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Original Article

Prevalence and severity of pharmacy deserts in West Texas: A dual-distance threshold (10- and 20- mile) GIS analysis

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Abstract

Background: Community pharmacies serve as critical access points for medications and healthcare services, yet geographic access in large rural and frontier regions remains poorly characterized. This study assessed community and specialized pharmacy access across West Texas and evaluated the prevalence of pharmacy deserts using distance measures.

Methods: A cross-sectional geographic information systems analysis was conducted across 108 counties in West Texas. Licensed community pharmacies and specialized pharmacy service providers were mapped and analyzed using a 10-mile distance threshold consistent with commonly used definitions of rural pharmacy deserts. Community pharmacies was also assessed using a 20-mile threshold to account for the travel patterns in frontier regions.

Results: A total of 544 community pharmacies were identified. Using a 10-mile threshold, 480,764 residents (16.0%) resided within pharmacy desert areas and 98,848 square miles (75.0%) of the region lacked pharmacy access. At a 20-mile threshold, 285,819 residents (9.5%) and 49,026 square miles (37.0%) remained outside community pharmacy service areas. Access to specialized pharmacy services was substantially more limited. Only 46 sterile compounding pharmacies, 74 Class D pharmacies, and 11 specialty pharmacies were identified, with services concentrated within major metropolitan centers and limited availability across rural and frontier communities.

Conclusions: Despite broad distribution of community pharmacies throughout West Texas, substantial pharmacy desert regions persist, particularly across rural and frontier counties. Access disparities are even more pronounced for specialized pharmacy services. These findings highlight opportunities to improve geographic access to essential pharmacy services and inform workforce, infrastructure, and policy planning in underserved regions.

Keywords: Census Tract; Geographic Information Systems; Pharmacies; Texas; Health Services Accessibility; Pharmaceutical Services; Pharmacy

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Introduction

Access to pharmacy services is a cornerstone of healthcare delivery, particularly in rural regions where geographic isolation and limited provider availability exacerbate health disparities. Community pharmacies serve as essential access points for medication dispensing and counseling, chronic disease management, and preventive services, including immunizations.[1] However, pharmacy deserts, areas where residents lack reasonable geographic access to a pharmacy, remains a significant barrier to care in the United States.[2] These deserts disproportionately affect rural communities, low-income populations, and racial and ethnic minorities, contributing to worse health outcomes and increased healthcare costs.[2-4]

Nationally, approximately 18% of the U.S. population lives in pharmacy deserts and an additional 9% resides in areas served by a single "keystone" pharmacy, meaning closure of that pharmacy would create a desert.[5,6] Rural communities are particularly vulnerable to these access gaps due to travel distances, limited transportation infrastructure, and fewer alternative healthcare resources. In Texas, these challenges are especially pronounced in the 108 most western counties, a region characterized by vast land areas, low population density, and limited healthcare infrastructure. Approximately 150 Texas counties lack a pharmacy entirely, and more than 4.8 million Texans live in counties served by only one pharmacy.[7,8]

Pharmacy deserts are commonly defined using census-based measures that identify areas without a pharmacy within one mile in urban settings or 10 miles in rural areas.[5] Nationally, an estimated 15.8 million people (4.7% of the U.S. population) reside in pharmacy deserts.[2] These communities frequently experience compounding social and structural barriers including higher poverty rates, lower educational attainment, limited transportation access, and higher burdens of chronic disease, all of which increase reliance on consistent medication access.[2, 3, 9]. Recent trends in pharmacy closures have intensified concerns about geographic access to care. Between 2018 and 2023, the total count of retail pharmacies in the United States declined by 3.9%, with rural communities experiencing a disproportionately greater loss (5.9%) compared to urban areas (3.4%).[10] Although pharmacy 'churn' has maintained nominal access in some locations, many rural communities remain highly vulnerable to the loss of a single pharmacy, which can rapidly transform limited access into a pharmacy desert.[5]

Prior research has described the prevalence of community pharmacy deserts in Texas using county-level measures.[7] While informative, this approach does not capture intra-county variation in access, proximity to pharmacies in neighboring counties, or differential access to specialized pharmacy services such as non-sterile and sterile compounding, Class D (charitable/clinic) pharmacies, or specialty pharmacies. Moreover, national rural access thresholds may underestimate access barriers in frontier regions where residents routinely travel farther for healthcare services. [11, 12]

To address these gaps, this study used Geographic Information System (GIS) methods to quantify community pharmacy access across the 108 westernmost counties of Texas using dual distance thresholds of 10 and 20 miles. In addition, the analysis examined geographic availability of non-sterile compounding, sterile compounding, Class D, and specialty pharmacy services. By incorporating both land-area and population-based measures, this study provides a detailed, region-specific assessment of pharmacy deserts in West Texas to better inform healthcare planning and access-focused interventions.

Methods

Geographic Area

The study focused on the 108 westernmost counties of Texas, a predominantly rural and frontier region characterized by larger geographic size, low population density, and limited healthcare infrastructure. According to the 2020 U.S. Census, the region has a total population of approximately 2,999,016 and a combined land area of approximately 131,840 square miles, resulting in a population density of

approximately 23 persons per square mile.[13,14,15] Major population centers within the region include the El Paso (population of 868,912), Lubbock (population of 351,253), Amarillo (population of 268,705), Abilene (population of 176,611), Midland (population of 175,587), and Odessa (population of 165,182) metropolitan areas.[16]

Pharmacy Data Sources and Classification
Pharmacy locations and service attributes were obtained from the Texas State Board of Pharmacy (TSBP) license database, with data extracted on October 30, 2025.[17] All licensed community pharmacies located within the 108-county study region were included. Pharmacies were classified by service type based on licensure and publicly reported attributes, including community pharmacies (Class A) and specialized pharmacy services (including non-sterile compounding, sterile compounding, Class D (charitable/clinic), and specialty services).

Geospatial Analysis
All pharmacies were geocoded by physical address and mapped using latitude and longitude coordinates in ArcGIS Pro (ESRI; Redlands, CA). To quantify geographic access, circular Euclidean buffers with radii of 10 miles and 20 miles were generated around each pharmacy location using ArcGIS geoprocessing tools. Overlapping buffers were dissolved into a single coverage polygon for each threshold to avoid double-counting of covered areas. The dissolved coverage polygons were clipped to the boundaries of the 108-county study region. Covered and uncovered land areas were calculated based on the clipped coverage layers.

Population Coverage Estimation
Population coverage was estimated using 2020 U.S. Census tract and population place data. Census tracts fully contained within a coverage polygon were counted in full. For census tracts and population places partially intersecting the coverage boundary, population was apportioned using areal weighting to estimate the proportion of residents within the covered area.

Covered and uncovered population estimates were derived by subtracting the estimated covered population from the total population of the 108-county study region.

Distance Threshold Selection
A 10-mile distance threshold was applied to community and specialized pharmacy services to maintain comparability with commonly applied definitions of rural pharmacy deserts in the existing literature[2,5]. Because residents of frontier regions routinely travel greater distances for healthcare services, an additional 20-mile threshold was applied to community pharmacies better reflect the geographic context of West Texas. Federal analyses and national studies document substantially longer travel distances for rural care, including pharmacy-related trips in nonmetropolitan areas, supporting evaluation of access beyond conventional rural thresholds.[11,12]

Use of dual distance thresholds allowed assessment of pharmacy access under both standardized rural definitions and region-specific travel conditions using the same geospatial methods, without altering underlying analytic assumptions.

Pharmacy Service Definitions
Community pharmacies (Class A) were defined as pharmacies licensed to dispense prescription medications directly to patients. Non-sterile compounding pharmacies were defined as those authorized to prepare customized non-sterile products in accordance with 22 TAC §291.131 and United States Pharmacopeia (USP) Chapter 795.[18,19] Sterile compounding pharmacies were defined as those meeting requirements under 22 TAC §291.133 and USP Chapter 797, including preparation of injectable, infusion, or ophthalmic sterile products in controlled cleanroom environments. Class D pharmacies (charitable/clinic) were defined as pharmacies within licensed clinics that dispense or provide a limited formulary of medications directly to clinic patients, often serving uninsured or underinsured populations. Specialty pharmacies were defined as pharmacies specializing in medications requiring special handling, distribution, or patient management services, including high-cost or biologic therapies.

Methodological Considerations

This analysis used straight-line (Euclidean) distance buffers, a standard and reproducible approach for large-area rural access studies. While road-network-based drive-time analyses may provide more precise estimates of travel burden, Euclidean buffers were selected due to their suitability for regional-scale analysis and the limited availability of routable, high-resolution road network data across sparsely populated frontier counties. Drive-time modeling represents an important area for future research.

Results

Pharmacy Distribution

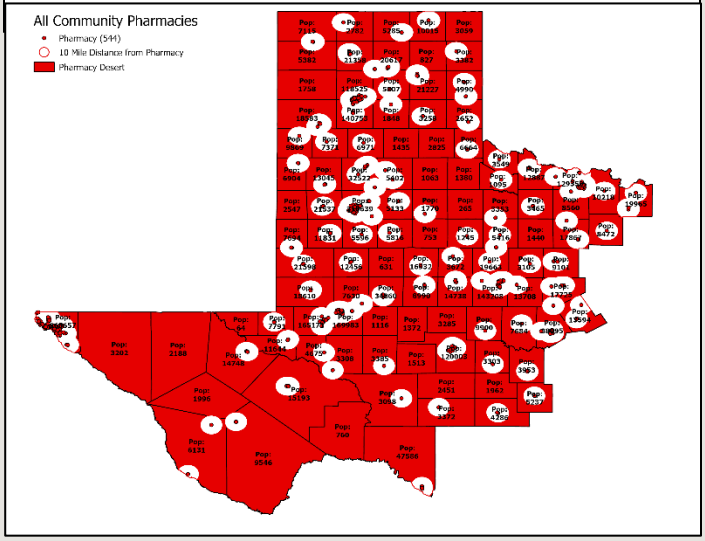
There were 544 community pharmacies located within the 108 westernmost counties of Texas (Figure 1). The majority (68%) were in counties with populations greater than 50,000, clustering around metropolitan hubs including El Paso, Lubbock, Amarillo, Abilene, Midland, and Odessa. Large portions of the region outside these metropolitan areas were served by a limited number of pharmacies, with many counties relying on a single community pharmacy for geographic access.

Access to Community Pharmacies

10-Mile Distance Threshold:

When applying the more commonly used 10-mile rural threshold, geographic access declined substantially. Only 32,992 square miles (25.0%) of the region were within 10 miles of a community pharmacy, leaving 98,848 square miles (75.0%) of land area without access within this distance. (Figure 1) At the population level, 2,518,252 residents (84.0%) lived within 10 miles of a community pharmacy, while 480,764 residents (16.0%) lived more than 10 miles from the closest community pharmacy.

Figure 1: 10-Mile Distance Threshold



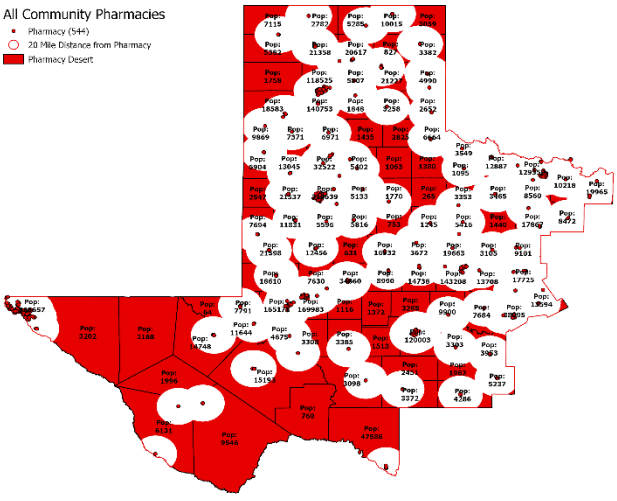
20-Mile Distance Threshold:

Using a 20-mile distance threshold, 82,814 square miles (62.8%) of the 108-county region were within geographic coverage of a community pharmacy, while 49,026 square miles (37.2%) of land area were located more than 20 miles from the nearest pharmacy (Figure 2).

Based on 2020 U.S. Census population data, 2,713,197 residents (90.5%) lived within 20 miles of a community pharmacy. An estimated 285,819 residents (9.5%) lived more than 20 miles from the nearest pharmacy. Areas lacking pharmacy access at the 20-mile threshold were concentrated in rural and frontier regions of West Texas (Figure 2).

Access to Specialized Pharmacy Services (10-Mile Threshold)

Figure 2: 20-Mile Distance Threshold



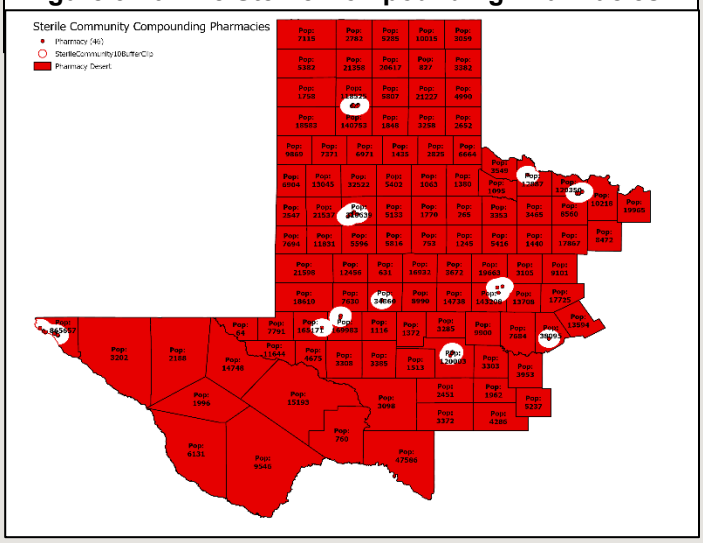
Non-Sterile Compounding Pharmacies:

There were 388 community pharmacies providing non-sterile compounding services,

representing 71% of all community pharmacies in the study region (Figure 3). Using a 10-mile threshold, non-sterile compounding pharmacies covered 21,215 square miles, leaving 110,625 square miles (83.9%) of land area without access to these services.

At the population level, 2,375,722 residents (79.2%) lived within 10 miles of a non-sterile compounding pharmacy, while 623,294 residents (20.8%) lived further away.

Figure 3:10-Mile Sterile Compounding Pharmacies

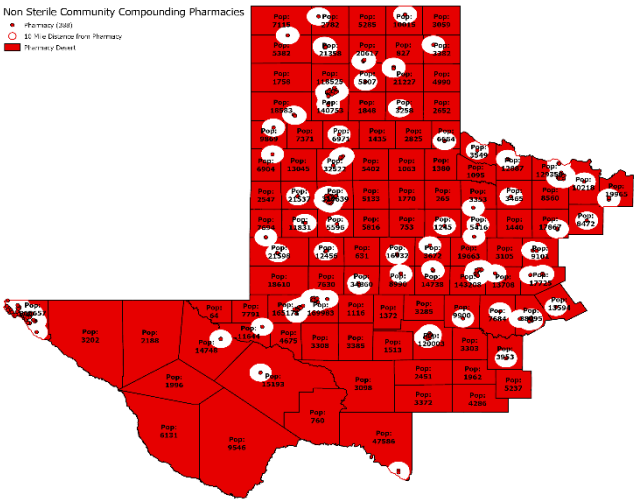


Sterile Compounding Pharmacies:
Geographic access to community pharmacies offering sterile compounding services was markedly limited, with only 46 such pharmacies across the 108-county region (Figure 3). Using a 10-mile threshold, sterile compounding pharmacies covered just 4,295 square miles (3.3%), leaving 127,545 square miles (96.7%) of the region without access to sterile compounding pharmacies within this distance (Figure 4).

An estimated 1,820,424 residents (60.7%) lived within 10 miles of a sterile compounding pharmacy, while 1,178,592 residents (39.3%) lived more than 10 miles from access to sterile compounding services.

Sterile compounding pharmacies were predominantly located in higher-population counties, with only 6.5% situated in counties with populations less than 50,000.

Figure 4: 10-Mile Non-Sterile Compounding Pharmacies



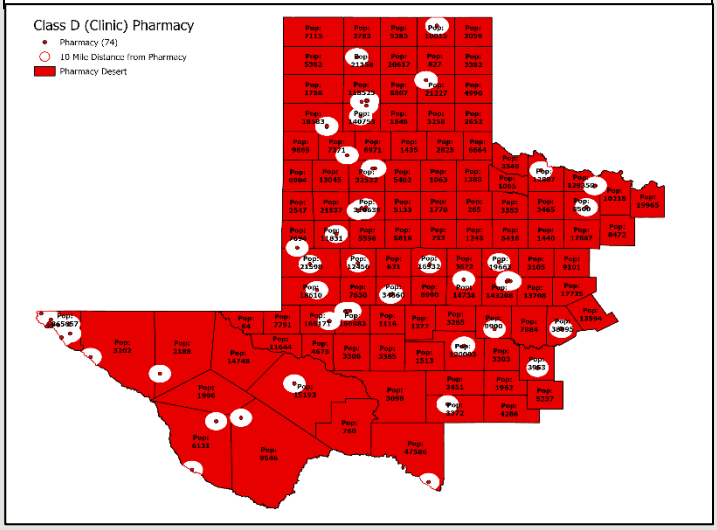
Class D (Charitable/Clinic) Pharmacies:
There were 74 Class D pharmacies located in 36 of the 108 counties (33%) (Figure 4). Using a 10-mile threshold, Class D pharmacies covered 12,319 square miles, leaving 119,521 square miles (90.66%) of land area without access within this distance (Figure 5.) At the population level, 2,151,347 residents (71.7%) lived within 10 miles of a Class D pharmacy, while 847,669 residents (28.3%) lived more than 10 miles from these services.

Specialty Pharmacies:
There were only 11 specialty pharmacies located in the 108 counties (Lubbock = 3, El Paso = 2, Amarillo = 2, Other cities = 4). These 11 pharmacies represent 9.2% of the 119 specialty pharmacies with active licenses and a Texas physical address. These results show that there is limited access to specialty pharmacy services outside of metropolitan hubs.

Geographic Patterns of Access

Across all pharmacy types, geographic access was highest within and surrounding metropolitan hubs and declined sharply in rural and frontier counties. Disparities in access were most pronounced for community pharmacies providing sterile compounding services, Class D pharmacy services and specialty services, which were largely absent outside high-population centers.

Figure 5: Class D Pharmacies



Discussion

GIS-based spatial analysis provides a precise and reproducible approach for measuring geographic accessibility, enabling evaluation of intra-county variation in pharmacy access that is not captured by county-level definitions. By integrating geospatial buffers, census geography, and pharmacy service attributes, this analysis offers an assessment of access gaps and their relevance for rural and frontier healthcare delivery. This perspective highlights how extended travel distances and large geographic coverage areas can persist as meaningful access barriers outside metropolitan hubs.

A comparison of 10-mile and 20-mile distance thresholds illustrates the sensitivity of pharmacy desert estimates to underlying distance assumptions. Earlier national work has reported that approximately 89% of U.S. residents live within five miles of a community pharmacy, a figure that can obscure substantial regional variation when applied to frontier areas.[20] In contrast, our findings align with prior studies demonstrating that rural regions are disproportionately affected by limited pharmacy access, even when extended distance thresholds are applied.[21] While some states, such as Wisconsin, report near-universal access within 30 minutes of a pharmacy, other rural regions, including Georgia and West Texas, exhibit markedly longer travel distances. [10,22] In extreme cases, residents of remote West Texas communities, such as Terlingua, may travel more than 80 miles to reach the nearest pharmacy.[23]

Recent national analyses describe pharmacy "churn," in which openings and closures may offset one another at an aggregate level, masking underlying instability. [5] In rural and frontier settings, this dynamic represents heightened vulnerability rather than resilience. Many communities depend on a single community pharmacy for geographic access, and closure of that pharmacy is unlikely to be offset by replacement due to low population density, workforce shortages, and financial constraints. Under these conditions, churn can rapidly convert marginal access into a pharmacy desert, compounding the risk for already underserved populations.

Recent national studies have further identified the concept of "keystone pharmacies," defined as sole community pharmacies whose closure would immediately create a pharmacy desert.[5] Although this study did not explicitly classify keystone pharmacies, the observed reliance of many West Texas counties on a single community pharmacy suggests substantial exposure to this form of vulnerability, particularly in rural and frontier areas.

Access disparities were more pronounced for specialized pharmacy services than for community pharmacies overall. Although nonsterile compounding services were available at many community pharmacies, large portions of the region remained geographically isolated from these services. Access limitations were most severe for sterile compounding and specialty pharmacy services, which were concentrated almost exclusively in higher-population counties. Limited access to sterile compounding services has important clinical implications for patients requiring oncology therapies, ophthalmic preparations, parenteral nutrition, and home infusion services, where timely access to appropriately prepared sterile products is essential.[24,25,26]

Class D (charitable or clinic-based) pharmacies also demonstrated substantial geographic gaps.

These pharmacies serve an important safety-net function for uninsured and underinsured patients, yet were unevenly distributed across the region and largely absent from rural and frontier counties. Limited geographic access to Class D pharmacies may exacerbate medication access barriers in areas with high poverty and limited healthcare infrastructure, particularly where retail pharmacy access is also constrained.[27]

Access to specialty pharmacy services was particularly limited across West Texas, with only 11 specialty pharmacies identified across the 108-county study region. These pharmacies were concentrated within major metropolitan centers, leaving large rural and frontier areas without nearby specialty pharmacy access. Specialty pharmacies play an important role in the management of complex therapies and frequently provide services beyond medication dispensing, including patient education, medication monitoring, financial assistance navigation, and coordination of care with specialty providers. Although specialty medications may be obtained through mail-order and centralized distribution networks, and telepharmacy models may mitigate some geographic barriers to care, the geographic concentration of specialty pharmacies may still limit access to pharmacist-provided support services for patients residing in geographically isolated communities.[28, 29] Notably, evidence evaluating specialty pharmacy deserts remains limited compared with the broader literature on community pharmacy access and pharmacy deserts.[5, 30, 31] Future research should evaluate how geographic access to specialty pharmacy services influences care coordination, treatment initiation, and medication management in rural populations.

The geographic patterns observed in this study reflect structural characteristics unique to West Texas. Large county size, sparse population distribution, transportation limitations, and workforce shortages constrain both the establishment and sustainability of pharmacy services. While metropolitan hubs provide concentrated access, vast areas between these centers remain underserved. These findings are consistent with prior work linking pharmacy deserts to broader social and infrastructural vulnerabilities, including food insecurity and limited digital connectivity.[32]

Pharmacy deserts also carry significant economic implications. Pharmacy closures are associated with increased annual healthcare costs for residents in medically underserved areas compared with non-underserved regions.[33] Financial pressures, including declining reimbursement rates and workforce shortages, continue to threaten the sustainability of independent community pharmacies, particularly in rural settings.[34] Antitrust and market consolidation dynamics may further contribute to pharmacy closures and reduced competition.[35] Recent surveys indicate that a substantial proportion of independent pharmacies anticipate closure, raising concern for further expansion of pharmacy deserts in rural communities.[36, 37]

Policy and practice responses aimed at mitigating pharmacy deserts are emerging. State-level reforms, payer initiatives, and proposed federal legislation seek to stabilize pharmacy access in underserved areas.[38-40] Telepharmacy has also been identified as a potential strategy to extend pharmacy services in rural regions, although its effectiveness is influenced by broadband availability, regulatory frameworks, and digital literacy.[3, 41]

Several limitations should be considered. This analysis relied on Euclidean distance buffers rather than road-network-based travel times, which may overestimate practical access in some areas. Additionally, the study did not evaluate affordability, hours of operation, staffing capacity, or patient-level outcomes such as medication adherence. These factors warrant further investigation using complementary analytic approaches.

Despite these limitations, this study provides a region-specific, service-level assessment of pharmacy access that extends beyond county-level measures and conventional rural

thresholds. By evaluating both 10-mile and 20-mile distance standards and differentiating among pharmacy service types, this analysis highlights persistent and clinically relevant access gaps in West Texas and offers a framework for future evaluations of pharmacy access in rural and frontier regions.

Conclusion

This study provides a region-specific, GIS-based assessment of pharmacy access across the 108 westernmost counties of Texas and demonstrates that substantial geographic disparities persist in this frontier region. Evaluation using both 10-mile and 20-mile distance thresholds shows that while extended travel distances reduce the proportion of the population classified as underserved, large geographic areas, and clinically important subsets of the population, remain isolated from pharmacy services.

Access gaps were pronounced for specialized pharmacy services, including non-sterile compounding, sterile compounding, Class D (charitable or clinic-based), and specialty pharmacies, which were concentrated in higher-population counties and largely absent from rural and frontier areas. These service-level disparities have important implications for medication access, continuity of care, and the delivery of specialized therapies in West Texas.

By moving beyond county-level measures and conventional rural distance thresholds, this analysis highlights how land area, travel burden, and service availability interact to shape pharmacy access in frontier settings. These findings underscore the need for regionally tailored approaches to pharmacy access assessment and provide a framework for future evaluations incorporating service capacity, travel time, and patient-level outcomes in rural and frontier healthcare systems.

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References

1. Catalano G, Khan MMM, Chatzipanagiotou OP, Pawlik TM. Pharmacy accessibility and social vulnerability. JAMA Netw Open. 2024;7(8):e2429755. doi:10.1001/jamanetworkopen.2024.29755

2. Wittenauer R, Shah PD, Bacci JL, Stergachis A. Locations and characteristics of pharmacy deserts in the United States: a geospatial study. Health Aff Sch. 2024;2(4):qxae035. doi:10.1093/haschl/qxae035

3. Catalano G, Woldesenbet S, Pawlik TM. Distribution of pharmacy deserts and its association with digital divide and residential redlining across the United States. PLoS One. 2025;20(8):e0330027. doi:10.1371/journal.pone.0330027

4. Murphy M, Rodis J. The growing crisis of pharmacy deserts. The Ohio State University College of Pharmacy. Published April 28, 2025. Accessed October 29, 2026. https://pharmacy.osu.edu/news/growing-crisis-pharmacy-deserts

5. Mathis WS, Berenbrok LA, Kahn PA, Appolon G, Tang S, Hernandez I. Vulnerability index approach to identify pharmacy deserts and keystone pharmacies. JAMA Netw Open. 2025;8(3):e250715. doi:10.1001/jamanetworkopen.2025.0715

6. Locklear M. A new metric to identify—and prevent—pharmacy deserts. Yale School of Medicine. Published April 11, 2025. Accessed October 29, 2026. https://medicine.yale.edu/news-article/a-new-metric-to-identify-prevent-pharmacy-deserts/

7. Doan K, Appiah D, Aljanabi N, Hall R. Analysis of county-level pharmacist and pharmacy deserts in Texas. West Tex J Med. 2023;1(2):24-30. Accessed October 29, 2026. https://westtexasjom.org/index.php/wtjm/article/

view/17

8. McCool H, Weitz A. Pharmacy deserts in Texas and how they contribute to ER admissions: a literature review. Poster presented at: Texas Tech University Health Sciences Center Student Research Week; March 2022; Lubbock, TX. Accessed October 29, 2026. https://www.researchgate.net/publication/372980489_Pharmacy_Deserts_in_Texas_and_How_They_Contribute_to_ER_Admissions_A_Literature_Review

9. Centers for Disease Control and Prevention. PLACES: local data for better health, county data 2024 release. Accessed October 29, 2026. https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-County-Data-20/fu4u-a9bh/about_data

10. Ullrich F, Muller K. Changes in rural pharmacy presence, 2023. RUPRI Center for Rural Health Policy Analysis; 2024. Policy Brief No. 2024-4. Revised February 27, 2025. Accessed October 29, 2026. https://rupri.public-health.uiowa.edu/publications/policybriefs/2024/Rural_Pharmacy_Presence.pdf

11. Marsh T, Cisneros T. 48.4 million Americans lack adequate access to a pharmacy. GoodRx. Updated March 20, 2025. Accessed October 29, 2026. https://www.goodrx.com/healthcare-access/research/many-americans-lack-convenient-access-to-pharmacies

12. US Government Accountability Office. Rural hospital closures: affected residents had reduced access to health care services. Published January 21, 2021. Accessed October 29, 2026. https://www.gao.gov/products/gao-21-93

13. United States Census Bureau. Decennial Census: total population. Accessed December 5, 2025. https://data.census.gov/table/DECENNIALPL2020.P1

14. United States Census Bureau. County population totals and components of change: 2020-2025. Accessed October 29, 2026. https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html

15. United States Census Bureau. GEOINFO-Annual geographic information table. Accessed October 29, 2026. https://data.census.gov/table/GEOINFO2023.GEOINFO

16. United States Census Bureau. Metropolitan and micropolitan statistical area population totals and components of change: 2020-2025. Accessed October 29, 2026. https://www.census.gov/data/tables/time-series/demo/popest/2020s-total-metro-and-micro-statistical-areas.html

17. Texas State Board of Pharmacy. Download tables for license verifications. Accessed October 29, 2026. https://www.pharmacy.texas.gov/dbsearch/tables.asp

18. Texas State Board of Pharmacy. Board rules. Updated September 1, 2026. Accessed October 29, 2026. https://www.pharmacy.texas.gov/files_pdf/TSBP%20Rules_MASTER%20FILE.pdf

19. United States Pharmacopeia. USP General Chapter <795>. Accessed October 29, 2026. https://www.usp.org/compounding/general-chapter-795

20. Berenbrok LA, Tang S, Gabriel N, et al. Access to community pharmacies: a nationwide geographic information systems cross-sectional analysis. J Am Pharm Assoc (2003). 2022;62(6):1816-1822.e12. doi:10.1016/j.japh.2022.07.003

21. Pednekar P, Peterson A. Mapping pharmacy deserts and determining accessibility to community pharmacy services for elderly enrolled in a State Pharmaceutical Assistance Program. PLoS One. 2018;13(6):e0198173. doi:10.1371/journal.pone.0198173

22. Look KA, Dekeyser C, Conjurske S, et al. Illustrating access to community pharmacies in Wisconsin. J Am Pharm Assoc (2003). 2021;61(4):492-499. doi:10.1016/j.japh.2021.02.004

23. Texas Health and Human Services. Texas

Cares Rx annual program report. Published 2024. Accessed October 29, 2026. https://www.hhs.texas.gov/sites/default/files/documents/texas-cares-annual-program-report-dec-2024.pdf

24. Carvalho M, Almeida IF. The role of pharmaceutical compounding in promoting medication adherence. Pharmaceuticals (Basel). 2022;15(9):1091. doi:10.3390/ph15091091

25. Institute for Safe Medication Practices. ISMP guidelines for sterile compounding and the safe use of sterile compounding technology. Published 2022. Accessed October 29, 2026. https://www.ismp.org/system/files/resources/2022-04/ISMP195-Compouding%20Guidelines%20v1-042722-2.pdf

26. American Society of Health-System Pharmacists. Pharmaceutical cold chain management in health systems. Published 2022. Accessed October 29, 2026. https://www.ashp.org/-/media/assets/innovation/docs/ASHP-Cold-Chain-Management-Resource-Guide-1.pdf

27. RxRoundtable. Charitable pharmacies improve access to prescription medications. Accessed October 29, 2026. https://therxroundtable.com/rxr-briefings/the-growing-role-of-charitable-pharmacies

28. Urick BY, Adams JK, Bruce MR. State telepharmacy policies and pharmacy deserts. JAMA Netw Open. 2023;6(8):e2328810. doi:10.1001/jamanetworkopen.2023.28810

29. Sugita H, Takenaka Sato M, Yamaji N, et al. Clinical effectiveness of telepharmacy services in patients with non-communicable diseases in ambulatory care settings. Cochrane Database Syst Rev. 2026. doi:10.1002/14651858.CD015136.pub2

30. Ford CD, Cameron NA, Clark D, et al. Rural health and health disparities in hypertension management: a scientific statement from the American Heart Association. Hypertension. 2026;83(8):e00263. doi:10.1161/HYP.0000000000000263

31. Roubin S, Holler J, Kedron P. Urban-rural disparities in spatiotemporal accessibility of pharmacy care: a case study of Vermont, USA. BMC Health Serv Res. 2025;25(1):1484. doi:10.1186/s12913-025-13653-1

32. Poondi N, Douglas A, McDaniel P, et al. Mapping pharmacy deserts in North Carolina: a geospatial analysis and its implications for University of North Carolina Health's catchment population. J Am Pharm Assoc (2003). 2024;64(6):102215. doi:10.1016/j.japh.2024.102215

33. Adepoju OE, Kiaghadi A, Shokouhi Niaki D, Karunwi A, Chen H, Woodard L. Rethinking access to care: a spatial-economic analysis of the potential impact of pharmacy closures in the United States. PLoS One. 2023;18(7):e0289284. doi:10.1371/journal.pone.0289284

34. Dugani S, Choudhary V, Williams BG. Rural independent pharmacies sustainability strategy. National Rural Health Association Policy Brief. 2024. Accessed October 29, 2026. https://www.ruralhealth.us/nationalruralhealth/media/documents/advocacy/policy%20brief/nrha-policy-brief-independent-retail-pharmacy-final.pdf

35. Leslie CR. Pharmacy deserts and antitrust law. Boston Univ Law Rev. 2024;104(6):1593-1620. Accessed October 29, 2026. https://www.bu.edu/bulawreview/files/2024/12/LESLIE.pdf

36. National Community Pharmacists Association. Local pharmacies on the brink, new survey reveals. Published February 27, 2024. Accessed October 29, 2026. https://ncpa.org/newsroom/news-releases/2024/02/27/local-pharmacies-brink-new-survey-reveals

37. Damp P. With dozens of independent and local pharmacies closing their doors, local lawmakers look for a solution. CBS News. Published May 11, 2024. Accessed October 29, 2026. https://www.cbsnews.com/pittsburgh/news/with-dozens-of-independent-and-local-pharmacies-closing-their-doors-local-lawmakers-look-for-a-

solution/

38. Cantrell J. Arkansas leads the nation with landmark pharmacy benefit manager reform. The Rheumatologist. Published June 22, 2025. Accessed October 29, 2026. https://www.the-rheumatologist.org/article/arkansas-leads-the-nation-with-landmark-pharmacy-benefit-manager-reform/

39. Academy of Managed Care Pharmacy. Health equity action brief. Published January 2024. Accessed October 29, 2026. https://www.amcp.org/sites/default/files/2024-01/AMCP-Geographic-Inequality-Health-Equity-Action-Brief-Jan-2024.pdf

40. Pharmacy Desert Act. The Pharmacy Desert Act. Published 2023. Accessed October 29, 2026. https://thepharmacydesertact.org/home

41. Dowell MA. The evolving telepharmacy dispensing landscape. US Pharmacist. Published October 14, 2025. Accessed October 29, 2026. https://www.uspharmacist.com/article/the-evolving-telepharmacy-dispensing-landscape

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