 or older who received at least one shingles vaccine (Shingrix or Zostavax) between the dates of 1/1/2022 – 12/31/2022 were geocoded and assigned to a census tract. These data are limited to Massachusetts residents only and include both administered and historically reported immunizations. Many individuals have received vaccinations that are not present in MIIS, and the data included here are thus an underestimation of vaccination rates. Some providers who are enrolled in the MIIS have not loaded historical immunization information into the database. Duplicate patient records exist when patient information is not entered in the same way into the health record.
Nevada Department of Health and Human Services (DHHS)	• **Immunization Information System:** "Nevada's statewide Immunization Information System (WebIZ)" • Mandatory reporting for shingles vaccinations: Yes • **Proportion of shingles vaccinations delivered in pharmacies:** In 2022, 87.3% of shingles vaccinations were delivered in pharmacies

	• Additional state DOH notes: None.
Oklahoma State Department of Health (OSDH)	• **Immunization Information System:** “Oklahoma State Immunization Information System (OSIIS)” • Mandatory reporting for shingles vaccinations: No • Proportion of shingles vaccinations delivered in pharmacies: Not reported • Additional state DOH notes: None.
Washington State Department of Health (DOH)	• **Immunization Information System:** “Washington State Immunization Information System (WAIIS)” • Mandatory reporting for shingles vaccinations: No • Proportion of shingles vaccinations delivered in pharmacies: Not reported • **Additional state DOH notes:** Only individuals with Washington addresses were included. Due to privacy concerns, any cell values below 10 are suppressed, and as a result, some of the coverage estimates could not be calculated. The authors note that for the 22 our of 1771 census tracts (1.2%) with suppressed cell values, we assumed a value of n=5 vaccinations in that tract (middle value between n=1 and 10) rather than exclude the tract from analysis, since suppression of small cell counts likely affects rural census tracts disproportionately, and may underestimate the relationship between pharmacy access and shingles vaccination rates in these areas which are already more likely to have low access to pharmacies.
Wisconsin Department of Health Services (DHS)	• **Immunization Information System:** “Wisconsin Immunization Registry (WIR)” • Mandatory reporting for shingles vaccinations: No • **Proportion of shingles vaccinations delivered in pharmacies:** In 2022, 43% of immunizations were given in pharmacies. The authors note that this state’s relatively low proportion of vaccinations delivered in pharmacies versus other care locations likely attenuates the effect seen on vaccination rates for a given pharmacy desert exposure. • **Additional state DOH notes:** 3.2% of doses were unable to have the corresponding address geocoded and were excluded from analysis. Individuals who have deceased or asked to be removed from the registry were not included in the cohort. Data was only provided for individuals with a Wisconsin address.

APPENDIX E: Sample covariates pre-matching for secondary analysis

Table S-E-1. Distribution of sample covariates pre-matching in the secondary analysis

	Low Pharmacy Access (N=1,788)	**Not Low Pharmacy Access (N=7,864)**	**Overall (N=9,652)**
Shingles per 1000 pop.	42.2 (34.8)	49.1 (24.2)	47.8 (26.6)
State			
Colorado	336 (18.8%)	1096 (13.9%)	1432 (14.8%)
Louisiana	155 (8.7%)	1211 (15.4%)	1366 (14.2%)
Massachusetts	127 (7.1%)	1467 (18.7%)	1594 (16.5%)
Nevada	178 (10.0%)	593 (7.5%)	771 (8.0%)
Oklahoma	197 (11.0%)	999 (12.7%)	1196 (12.4%)
Washington	456 (25.5%)	1313 (16.7%)	1769 (18.3%)
Wisconsin	339 (19.0%)	1185 (15.1%)	1524 (15.8%)
Demographics			
Prop. Age 65+ years	0.170 (0.0898)	0.162 (0.0758)	0.164 (0.0786)
Prop Age 50+ years	0.374 (0.124)	0.364 (0.0982)	0.365 (0.104)
Prop. Married	0.503 (0.144)	0.489 (0.138)	0.492 (0.139)
Prop. Female	0.492 (0.0610)	0.504 (0.0463)	0.501 (0.0496)
Income and education			
Median Income	70700 (29300)	77600 (37100)	76300 (35900)
GINI Index	0.411 (0.0651)	0.422 (0.0682)	0.420 (0.0678)
Prop Receiving Income Asst.	0.130 (0.105)	0.133 (0.115)	0.132 (0.113)
Prop. HS Education or less	0.298 (0.111)	0.269 (0.111)	0.274 (0.112)
Prop. Grad or Prof. Degree	0.0922 (0.0842)	0.123 (0.102)	0.117 (0.0995)
Prop. Access to Internet	0.860 (0.0993)	0.873 (0.0967)	0.870 (0.0973)
Prop. Low English-speaking	0.0224 (0.0486)	0.0209 (0.0501)	0.0212 (0.0498)
Healthcare and insurance			
Prop. No Insurance	0.0974 (0.0765)	0.0859 (0.0765)	0.0880 (0.0766)
Prop. Public Insurance	0.375 (0.130)	0.357 (0.124)	0.361 (0.125)
Pop to PCP Ratio	1940 (2190)	1600 (1420)	1660 (1590)
Prop. Poor Health Status	0.140 (0.0378)	0.137 (0.0400)	0.137 (0.0396)
Race and ethnicity			
Prop. Race NH White	0.666 (0.243)	0.658 (0.238)	0.659 (0.239)
Prop. Race NH Black	0.0734 (0.151)	0.105 (0.190)	0.0993 (0.183)
Prop. Race NH AIAN	0.0226 (0.0746)	0.0131 (0.0371)	0.0148 (0.0465)

	Low Pharmacy Access (N=1,788)	**Not Low Pharmacy Access (N=7,864)**	**Overall (N=9,652)**
Prop. Race NH Asian	0.0405 (0.0692)	0.0474 (0.0734)	0.0461 (0.0727)
Prop. Race Hisp. White	0.0676 (0.0888)	0.0576 (0.0753)	0.0595 (0.0781)
Voted Dem. In 2020	0.520 (0.500)	0.576 (0.494)	0.565 (0.496)

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APPENDIX F: Pharmacy services claims analysis

F.1 Vaccinations by NDC number, CPT code, and price

Vaccine	Brand Name	Packaging	Timing	NDC Number	CPT Code	Private Sector Price
Influenza	Fluzone Quadrivalent	10 dose vial	8/2020-8/2021	49281-0633-15	90688	$ 16.94
Influenza	Fluzone Quadrivalent	10 dose vial	8/2021-8/2022	49281-0635-15	90688	$ 17.59
Influenza	Fluzone Quadrivalent	10 dose vial	8/2022-8/2023	49281-0637-15	90688	$ 18.09
Influenza	Fluzone Quadrivalent	10 pack – 1 dose vial	8/2020-8/2021	49281-0420-10	90682	$ 18.14
Influenza	Fluzone Quadrivalent	10 pack – 1 dose vial	8/2021-8/2022	49281-0421-10	90682	$ 18.84
Influenza	Fluzone Quadrivalent	10 pack – 1 dose vial	8/2022-8/2023	49281-0422-10	90682	$ 18.84
Influenza	Fluzone Quadrivalent	10 pack – 1 dose syringe	8/2020-8/2021	49281-0420-50	90686	$ 18.14
Influenza	Fluzone Quadrivalent	10 pack – 1 dose syringe	8/2021-8/2022	49281-0421-50	90686	$ 18.84
Influenza	Fluzone Quadrivalent	10 pack – 1 dose syringe	8/2022-8/2023	49281-0422-50	90686	$ 19.38
Influenza	Fluarix Quadrivalent	10 pack- 1 dose syringe	8/2020-8/2021	58160-0885-52	90686	$ 17.30
Influenza	Fluarix Quadrivalent	10 pack- 1 dose syringe	8/2021-8/2022	58160-0887-52	90686	$ 18.13
Influenza	Fluarix Quadrivalent	10 pack- 1 dose syringe	8/2022-8/2023	58160-0890-52	90686	$ 19.00
Influenza	Flulaval Quadrivalent	10 pack- 1 dose syringe	8/2020-8/2021	19515-0816-52	90686	$ 17.30
Influenza	Flulaval Quadrivalent	10 pack- 1 dose syringe	8/2021-8/2022	19515-0818-52	90686	$ 14.04
Influenza	Flulaval Quadrivalent	10 pack- 1 dose syringe	8/2022-8/2023	19515-0808-52	90686	$ 19.00
Influenza	Flucelvax Quadrivalent	10 pack – 1 dose syringe	8/2020-8/2021	70461-0320-03	90674	$ 25.76
Influenza	Flucelvax Quadrivalent	10 pack – 1 dose syringe	8/2021-8/2022	70461-0321-03	90674	$ 26.39
Influenza	Flucelvax Quadrivalent	10 pack – 1 dose syringe	8/2022-8/2023	70461-0322-03	90674	$ 28.44
Influenza	Flucelvax Quadrivalent	10 dose vial	8/2020-8/2021	70461-0420-10	90756	$ 24.42

Influenza	Flucelvax Quadrivalent	10 dose vial	8/2021-8/2022	70461-0421-10	90756	$ 25.01
Influenza	Flucelvax Quadrivalent	10 dose vial	8/2022-8/2023	70461-0422-10	90756	$ 26.95
Influenza	Afluria Quadrivalent	10 pack – 1 dose syringe	8/2020-8/2021	33332-0320-01	90686	$ 18.66
Influenza	Afluria Quadrivalent	10 pack – 1 dose syringe	8/2021-8/2022	33332-0321-01	90686	$ 19.11
Influenza	Afluria Quadrivalent	10 pack – 1 dose syringe	8/2022-8/2023	33332-0322-03	90686	$ 20.03
Influenza	Afluria Quadrivalent	10 dose vial	8/2020-8/2021	33332-0420-10	90686	$ 17.26
Influenza	Afluria Quadrivalent	10 dose vial	8/2021-8/2022	33332-0421-10	90686	$ 17.67
Influenza	Afluria Quadrivalent	10 dose vial	8/2022-8/2023	33332-0422-10	90686	$ 18.52
Influenza	FluMist Quadrivalent	10 pack- 1 dose sprayer (Intranasal)	8/2020-8/2021	66019-0307-10	90672	$ 23.70
Influenza	FluMist Quadrivalent	10 pack- 1 dose sprayer (Intranasal)	8/2021-8/2022	66019-0308-10	90672	$ 23.70
Influenza	FluMist Quadrivalent	10 pack- 1 dose sprayer (Intranasal)	8/2022-8/2023	66019-0309-10	90672	$ 22.95
Recombinant Zoster	Shingrix	1 pack – 1 dose vial	1/2021-2/2021	58160-0819-12	90750	$ 151.41
Recombinant Zoster	Shingrix	10 pack – 1 dose vial	1/2021-2/2021	58160-0823-11	90750	$ 151.41
Recombinant Zoster	Shingrix	1 pack – 1 dose vial	3/2021-6/2022	58160-0819-12	90750	$ 162.01
Recombinant Zoster	Shingrix	10 pack – 1 dose vial	3/2021-6/2022	58160-0823-11	90750	$ 162.01
Recombinant Zoster	Shingrix	10 pack – 1 dose vial	7/2022-1/2023	58160-0823-11	90750	$ 171.57
Any - Services	Immunization administration (includes percutaneous, intradermal, subcutaneous, or intramuscular injections); **one vaccine**			NA	90471	NA
Any - Services	Immunization administration (includes percutaneous, intradermal, subcutaneous, or intramuscular injections); **each additional vaccine**			NA	90472	NA
Any - Services	Immunization administration by intranasal or oral route; **one vaccine**.			NA	90473	NA
Any - Services	Immunization administration for intra-nasal or oral route, **each additional vaccine**			NA	90474	NA
Any - Services	Immunization administration with counseling by physician or other qualified health care professional, **one vaccine**			NA	90460	NA
Any - Services	Immunization administration with counseling by physician or other qualified health care professional, **each additional vaccine**			NA	90461	NA

F.2 Key measures used in pharmacy claims analysis

Table S-F-2. Definitions of key measures used in analysis

Measure	Role	Coding	Definition
Vaccination visit	Unit of analysis	Corresponds to one row in the data	Corresponds to all shingles or flu vaccine-related claims for one patient at one pharmacist-provided vaccination visit. This includes all drug claims and all service claims provided by a pharmacist in a pharmacy.
Provider status state	Predictor	Binary: 1 = PS state, 0 = non-PS	Indicates whether pharmacists are legally recognized as "providers" for purposes of reimbursement by commercial health plans in a state. See Supplemental Table S-2 for list of PS states.
Profitability	Outcome (1)	Binary: 1 = Profitable, 0 = not Profitable	Indicates whether the reimbursement to a pharmacy was greater than the private sector list price for the vaccine + a 20% administration fee. See Supplemental Table S-3 for list prices by vaccine type.
Profit	Outcome (2)	Continuous.	Reports the percent profitability of the vaccination visit (e.g., 0% indicates breaking even, 10% indicates the pharmacy was reimbursed 10% more than the list price)
Year	Covariate	Categorical. Values are 2021 or 2022	Indicates whether the claim occurred in 2021 or 2022.
Age	Covariate	Continuous. Range begins at 18 for influenza and 50 for shingles	Indicates patient age at time of vaccination visit.
Sex	Covariate	Categorical. 1 = male, 2 = female	Indicates the patient's sex assigned at birth.
Plan Type	Covariate	Categorical. 1 = "Basic/major medical", 2 = "Comprehensive , 3 = "EPO" , 5 = "POS", 6 = "PPO" , 8 = "CDHP", 9 = "HDHP.	Indicates the patient's health plan type that was billed for that vaccination visit. Capitated health plans and HMOs were removed from this analysis.
Urbanicity	Covariate	Binary. 1 = Urban, 0 = Rural	Indicates whether that patient resides in an urban area (any metropolitan statistical area) or a rural area (outside any metropolitan statistical area).

F.3 Additional results of pharmacy services claims analysis

Table S-F-3. Cost characteristics by Claim Type

	Influenza			Shingles			Overall		
	Both (N=5)	**Drug Claim (N=1,919,686)**	**Service Claim (N=8,463)**	**Both (N=2)**	**Drug Claim (N=359,556)**	**Service Claim (N=1,182)**	**Both (N=7)**	**Drug Claim (N=2,279,242)**	**Service Claim (N=9,645)**
Profitable (%)	1.00 (0)	0.91 (0.29)	0.99 (0.033)	1.00 (0)	0.88 (0.32)	0.99 (0.10)	1.00 (0)	0.91 (0.29)	0.99 (0.05)
State Status									
Not PS State	1 (20.0%)	1,591,036 (82.9%)	7,078 (83.6%)	2 (100%)	295,640 (82.2%)	945 (79.9%)	3 (42.9%)	1,886,676 (82.8%)	8,023 (83.2%)
Provider Status State	4 (80.0%)	328,650 (17.1%)	1,385 (16.4%)	0 (0%)	63,916 (17.8%)	237 (20.1%)	4 (57.1%)	392,566 (17.2%)	1,622 (16.8%)

Table S-F-4. Post-hoc analyses of missed reimbursements for administration Jan 2021 – Dec 2022

The table below summarizes the hypothetical missed payments to pharmacies from not billing claims for vaccine administration during vaccination visits despite being allowed to under provider status legislation. The mean payment per administration for both shingles and influenza vaccinations is $12.90. We applied this to the total number of visits without an administration code included in the visit, first for our sample of visits in states that currently recognize pharmacists as providers for commercial insurance and then for all states in the sample. Taking shingles vaccination visits as an example: there were 63,978 vaccination visits with only drug claims within provider status states in our sample. We then multiplied this by $12.90 to get $825,316 reimbursements. Since our sample contains two years of data, this equates to approximately $412,658 per year that pharmacies in provider status states in the Marketscan sample of commercial claims could have received. The same approach was taken for influenza vaccinations.

	Influenza			**Shingles**		
	Not PS State (N=1,598,115)	**PS State** (N=330,039)	**Total** (N=1,928,154)	**Not PS State** (N=296,587)	**PS State** (64,153)	**Total** (N=360,740)
Administration code billed during vaccination visit?						
No	1,591,194 (99.6%)	328,670 (99.6%)	1,919,864 (99.6%)	295,652 (99.7%)	63,978 (99.7%)	359,630 (99.7%)
Yes	6,921 (0.4%)	1,369 (0.4%)	8,290 (0.04%)	935 (0.3%)	175 (0.3%)	1,110 (0.3%)
Hypothetical missed reimbursements if administration codes had been billed						
PS states only	--	$4,239,843	--	--	$825,316	--
If all states	--	--	$24,763,924	--	--	$4,639,227