West Texas Journal *of* Medicine

Original Article

Pediatric Trauma Patterns and Prevention Strategies in West Texas: Implications for Emergency Medicine and Community Outreach

Grady Edens, M.S.[1]; Joel P. White, M.S.[1]; Christopher Hidalgo, D.O.[1]; Glenda Grawe, M.D.[1]; Stephanie Stroever, Ph.D., MPH[1]

Abstract

Background: Pediatric trauma is the leading cause of mortality among U.S. children and adolescents. Rural populations experience disproportionately high injury burden due to geographic isolation, prolonged transport times, and increased exposure to off-road vehicle (ORV) use. However, broad rural–urban classifications may obscure important regional variability. West Texas and Eastern New Mexico represent a unique catchment area with expansive rural zones, long transport distances, and significant reliance on regional trauma referral networks.

Objectives: The primary objective of this study was to characterize pediatric trauma patterns and Injury Severity Score (ISS) distribution among children presenting to a Level 1 trauma center serving West Texas and Eastern New Mexico. Secondary objectives included evaluating differences in mechanism of injury (MOI) between rural and urban populations, comparing injury severity across geographic classifications, and assessing predictors of ORV-related trauma.

Methods: This retrospective observational cohort study analyzed pediatric trauma registry data from University Medical Center (UMC) in Lubbock, Texas. Patients younger than 18 years evaluated for traumatic injury during the study period were included. Counties were categorized using Rural–Urban Continuum Codes (RUCC), with metropolitan counties defined as RUCC 1–3 and nonmetropolitan counties defined as RUCC 4–9. Additional regional stratification was performed using Regional Advisory Council (RAC) trauma service designations. Demographic variables, mechanism of injury, and Injury Severity Score were analyzed using descriptive statistics, chi-square analysis, and logistic regression.

Results: A total of 2,720 pediatric trauma patients were included. Injury severity distribution demonstrated a strong right-skewed pattern, with most injuries classified as mild (ISS 1–8). Rural and urban populations showed no statistically significant differences in overall mechanism of injury distribution or ISS categories. However, significant regional differences in trauma severity emerged when patients were stratified according to RAC region. ORV-related injuries demonstrated significant associations with specific RUCC categories, age, and sex. Compared to RUCC 2 counties, RUCC 6 counties demonstrated significantly higher odds of ORV injury after adjustment for demographic factors.

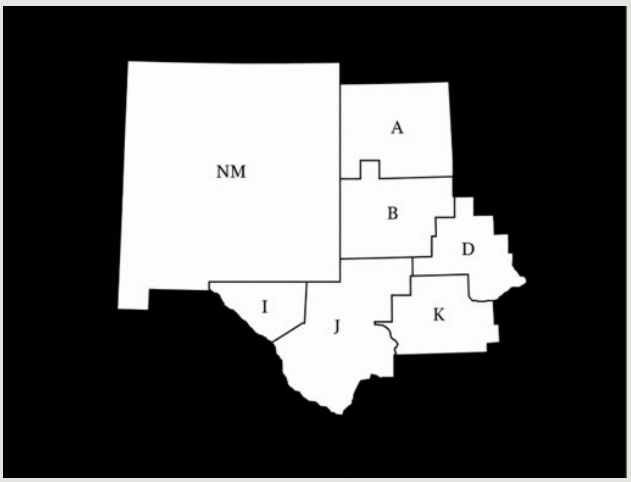
Conclusions: Broad rural–urban classifications may inadequately capture meaningful geographic variation in pediatric trauma patterns. Regional heterogeneity within West Texas suggests the need for localized prevention initiatives, improved EMS protocols, and targeted outreach programs emphasizing ORV safety and rapid trauma transport. Data-driven understanding of local epidemiology may improve both pediatric trauma prevention and acute trauma system performance.

Keywords: pediatric trauma, rural health, injury severity score, off-road vehicle injuries, emergency medicine, trauma systems, West Texas, Rural-Urban Continuum Codes

Introduction

Trauma remains the leading cause of death among pediatric patients in the United States and represents a substantial source of long-term disability, healthcare utilization, and socioeconomic burden[1,2]. According to the Centers for Disease Control and Prevention (CDC), unintentional injuries account for most pediatric mortality beyond infancy, with motor vehicle crashes, recreational injuries, falls, and firearm-related trauma contributing significantly to morbidity and mortality across childhood and adolescence[2–5]. Prior literature suggests that while pediatric trauma affects all geographic regions, rural communities consistently experience worse outcomes than urban populations[6–8]. The disparity between rural and urban trauma outcomes is multifactorial as rural communities frequently face reduced access to pediatric trauma centers, increased reliance on volunteer emergency medical services, limited availability of subspecialty surgical care, and prolonged transport times[8–12]. Additionally, rural children often experience increased exposure to high-risk mechanisms of injury associated with agricultural work, recreational vehicle use, livestock handling, and outdoor activities[7]. Prior studies have demonstrated that ATV and offroad vehicle (ORV)-related injuries occur at significantly higher rates among rural pediatric populations and are associated with severe orthopedic injuries, traumatic brain injury, and increased mortality[13–15]. Despite extensive national-level trauma research, broad geographic classifications may inadequately represent the variability that exists within individual trauma systems[16–18]. Rural designation alone may not meaningfully capture differences in injury epidemiology, EMS infrastructure, transportation barriers, or healthcare access[4,10–12,16,18]. Trauma mortality risk varies substantially across geographic regions and suggested that more granular spatial analyses are necessary to identify localized disparities and optimize trauma system performance[6,18]. West Texas and Eastern New Mexico provide a unique setting for pediatric trauma analysis as the region encompasses large geographic distances, multiple rural counties, agricultural economies, oilfield industries, and recreational ORV activity[7,9,13,14]. University Medical Center in Lubbock serves as the primary Level 1 trauma center for a broad catchment area extending across West Texas and portions of Eastern New Mexico (Figure 1). Given the diversity of regional populations and trauma mechanisms, a more detailed understanding of pediatric trauma patterns may provide valuable insight for emergency medicine physicians, trauma surgeons, EMS agencies, and public health organizations[6,7]. The present study sought to characterize pediatric trauma patterns within this regional trauma network. The primary objective was descriptive in nature and aimed to evaluate Injury Severity Score distribution and mechanism of injury trends among pediatric trauma patients. Secondary objectives included comparison of rural versus urban injury mechanisms, assessment of regional differences in trauma severity, and evaluation of predictive factors associated with ORV-related trauma.

Figure 1: UMC Service Area



Background

Pediatric trauma research has consistently demonstrated disparities between rural and urban populations[6–9]. Children living in rural communities are more likely to experience delayed access to definitive trauma care, increased prehospital transport times, and reduced availability of pediatric specialty services[7,9,11,19]. These limitations contribute to increased mortality rates even when injury severity appears similar between geographic groups[6,8,20,21]. Several mechanisms contribute to

increased pediatric trauma risk in rural environments. Recreational ORV use represents one of the most important contributors to severe pediatric injury in agricultural regions[13,14,22,23]. Children and adolescents in rural communities are frequently exposed to ATVs, utility terrain vehicles, dirt bikes, and other recreational vehicles beginning at young ages[13,14]. Limited helmet use, lack of formal safety training, and operation on unregulated terrain substantially increase the risk of traumatic brain injury, spinal trauma, thoracic injury, and extremity fractures[13,14,24–26]. In addition to recreational injury exposure, rural communities often face infrastructural limitations affecting trauma outcomes[7–9,11,19,21]. EMS response times may be prolonged by geographic distance, workforce shortages, or adverse weather conditions[27–33]. Helicopter transport availability may also vary significantly across rural regions[34,35]. Consequently, mortality differences may emerge even in the absence of major differences in injury severity distributions[6,8,9,21,36]. Existing literature has emphasized the importance of geographic specificity in trauma analysis[8,37–39]. Traditional metropolitan vs. non-metropolitan classifications may oversimplify trauma epidemiology by grouping together populations with substantially different risk profiles[8,21,38,39]. For example, a county classified as non-metropolitan may contain agricultural communities, oilfield regions, recreational tourism centers, or frontier populations with very different mechanisms of injury and healthcare access challenges[38,40,41]. The Rural–Urban Continuum Code system developed by the United States Department of Agriculture offers a more nuanced method for categorizing counties according to population size and proximity to metropolitan areas[6,40,42]. Combining RUCC classification with regional trauma service designations may provide greater insight into pediatric injury patterns than broad rural–urban grouping alone[6,19,38,43]. Understanding local epidemiology is particularly important for trauma prevention efforts[44]. Community outreach strategies targeting helmet use, ORV safety, and injury prevention education are most effective when tailored to the specific risks of a given population[14,44–46]. Similarly, trauma response systems benefit from data-driven resource allocation, EMS protocol development, and transport optimization[36,37,47,48]. This study contributes to the growing body of literature emphasizing localized pediatric trauma analysis and may inform future prevention strategies throughout West Texas and similar rural populations.

Table 1. Cohort characteristics and injury severity

Population Characteristics	*Overall (N = 2,720)*
Age, years	
Mean ± SD	7.04 +/- 4.56
Median (IQR)	7 (8)
Sex, n (%)	
Male	1691 (62.2)
Female	1029 (37.8)
Ethinicity, n (%)	
White	2420 (89.0)
Asian	12 (0.4)
Native American	5 (0.2)
Black	139 (5.1)
Other/Unknown	141 (5.3)
Geographic classification, n (%)	
Urban	1381 (50.8)
Rural	1339 (49.2)
ISS	
Mean ± SD	7.04
Median	4
ISS category, n (%)	
Mild (1–8)	1,850 (68.0)
Moderate (9–15)	594 (21.8)
Severe (16–24)	153 (5.6)
Very severe (25–75)	123 (4.5)

Methods

This study was conducted as a retrospective observational cohort analysis of pediatric trauma patients evaluated at University Medical Center (UMC) in Lubbock, Texas. UMC serves as a

Level 1 trauma center and receives referrals from a broad geographic region encompassing West Texas and Eastern New Mexico. The study was designed primarily as a descriptive investigation intended to generate hypotheses

regarding regional pediatric trauma patterns. The study met criteria for exemption from formal institutional review board review in accordance with 45 CFR 46.104(d)(4)(iii) as designated by the Texas Tech University Health Sciences Center Institutional Review Board for the Protection of Human Subjects. Pediatric patients younger than 18 years who were evaluated for traumatic injury and entered the institutional trauma registry during from January 1, 2016 to December 31, 2024 were eligible for inclusion. Patients represented both metropolitan and nonmetropolitan communities across West Texas and Eastern New Mexico. Patients with incomplete geographic information or missing Injury Severity Score data were excluded from subgroup analyses when appropriate; this accounted for 175 patients or 6% of the original raw data. County-level geographic classification was performed using Rural–Urban Continuum Codes (RUCC). Metropolitan counties were defined as RUCC categories 1 through 3, while nonmetropolitan counties were defined as RUCC categories 4 through 9. Additionally, patients were assigned as either Rural or Urban based on USDA classification of their county. Additional stratification was performed using Regional Advisory Council (RAC) trauma service regions. Patients were grouped according to Region A (Panhandle), Region B (Lubbock area), Region NM (New Mexico), and combined Regions D, I, J, and K (surrounding regions of Lubbock/Region B) as seen in Figure 1. Lower-volume regions were combined to improve statistical stability and reduce the influence of sparse subgroup counts. Demographic variables included age and sex. Injury-related variables included mechanism of injury and Injury Severity Score (ISS). ISS values were analyzed both continuously and categorically. Standard ISS categories were defined as follows: Mild injury: ISS 1–8, Moderate injury: ISS 9–14, Severe injury: ISS 16–24, Very severe injury: ISS 25–75.[49]

All statistical analyses were conducted using IBM SPSS Statistics (Version 31.0; IBM Corp., Armonk, NY). The primary descriptive outcome involved characterization of ISS distribution across the study population. Descriptive statistics were used to summarize demographic and injury characteristics. Continuous variables were evaluated for normality using histogram analysis and visual inspection. ISS demonstrated a non-normal right-skewed distribution, with a median score of 4 and mean score of 7, reflecting the predominance of lower-severity trauma. Chi-square analysis was used to compare mechanism of injury distributions and ISS severity categories between geographic groups. Logistic regression analysis was performed to evaluate predictors of ORV-related trauma while controlling for age and sex. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 2,720 pediatric trauma patients were included in the analysis. The study population represented a broad geographic catchment area spanning metropolitan and nonmetropolitan counties across western Texas as demonstrated in Table 1. Injury Severity Score (ISS) distribution demonstrated substantial right skew, reflecting predominance of lower-acuity trauma within the cohort. Mild injuries (ISS 1–8) accounted for 68.0% of all cases (n = 1,850), while moderate injuries (ISS 9–14) comprised 21.8% (n = 594). Severe injuries (ISS 16–24) represented 5.6% of cases (n = 153), and very severe injuries (ISS 25–75) accounted for 4.5% (n = 123). The median ISS was 4, whereas the mean ISS was 7.04, further demonstrating a non-normal distribution driven by a large proportion of mild injuries.

Chi-square analysis comparing mechanisms of injury between RUCC Rural and Urban populations demonstrated no statistically significant differences (χ^2 (df) = 19.5(13), p = 0.109) as demonstrated in Table 2. Mechanisms of injury were proportionally distributed across both geographic categories, with no major variation identified between rural and urban patient populations.

Comparison of ISS severity categories between Rural and Urban populations similarly

demonstrated no statistically significant differences (χ^2 (df) = 4.9(3), p = 0.183). Mild, moderate, severe, and very severe injuries occurred at proportionally comparable rates as seen in Table 2. These findings indicate that injury severity distributions were largely similar when analyzed using broad rural–urban geographic groupings.

When patients were stratified according to Regional Advisory Council (RAC) trauma service regions rather than broad rural–urban classification, significant variation in injury severity distribution emerged (χ^2 (df) = 58.9(9), p < 0.001). Region B, corresponding to the greater Lubbock metropolitan area, demonstrated a higher proportion of mild injuries relative to other regions. In contrast, Region A demonstrated a greater proportion of moderate injuries, while combining Regions D, I, J, and K demonstrated variable distributions of severe and very severe trauma. These findings are demonstrated in Table 3.

Logistic regression analysis was performed to evaluate predictors associated with ORV-related trauma as seen in Table 4. After adjustment for age and sex, overall RUCC classification was significantly associated with ORV-related injury patterns (Wald χ^2 (df) = 18.3(7), p = 0.011). Compared with RUCC 2 counties, patients from RUCC 6 counties demonstrated significantly greater odds of ORV-related injury (OR 2.5, p < 0.001), while RUCC 7 counties also demonstrated increased odds of ORV-related trauma (OR 2.5, p = 0.021). No statistically significant differences were identified for RUCC 3, 4, 5, 8, or 9 counties relative to the reference group. Female sex was independently associated with increased odds of ORV-related trauma compared with males (OR 1.6, p = 0.007). Increasing age was also associated with greater likelihood of ORV-related injury, with each additional year of age corresponding to an increase in odds of ORV trauma (OR 1.3, p < 0.001).

Discussion

The present study provides insight into pediatric trauma epidemiology within a large rural trauma catchment area encompassing West Texas and Eastern New Mexico. Several important findings emerged from the analysis. First, pediatric trauma patterns demonstrated greater similarity between metropolitan and nonmetropolitan populations than initially anticipated. Mechanism of injury distributions and Injury Severity Score categories did not significantly differ between broad rural and urban classifications. This finding contrasts with portions of the existing literature suggesting substantially higher trauma burden among rural pediatric populations[8,21,38]. However, it may reflect the limitations of broad geographic classification systems in capturing the complexity of regional trauma epidemiology[6,8,38–40]. The absence of significant rural–urban differences does not necessarily imply equivalent trauma risk across

Table 3. Injury Severity by RAC Region

ISS category	Region A	Region B	Regions D/I/J/K	New Mexico	Total
Mild (1–8)	231 (59.1%)	791 (73.9%)	479 (62.9%)	349 (70.4%)	1,850 (68.0%)
Moderate (9–14)	119 (30.4%)	185 (17.3%)	189 (24.8%)	101 (20.4%)	594 (21.8%)
Severe (16–24)	31 (7.9%)	41 (3.8%)	55 (7.2%)	26 (5.2%)	153 (5.6%)
Very severe (25–75)	10 (2.6%)	54 (5.0%)	39 (5.1%)	20 (4.0%)	123 (4.5%)
Total	**391 (100%)**	**1,071 (100%)**	**762 (100%)**	**496 (100%)**	**2,720 (100%)**

communities. Rather, it suggests that trauma exposure and injury patterns within West Texas may be influenced by localized cultural, economic, and environmental factors extending beyond conventional population-density metrics. Second, regional stratification using RAC designations revealed meaningful geographic variation in injury severity. This observation supports the hypothesis that localized analysis may identify disparities obscured by broader classifications. Regions characterized by greater transport distances, reduced EMS density, or increased recreational ORV exposure may experience distinct trauma patterns despite sharing similar RUCC categories.

The finding that Region B demonstrated a greater proportion of mild injuries may reflect proximity to tertiary care resources and lower thresholds for emergency evaluation within metropolitan settings[50]. Additionally, Region B, where study site is located, would not attract mild injuries from other surrounding areas as they can be well managed without a referral for greater resources. This claim is similarly reflected by Region A having significantly more Moderate injuries as they would require referral for a higher level of care. Conversely, rural regions may experience selective referral bias in which only higher-acuity patients are transferred to tertiary centers[9,51,52]. The ORV-specific findings are particularly important for pediatric injury prevention efforts. Although ORV-related injuries were anticipated to occur more frequently in rural regions, broad metropolitan versus nonmetropolitan categorization did not reveal substantial differences in overall mechanism patterns. ORV trauma continues to represent a major source of pediatric morbidity in rural environments[14,26,53]. Increased odds of ORV injury among RUCC 6 counties suggest that certain semi-rural or isolated communities may experience especially high exposure risk. Collectively, these findings suggest that ORV-related trauma patterns vary according to more granular geographic and demographic characteristics rather than broad rural–urban designation alone.

The association between increasing age and ORV injury is consistent with prior literature demonstrating elevated risk-taking behaviors among adolescents[14,54,55]. Older pediatric patients may engage in independent vehicle operation with limited supervision, increasing the likelihood of high-energy trauma[14]. The finding that female sex was independently associated with increased odds of ORV injury after adjustment was unexpected and may reflect regional recreational participation patterns or sampling characteristics. Further investigation is warranted to clarify this relationship. Prior literature suggests that rural pediatric trauma patients may experience increased mortality despite comparable injury severity[8,9,20,21]. Literature suggests that factors such as prolonged EMS response intervals, delayed access to blood products, limited pediatric airway expertise, and lengthy transport times contribute to these disparities[7,9,56–60]. These findings have important implications for emergency medicine and public health policy. Region-specific injury prevention programs may be more effective than broad statewide initiatives. Community outreach through schools, 4-H organizations, Future Farmers of America chapters, and recreational organizations may improve helmet utilization while riding and parental supervision practices[44,46,54]. Additionally, trauma systems serving rural populations should prioritize optimization of prehospital care protocols. Strategies such as rapid transport, expanded airway management training, telemedicine consultation, and improved access to prehospital blood products may reduce preventable mortality[36,60,61].

Several limitations should be considered when interpreting the findings of this study. Firstly, the retrospective observational design limited the ability to establish causal relationships between geographic factors and trauma outcomes. The study was intended primarily as a descriptive and hypothesis-generating investigation. Secondly, the analysis relied on trauma registry data from a single Level 1 trauma center. Although UMC serves a large regional catchment area, findings may not be generalizable to other trauma systems with different demographic or geographic characteristics. Thirdly, the absence of significant rural–urban differences in ISS

distribution may partly reflect referral bias. Rural patients managed at local facilities without transfer to UMC are not captured in this dataset, which likely enriches the rural cohort for higher-acuity injuries and may mask true differences in injury severity between geographic groups. Relatedly, the study focused primarily on patients who survived long enough to reach definitive trauma care; prehospital fatalities and patients treated at outside institutions may not have been fully captured. Fourthly, broad grouping of RAC regions may have obscured additional local variation. Lower-volume regions were combined to improve analytic stability, but this may have reduced sensitivity for detecting smaller geographic differences. Fifthly, this study did not include outcomes such as mortality, length of stay, or discharge disposition. This is an important limitation because prior literature suggests that rural patients may experience worse outcomes even when injury severity is comparable to that of urban patients. The present analysis is therefore unable to determine whether the absence of measurable differences in injury severity translates into equivalent clinical outcomes across geographic groups. Additionally, certain variables relevant to trauma outcomes were not available for analysis, including transport times, EMS response intervals, helmet utilization, socioeconomic status, and more detailed injury mechanism characteristics. Finally, ORV-related injuries likely encompass heterogeneous vehicle types, including ATVs, dirt bikes, and utility terrain vehicles, which could not be reliably distinguished within the registry.

Future investigations should focus on more detailed characterization of regional pediatric trauma epidemiology across West Texas and Eastern New Mexico. Prospective studies incorporating prehospital transport metrics, EMS response intervals, helicopter utilization, and mortality outcomes may provide greater insight into the relationship between geography and pediatric trauma survival. Additional work should evaluate the effectiveness of region-specific injury prevention initiatives. Community-based programs targeting helmet use, age-appropriate ORV supervision, and safe recreational practices may substantially reduce pediatric injury burden. Partnerships with school districts, 4-H organizations, agricultural associations, and community outreach programs may improve dissemination of injury prevention education. Future research should also evaluate opportunities to optimize rural trauma system performance through advanced airway training, telemedicine integration, prehospital blood product availability, and rapid transfer protocols. More granular geographic analyses incorporating GIS mapping and county-level socioeconomic indicators may further improve understanding of localized trauma risk. Ultimately, data-driven regional trauma analysis may improve both pediatric injury prevention and emergency trauma care delivery throughout rural healthcare systems.

Conclusion

Pediatric trauma patterns within West Texas and Eastern New Mexico demonstrated greater similarity between metropolitan and nonmetropolitan populations than initially expected. However, meaningful regional differences emerged when trauma severity was analyzed using more granular geographic stratification. ORV-related injuries demonstrated identifiable demographic and geographic associations, emphasizing the importance of targeted prevention strategies in rural communities. These findings support the need for region-specific trauma prevention initiatives, optimized EMS transport protocols, and continued investigation into localized pediatric injury epidemiology. Broad rural–urban classifications alone may inadequately characterize trauma risk within large regional trauma systems. A more nuanced, data-driven approach may improve both preventive interventions and acute pediatric trauma outcomes.

Acknowledgments

The authors would like to acknowledge the support of the Texas Tech University Health Sciences Center School of Medicine, University Medical Center trauma services, and the faculty mentors who contributed to the development of this project. The authors thank Dr. Melisa Williams Ibora, PhD, with Texas Tech University Health Sciences Center‘s Office of Research

and Innovation, for assistance in review of this manuscript to its completion.
This project met the criteria for exemption from formal review by the Texas Tech University Health Sciences Center Institutional Review Board for the Protection of Human Subjects in accordance with 45 CFR 46.104(d)(4)(iii).

Disclosure: The authors report no conflicts of interest and no external funding related to this work.

References

1. Sleet DA, Ballesteros MF, Borse NN. A Review of Unintentional Injuries in Adolescents. *Annu Rev Public Health*. 2010;31(1):195-212. doi:10.1146/annurev.publhealth.012809.103616

2. FastStats - Child Health. February 2026. https://www.cdc.gov/nchs/fastats/child-health.htm.

3. Cunningham RM, Walton MA, Carter PM. The Major Causes of Death in Children and Adolescents in the United States. *N Engl J Med*. 2018;379(25):2468-2475. doi:10.1056/NEJMsr1804754

4. Grossman DC. The history of injury control and the epidemiology of child and adolescent injuries. *Future Child*. 2000;10(1):23-52.

5. West BA, Rudd RA, Sauber-Schatz EK, Ballesteros MF. Unintentional injury deaths in children and youth, 2010-2019. *J Safety Res*. 2021;78:322-330. doi:10.1016/j.jsr.2021.07.001

6. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: Geographic disparities in trauma mortality. *Surgery*. 2016;160(6):1551-1559. doi:10.1016/j.surg.2016.06.020

7. Pai PK, Klinkner DB. Pediatric trauma in the rural and low resourced communities. *Semin Pediatr Surg*. 2022;31(5):151222. doi:10.1016/j.sempedsurg.2022.151222

8. Butler EK, Johnson R, Saltzman DA, Segura BJ, Minneapolis, Minnesota. Beyond rural versus urban: A gradient of mortality risk among injured children across a four-level rurality scale. *J Trauma Acute Care Surg*. March 2026. doi:10.1097/TA.0000000000004977

9. Hernandez N, Zagales R, Awan MU, et al. Factors contributing to disparities in trauma care between urban vs rural trauma centers: Towards improving trauma care access and quality of care delivery. *Injury*. 2024;55(12):112017. doi:10.1016/j.injury.2024.112017

10. Ashburn NP, Hendley NW, Angi RM, et al. Prehospital Trauma Scene and Transport Times for Pediatric and Adult Patients. *West J Emerg Med*. 2020;21(2):455-462. doi:10.5811/westjem.2019.11.44597

11. Burdick KJ, Lee LK, Mannix R, Monuteaux MC, Hirsh MP, Fleegler EW. Racial and Ethnic Disparities in Access to Pediatric Trauma Centers in the United States: A Geographic Information Systems Analysis. *Ann Emerg Med*. 2023;81(3):325-333. doi:10.1016/j.annemergmed.2022.08.454

12. Bohnhoff JC, Cutler A, Hagenbuch S, Kurland K. Pediatric subspecialty outreach clinics: reach and impact on access to care. *BMC Pediatr*. 2024;24(1):519. doi:10.1186/s12887-024-04995-6

13. Ganga A, Kim EJ, Araia ES, et al. Pediatric all-terrain vehicle (ATV) related head injury rates and patterns: A 10-year nationwide analysis. *Am J Emerg Med*. 2023;67:56-62. doi:10.1016/j.ajem.2023.02.007

14. Jennissen CA, Denning GM, Aitken ME, et al. American Academy of Pediatrics Recommendations for the Prevention of Pediatric ATV-Related Deaths and Injuries. *Pediatrics*. 2022;150(4):e2022059279. doi:10.1542/peds.2022-059279

15. Hadad I, Goldman RD. All-terrain vehicle injuries in children and adolescents. *Can*

Fam Physician Med Fam Can. 2025;71(2):112-114. doi:10.46747/cfp.7102112

16. Beiriger J, Silver D, Lu L, et al. The Geography of Injuries in Trauma Systems: Using Home as a Proxy for Incident Location. *J Surg Res*. 2023;290:36-44. doi:10.1016/j.jss.2023.04.004

17. Ordoobadi AJ, Castillo-Angeles M, Tabata-Kelly M, et al. System-Level Variability in Trauma Center Utilization for Seriously Injured Older Adults. *J Surg Res*. 2025;305:10-18. doi:10.1016/j.jss.2024.10.047

18. Zogg CK, Becher RD, Dalton MK, et al. Defining Referral Regions for Inpatient Trauma Care: The Utility of a Novel Geographic Definition. *J Surg Res*. 2022;275:115-128. doi:10.1016/j.jss.2021.12.050

19. Melhado C, Hancock C, Wang H, et al. Pediatric Readiness and Trauma Center Access for Children. *JAMA Pediatr*. 2025;179(4):455. doi:10.1001/jamapediatrics.2024.6058

20. Sadoway A, Kinden R, Erdogan M, et al. Epidemiology and factors associated with mortality among pediatric major trauma patients in Nova Scotia: A 17-year retrospective analysis. *Injury*. 2024;55(6):111484. doi:10.1016/j.injury.2024.111484

21. Holter JA, Jeppesen E, Dehli T, Ohm E, Wisborg T. Urban-rural disparities in fatal and non-fatal paediatric injuries after trauma - A national retrospective cohort study. *Injury*. 2024;55(12):111968. doi:10.1016/j.injury.2024.111968

22. Gilblom EA, Johnson AB, Sahr S, Syverson D, Sang HI. Children and youth agricultural injuries: A retrospective analysis of pediatric trauma admissions in North Dakota. *Heliyon*. 2023;9(6):e16626. doi:10.1016/j.heliyon.2023.e16626

23. Weichelt BP, Gorucu S, Burke RR, Salzwedel MA, Murphy DJ, Lee BC. Agricultural youth injuries: An updated review of cases from U.S. news media reports, 2016-2021. *Front Public Health*. 2022;10:1045858. doi:10.3389/fpubh.2022.1045858

24. Levy BE, Quattrone M, Castle JT, Doud AN, Draus JM, Worhunsky DJ. Injury Pattern and Outcomes Following All-Terrain Vehicle Accidents in Kentucky Children: A Retrospective Study. *Am Surg*. 2023;89(12):5874-5880. doi:10.1177/00031348231173955

25. Allen JH, Yengo-Kahn AM, Vittetoe KL, et al. The impact of helmet use on neurosurgical care and outcomes after pediatric all-terrain vehicle and dirt bike crashes: a 10-year single-center experience. *J Neurosurg Pediatr*. 2022;29(1):106-114. doi:10.3171/2021.6.PEDS21225

26. Giertych B, Morrow VR, Rizwan U, et al. ATV-Related Trauma in the Pediatric Population. *J Pediatr Orthop*. 2023;43(8):e669-e673. doi:10.1097/BPO.0000000000002447

27. Berry C, Escobar N, Mann NC, et al. Ambulance deserts and inequities in access to emergency medical services care: Are injured patients at risk for delayed care in the prehospital system? *J Trauma Acute Care Surg*. 2025;99(3):484-488. doi:10.1097/TA.0000000000004579

28. Miller KEM, James HJ, Holmes GM, Van Houtven CH. The effect of rural hospital closures on emergency medical service response and transport times. *Health Serv Res*. 2020;55(2):288-300. doi:10.1111/1475-6773.13254

29. Cash RE, Rivard MK, Chrzan K, Mercer CB, Camargo CA, Panchal AR. Comparison of Volunteer and Paid EMS Professionals in the United States. *Prehosp Emerg Care*. 2021;25(2):205-212.

doi:10.1080/10903127.2020.1752867

30. Brown JB, Berry C, Mann NC, Haut ER. Linking EMS and Trauma Registry Data to Improve Outcomes. *JAMA Surg*. 2026;161(5):445. doi:10.1001/jamasurg.2026.0471

31. Fertaly K, Javorka M, Brown D, Holman C, Nelson M, Glover A. Obstetric transport in rural settings: Referral and transport of pregnant patients in a state without a perinatal regionalized system of care. *Health Serv Res*. 2024;59(5):e14365. doi:10.1111/1475-6773.14365

32. Chen X, Gestring ML, Rosengart MR, et al. Logistics of air medical transport: When and where does helicopter transport reduce prehospital time for trauma? *J Trauma Acute Care Surg*. 2018;85(1):174-181. doi:10.1097/TA.0000000000001935

33. Beiriger J, Lu L, Silver D, Brown JB. Impact of patient, system, and environmental factors on utilization of air medical transport after trauma. *J Trauma Acute Care Surg*. 2024;96(1):62-69. doi:10.1097/TA.0000000000004153

34. Brown JB, Gestring ML, Stassen NA, et al. Geographic Variation in Outcome Benefits of Helicopter Transport for Trauma in the United States: A Retrospective Cohort Study. *Ann Surg*. 2016;263(2):406-412. doi:10.1097/SLA.0000000000001047

35. Sborov KD, Gallagher KC, Medvecz AJ, et al. Impact of a New Helicopter Base on Transport Time and Survival in a Rural Adult Trauma Population. *J Surg Res*. 2020;254:135-141. doi:10.1016/j.jss.2020.04.020

36. Newgard CD, Fu R, Bulger E, et al. Evaluation of Rural vs Urban Trauma Patients Served by 9-1-1 Emergency Medical Services. *JAMA Surg*. 2017;152(1):11. doi:10.1001/jamasurg.2016.3329

37. Abraham PJ, Crowley BM, Moore D, et al. Understanding the geography of trauma: Combining spatial analysis and funnel plots to create comprehensive spatial injury profiles. *J Trauma Acute Care Surg*. 2022;93(2):238-246. doi:10.1097/TA.0000000000003468

38. Kallies KJ, Beyer KM, Koehne WJ, et al. Pediatric Traumatic Injury in Rural and Urban Areas of Wisconsin. *Pediatr Emerg Care*. March 2026. doi:10.1097/PEC.0000000000003599

39. Keeves J, Ekegren CL, Beck B, Gabbe BJ. The relationship between geographic location and outcomes following injury: A scoping review. *Injury*. 2019;50(11):1826-1838. doi:10.1016/j.injury.2019.07.013

40. Zahnd WE, Del Vecchio N, Askelson N, et al. Definition and categorization of rural and assessment of realized access to care. *Health Serv Res*. 2022;57(3):693-702. doi:10.1111/1475-6773.13951

41. Zahnd WE, Hung P, Crouch EL, Ranganathan R, Eberth JM. Health care access barriers among metropolitan and nonmetropolitan populations of eight geographically diverse states, 2018. *J Rural Health Off J Am Rural Health Assoc Natl Rural Health Care Assoc*. 2025;41(1):e12855. doi:10.1111/jrh.12855

42. Kosar CM, Loomer L, Ferdows NB, Trivedi AN, Panagiotou OA, Rahman M. Assessment of Rural-Urban Differences in Postacute Care Utilization and Outcomes Among Older US Adults. *JAMA Netw Open*. 2020;3(1):e1918738. doi:10.1001/jamanetworkopen.2019.18738

43. Byrne JP, Nance ML, Scantling DR, et al. Association between access to pediatric trauma care and motor vehicle crash death in children: An ecologic analysis of United States counties. *J Trauma Acute Care Surg*. 2021;91(1):84-92. doi:10.1097/TA.0000000000003110

44. Pulliam K, Gardner D, Edmunds P, et al. Partnering with High-Risk Communities to Successfully Reduce Pediatric Injury Over Time. *J Pediatr Surg*. 2023;58(8):1506-1511. doi:10.1016/j.jpedsurg.2022.12.005

45. Howard KA, Griffin SF, Stuenkel M, Sease KK. Community features' varying insight into emergency department use for different childhood injuries. *J Safety Res*. 2023;86:209-212. doi:10.1016/j.jsr.2023.05.011

46. Goodon H, Gawaziuk JP, Comaskey B, et al. Social Determinants of Health and Injury Among Children. *JAMA Netw Open*. 2025;8(6):e2513584. doi:10.1001/jamanetworkopen.2025.13584

47. Ben Beck null, Tack G, Cameron P, Smith K, Gabbe B. Optimizing Trauma Systems: A Geospatial Analysis of the Victorian State Trauma System. *Ann Surg*. 2023;277(2):e406-e417. doi:10.1097/SLA.0000000000004904

48. Dooley JH, Ozdenerol E, Sharpe JP, Magnotti LJ, Croce MA, Fischer PE. Location, location, location: Utilizing Needs-Based Assessment of Trauma Systems-2 in trauma system planning. *J Trauma Acute Care Surg*. 2020;88(1):94-100. doi:10.1097/TA.0000000000002463

49. VanDerHeyden N, Cox TB. Trauma Scoring. In: Asensio JA, Trunkey DD, eds. Current Therapy of Trauma and Surgical Critical Care. Mosby; 2008:26-32. doi:10.1016/B978-0-323-04418-9.50010-2

50. Tillmann BW, Nathens AB, Guttman MP, et al. The impact of referring hospital resources on interfacility overtriage: A population-based analysis. *Injury*. 2024;55(3):111332. doi:10.1016/j.injury.2024.111332

51. Savard S, Ready LV, Mondal P, Sothilingam N, Davis P. A comparison of trauma patients in urban and rural areas presenting to a Canadian tertiary care centre. *Can J Surg J Can Chir*. 2024;67(4):E313-E317. doi:10.1503/cjs.013623

52. Min JG, Smith M, Englehart MS, et al. The Golden Hour is elusive in rural trauma: A 10-year analysis from a Level I trauma center in Montana. *Am J Emerg Med*. 2026;103:127-131. doi:10.1016/j.ajem.2026.01.053

53. Elzaim HS, Vatcheva K, Torres-Reveron A, Pequeno G, Betancourt-Garcia MM. Comparative analysis of all-terrain vehicles, motorcycle and automobile-related trauma in a rural border community of the USA. *BMJ Open*. 2022;12(9):e054289. doi:10.1136/bmjopen-2021-054289

54. Jennissen CA, Denning GM, Aitken ME, THE COUNCIL ON INJURY, VIOLENCE, AND POISON PREVENTION. A Comprehensive Report on All-Terrain Vehicles and Youth: Continuing Challenges for Injury Prevention. *Pediatrics*. 2022;150(4):e2022059280. doi:10.1542/peds.2022-059280

55. MacDougall W, Jiang X, Sobhan S, et al. Severity of All-Terrain Vehicle–Related Injuries by Age in Canada, 2002-2019. *JAMA Netw Open*. 2023;6(5):e2316060. doi:10.1001/jamanetworkopen.2023.16060

56. Goodman LF, Martino AM, Schomberg J, et al. Basic is Better? An Assessment of National Outcomes in Prehospital Airway Management in Critical Acuity Pediatric Trauma. *J Emerg Med*. 2025;70:68-79. doi:10.1016/j.jemermed.2024.08.016

57. Pusateri AE, Moore EE, Moore HB, et al. Association of Prehospital Plasma Transfusion With Survival in Trauma Patients With Hemorrhagic Shock When Transport Times Are Longer Than 20 Minutes: A Post Hoc Analysis of the PAMPer and COMBAT Clinical Trials. *JAMA Surg*. 2020;155(2):e195085. doi:10.1001/jamasurg.2019.5085

58. Hung G, Wang T, Hsieh E, Burjonrappa S. Comparing complications in pediatric trauma patients transported before and after 30 minutes. *J Pediatr Surg*. 2026;61(2):162664. doi:10.1016/j.jpedsurg.2025.162664

59. Tayes C, Schiro S, Smith B, Willner D, Winslow JE, Patel MD. Rural-urban differences in prehospital deaths due to injury in North Carolina. *Am J Emerg Med*. 2026;104:44-49. doi:10.1016/j.ajem.2026.02.039

60. Schaefer RM, Bank EA, Krohmer JR, et al. Removing the barriers to prehospital blood: A roadmap to success. *J Trauma Acute Care Surg*. 2024;97(2S Suppl 1):S138-S144. doi:10.1097/TA.0000000000004378

61. Hashmi ZG, Rokayak O, Boggs KM, et al. Teletrauma Use in US Emergency Departments. *JAMA Surg*. 2024;159(12):1383. doi:10.1001/jamasurg.2024.3758

West Texas Journal *of* Medicine



Original Article

A Pre-Post analysis of Albumin Exposure with Ideal Body Weight Dosing Compared to Fixed-Dosing of Albumin in Cirrhosis

Essilvo Sulejmani, PharmD[1]; Andrew Stone, PharmD[1]; Megan Bond, PharmD[1]; Lanla Conteh, MD, MPH, MBA[2]; Rachel M. Smith, PhD, MPH[1]; Eric McLaughlin, MS[3]; Megan Smetana, PharmD[3]

Abstract

Background: The American Association for the Study of Liver Diseases (AASLD) guidelines recommend intravenous (IV) albumin for patients with hypovolemia-induced acute kidney injury (AKI) at a dose of 1 g/kg body weight daily for 2 days, without specifying whether actual body weight (ABW) or ideal body weight (IBW) should be used.

Objective: To compare cumulative albumin exposure and clinical outcomes following an institutional transition from a fixed-dose order set approximating ABW to an IBW-based dosing protocol in patients with cirrhosis and AKI.

Methods: This single-center, retrospective cohort study evaluated adult patients with cirrhosis and AKI who received IV albumin during the 6 months before and 6 months after an institutional dosing protocol change. The primary outcome was cumulative albumin dose at 48 hours (day 2) and day 7. Secondary outcomes included AKI response rates, changes in serum creatinine (SCr), and in-hospital mortality. Unadjusted and adjusted multivariable logistic regression evaluated the association between dosing strategy and response.

Results: Sixty patients met inclusion criteria: 27 in the pre-intervention fixed-dose group and 33 in the post-intervention IBW-dosing group. No significant difference was observed in cumulative albumin exposure at day 2 (median 150 g vs. 150 g; p= 0.476) or day 7 (median 175 g vs. 187.5 g; p = 0.403). Albumin response rates by day 7 or discharge were comparable between the pre- and post-intervention cohorts (70.4% vs. 69.7%; adjusted OR 1.03, 95% CI 0.30–3.46; p = 0.966). No significant differences were observed in complete response rates (48.2% vs. 66.7%; p = 0.192) or in-hospital mortality. Partial response was observed more frequently in the pre-intervention group (22.2% vs. 3.0%; p = 0.039).

Conclusion: Transitioning from a fixed-dose order set approximating ABW to an IBW-based dosing protocol did not significantly alter cumulative albumin exposure or AKI response rates. IBW-based dosing represents a safe and feasible institutional strategy that avoids unintended exposure reductions or adverse clinical outcomes.

Keywords: Liver Cirrhosis, Albumin, Acute Kidney Injury, Ideal Body Weight

Affiliations:
[1] Department of Pharmacy, The Ohio State University Wexner Medical Center
[2] Department of Internal Medicine, The Ohio State University Wexner Medical Center
[3] Center for Biostatistics, The Ohio State University

Introduction

Acute kidney injury (AKI) is prevalent in hospitalized patients with decompensated cirrhosis and associated with increased morbidity and mortality.[1,2] The mechanism by which patients with cirrhosis develop AKI includes systemic vasodilation, compensatory mechanisms including renin-angiotensin-aldosterone system activation, and intravascular fluid loss leading to hypovolemia and decreased renal perfusion. [1,3] Hypovolemia accounts for about 50% of AKI cases in patients with cirrhosis and may be driven by compensatory processes and concurrent diuretic use.[4]

Volume resuscitation with albumin is recommended to improve renal perfusion in the treatment of AKI in cirrhosis and prevent hepatorenal syndrome (HRS).[2,5] The American Association for the Study of Liver Diseases (AASLD) recommends intravenous (IV) albumin for volume resuscitation in patients with hypovolemia-induced AKI, dosed at 1 gram (g)/kilogram (kg) body weight daily for 2 days.[2] No delineation is made, however, between actual body weight (ABW) or ideal body weight (IBW).[2] IBW dosing may better represent the plasma volume retention of albumin by reducing the effect of adipose tissue included in ABW. This distinction is important as the choice of weight used may result in a wide variance in albumin received, ABW can fluctuate significantly due to fluid displacement to extravascular spaces, and overexposure may cause pulmonary edema and volume overload.[6] The optimal dosing strategy of albumin to reverse AKI associated with cirrhosis remains undefined.

Our institution changed the albumin dosing for patients with cirrhosis and AKI from a fixed-dosing strategy approximating ABW to an IBW-based dosing strategy to more closely reflect guideline recommendations for weight-based dosing strategies. The purpose of this evaluation was to compare the change in albumin exposure in patients with cirrhosis and AKI receiving albumin between a fixed-dosing and an IBW-dosing strategy.

Methods

Study Design

This was a single-center, retrospective evaluation of an institutional albumin dosing protocol change reviewing patients admitted between November 9, 2022, and November 9, 2023. Patients included were at least 18 years of age, diagnosed with cirrhosis and AKI, and received IV albumin via an institutional albumin order-set.[5] Exclusion criteria included septic shock or receipt of IV vasopressors, albumin use outside of the AKI dosing order-set, weight other than IBW used for albumin weight-based dosing, large-volume paracentesis, diagnosis or treatment for HRS, transition to renal replacement therapy (RRT), or receipt of nephrotoxic medications during the initial 48-hour albumin resuscitation period.

Prior to May 9, 2023, the albumin dosing order-set for AKI with cirrhosis at our institution was a fixed regimen approximating ABW of 25g IV every 6 hours for 24 hours. This dosing strategy was implemented via the use of pre-built order-sets for patients with cirrhosis and AKI. Our institution altered this order-set with a change on May 9, 2023 to 0.5g/kg IV albumin every 12 hours using IBW dosing for 2 days. Both orders were followed by 12.5g albumin every 8 hours until AKI resolution or order discontinuation.

Patients were divided into two groups. The pre-intervention group contained all patients meeting inclusion criteria from November 9, 2022 to May 8, 2023 and used the fixed-dosing strategy of 25g IV every 6 hours for 24 hours followed by 12.5g every 8 hours until AKI resolution or order discontinuation. The post-intervention group contained all patients meeting inclusion criteria from May 9, 2023 to November 9, 2023 and the IBW-based albumin dosing strategy of 0.5 g/kg IV every 12 hours for 2 days followed by 12.5g every 8 hours until AKI resolution or order discontinuation. No run-in time was provided as the change did not require new education and was immediately available to order on the electronic health record. Of note, our institution rounds albumin to the nearest 12.5 g vial size.

Study data were collected and stored using the secure web-based electronic tool Research Electronic Data Capture (REDCap), with grant

support from the National Center for Advancing Translational Sciences (Grant-UL1TR001070).[7,8] Data were retrospectively collected from the electronic medical record and included baseline demographic variables; etiology of cirrhosis; Model for End-Stage Liver Disease 3.0 (MELD 3.0) at initiation of albumin infusion; mean arterial pressure (MAP) at time of initial albumin infusion; serum creatinine (SCr) at baseline, day 2, and day 7 or discharge during albumin administration; serum albumin at baseline, day 2, and day 7 or discharge during albumin administration; and administered crystalloid volume during the initial 2 day resuscitative period. Prior to the initiation of this evaluation, the protocol was reviewed by The Ohio State University Office of Research Institutional Review Board (IRB) and was approved with approval number 2023H0408. All research was conducted in accordance with both the Declaration of Helsinki and Declaration of Istanbul. The research received a waiver of informed consent by The Ohio State University Office of Research Institutional Review Board (IRB).

Definitions

AKI was defined per Kidney Disease Improving Global Outcomes (KDIGO) and AASLD guidance as an increase in SCr ≥0.3 mg/dL within 2 days or a ≥50% increase in serum creatinine within the preceding 7 days.[5] AKI stage was defined as the following: Stage 1, SCr increase ≥0.3 mg/dL in 2 days or 1.5-1.9 times the baseline SCr within 7 days; Stage 2, SCr increase 2-2.9 times baseline SCr within 7 days; Stage 3, SCr increase ≥3 times the baseline SCr or an increase to ≥4 mg/dL within 7 days, or transition to RRT. Baseline SCr was defined as the lowest SCr within 3 months of index admission, closest to the date of admission.[5] If no SCr value within 3 months, the lowest SCr value between month 4 and 12 prior to admission was deemed the baseline; if no SCr was available >1 year prior to hospitalization, the first SCr value at admission was deemed the baseline.[5] In patients who did not have a SCr available >1 year prior to hospitalization, AKI was defined as a clinical diagnosis of AKI on presentation with an initial response to volume resuscitation with albumin.

Albumin response was defined as patients who had a decrease of ≥1 AKI stage or a return of SCr to within 0.3 mg/dL of baseline by day of discharge or hospital day 7 after albumin initiation. Complete responders were subsequently defined as a return to within 0.3 mg/dL of baseline SCr by day of discharge or hospital day 7. Partial responders were subsequently defined as a decrease in AKI stage by ≥1, by day of discharge or hospital day 7. Non-responders were defined as a decrease in SCr without regression of AKI stage, an increase in SCr, diagnosis of HRS, or RRT following initial 48-hour albumin resuscitation.

Nephrotoxic medications were defined as receipt of the following: non-steroidal anti-inflammatory medications (NSAIDs), aminoglycosides, amphotericin, angiotensin-converting enzyme (ACE)-inhibitors, angiotensin receptor blockers (ARBs), calcineurin inhibitors, contrast dye (iodixanol, iohexol, barium), diuretics (loop, thiazide, acetazolamide), IV acyclovir, or lithium. Vasopressors were defined as angiotensin II, dopamine, epinephrine, norepinephrine, phenylephrine, terlipressin, or vasopressin.

Outcomes

The primary outcome was the cumulative albumin dose received in grams and g/kg in the first 2 days and 7 days of albumin infusion. Secondary outcomes included: proportion of patients with a partial or complete response by day of discharge or hospital day 7; comparison of SCr change in response to albumin resuscitation; proportion of patients who had a complete response to albumin resuscitation; proportion of patients who had a partial response to albumin within the same time frame; and, in-hospital all-cause mortality.

Statistical Analysis

Descriptive statistics were used to describe variables of interest, including counts and proportions for categorical variables and mean (standard deviation) and/or median (interquartile range) for continuous variables as appropriate. T-tests or Fisher's exact tests were used to compare outcomes between treatment groups for unadjusted continuous and categorical outcomes, respectively. Unadjusted and adjusted logistic regression models were used to

Table 1: Baseline Characteristics

Characteristic	Pre-intervention, n = 27	Post-intervention, n = 33
Age, years, median [IQR]	55 [45 – 63]	57 [47 –63]
Male, n (%)	14 (51.9)	17 (41.5)
Race, n (%)		
White	25 (92.6)	26 (78.8)
African-American	1 (3.7)	4 (12.1)
Other	1 (3.7)	3 (9.1)
Actual Body Weight, kg, median [IQR]	92.9 [65.7 – 117.9]	87.6 [74.2 – 95.9]
Ideal Body Weight, kg, median [IQR]	63.9 [57.0 – 77.7]	63.9 [57.0 – 70.8]
Body Mass Index, kg/m2, median [IQR]	31.6 [23.4 – 36.2]	28.6 [25.7 – 31.1]
MELD 3.0, median [IQR]	26 [22 – 31]	28 [21 – 32]
SCr, mg/dL, median [IQR]		
Baseline SCr prior to albumin	1.01 [0.72 – 1.33]	0.92 [0.80 – 1.16]
Time of first albumin dose	1.71 [1.38 – 2.46]	1.58 [1.38 – 1.93]
Day 2	1.55 [1.17 – 1.97]	1.25 [1.10 – 1.62]
Day 7 or discharge	1.42 [0.93 – 2.55]	1.22 [1.08 – 1.52]
Serum albumin, g/dL, median [IQR]		
Time of first albumin dose	2.8 [2.7 – 3.3]	2.8 [2.5 – 3.1]
Day 2	3.5 [3.0 – 3.7]	3.5 [3.2 – 3.8]
Day 7 or discharge	3.2 [3.0 – 3.5]	3.3 [3.0 – 3.9]
MAP, mmHg, median [IQR]	74 [78 – 82]	81 [75 – 94]
Duration of albumin use, days, median [IQR]	4 [3 – 5]	5 [3 – 7]
Crystalloid volume administered in first 48 hours of resuscitation, mL, median [IQR]	232 [41 – 288]	189 [250 – 1000]
Etiology of cirrhosis, n (%)		
Alcohol	14 (51.9)	20 (60.6)
MASH	10 (37.0)	10 (30.3)
AIH	0 (0.0)	2 (6.1)
PBC	0 (0.0)	1 (3.0)
PSC	0 (0.0)	3 (9.1)
Hep B virus	2 (7.4)	1 (3.0)
Hep C virus	0 (0.0)	4 (9.8)
Other	3 (11.1)	2 (6.1)

compare responder proportions between the pre- and post-intervention groups, with adjusted models accounting for prespecified covariates. Unadjusted and adjusted linear regression models were used to estimate the difference in percent change of SCr from baseline to day 7 or discharge between the two groups. Covariates for inclusion in adjusted models were determined a priori based on expert knowledge and a review of the literature. All analyses were conducted in SAS Statistical Software version 9.4 (Copyright © 2024, SAS Institute Inc., Cary, NC).

Results

A total of 595 patients were screened for inclusion between November 9, 2022 and

November 9, 2023. Sixty patients met inclusion criteria with 27 patients in the pre-intervention group and 33 patients in the post-intervention group. The most common reason for exclusion was albumin administration duration of <48 hours (n=239), nephrotoxic medication administration (n=167), and albumin administration outside of the order panel (n=141). Patients may have met more than one exclusion criterion. Baseline characteristics are displayed in Table 1. Alcohol was the most common etiology of cirrhosis at 51.9% and 60.6% for the pre- and post-intervention groups, respectively. Serum creatinine and albumin were similar between the fixed-dosing and IBW-dosing groups at time of albumin infusion, day 2, and day 7 or discharge.

Primary and secondary outcome data are displayed in Table 2. No significant difference was found in either the cumulative or weight-based albumin dose by day 2 (150 g vs 150 g, p=0.476) or day 7 (175 g vs 187.5 g, p=0.403). There was no difference observed in g/kg ABW or g/kg IBW at either time point.

No significant difference was found in the proportion of patients classified as albumin responders between pre-intervention fixed-dosing and post-intervention IBW-dosing strategies. The proportion of albumin responders by day 7 or day of discharge in the pre- and post-intervention group was 70.4% and 69.7%, respectively. This finding remained unchanged after adjustment for age, sex, and receipt of crystalloid fluids (OR 1.03, 95% CI 0.30 to 3.46; p=0.966). Among albumin responders, we did not observe a difference in the percent change in SCr from initiation of albumin infusion to day 7 or discharge between treatment groups (difference in change for post-intervention group=-0.18 [SE=0.28]; p=0.517, compared to the pre-intervention group). Complete response rates were higher in the post-intervention group but did not reach statistical significance (48.2% vs 66.7%; p=0.192). Partial response was observed more frequently in the pre-intervention group (22.2% vs 3.0%; p=0.039).

Discussion

When compared to fixed-dosing of albumin, an institutional change from a fixed-dose approximating ABW to an IBW-dosing strategy was not associated with a meaningful change in cumulative albumin exposure or a change in serum creatinine response to albumin. These findings provide support for the feasibility of implementing IBW-based albumin dosing protocols, which to date has not been described in comparison to other dosing strategies in the literature.

A concern with any weight-based dosing institutional change is the potential for unintended drug exposure changes. In this cohort, the median ABW of 92.9 kg in the pre-intervention and 87.6 kg in the post-intervention group substantially exceeded the median IBW of 63.9 kg in both groups, raising the hypothesis that IBW-based dosing would result in meaningfully lower albumin administration. This was not observed: both groups received a median of 150 g of albumin in the first 48 hours. This equivalence likely reflects the conservative structure of the fixed-dose regimen – standard 100 g over 24 hours - combined with institutional rounding conventions. While these overlapping exposures represent the practical reality of real-world protocol implementation, they provide reassurance that the IBW-based strategy does not inadvertently reduce albumin exposure to potentially sub-therapeutic amounts.

The rationale for changing to IBW-dosing was due to the pharmacokinetic characteristics of albumin. Albumin may reduce antinatriuretic systems for a short period of time, but this effect is neither consistent nor prolonged.[9] Albumin dosing based on IBW may therefore better reflect the relevant compartment for dosing in patients with elevated ABW. Additionally, ABW in patients with cirrhosis is subject to fluctuation due to ascites and peripheral edema, reducing its reliability as a dosing weight. The transition to IBW-based dosing aligns with guideline intent and may reduce pharmacokinetic variability without compromising clinical outcomes.

There is no literature comparing weight-based dosing of albumin and limited literature on clinical outcomes of weight-based albumin infusions on SCr, though our findings may complement prior work by China et al, who demonstrated no difference in renal, infectious,

or mortality outcomes with higher albumin exposure when targeting a serum albumin level of ≥3.5 g/dL.[6] The median albumin exposure in our evaluation of 150 g over 48 hours fell within the interquartile range of the albumin-targeted group in China et al [IQR 140-280 g] supporting the safety profile of the doses delivered in both dosing arms.[6] China and colleagues did suggest an increase, however, in pulmonary edema and fluid overload.[6] Our evaluation adds to the literature by characterizing the exposure of albumin with a dosing change but highlights the potential need for optimized dosing strategies to limit albumin exposure.

Our evaluation has several limitations. The retrospective single-center nature coupled with the small sample size precludes drawing causative conclusions. Retrospective single-center evaluations are also susceptible to documentation variability. The use of admission SCr as the baseline for patients who had no SCr available >1 year prior to hospitalization may have overrepresented the number of responders, as a reduction in SCr within the stated definitions would have resulted in a responder classification. An additional limitation was the lack of urine output. Given the retrospective nature of this evaluation, the decision was made to rely on SCr as a marker of renal function, which alone is not a comprehensive representation of renal function. Pulmonary edema and volume overload were not systematically captured as safety endpoints. Future prospective studies should formally evaluate safety outcomes, including fluid overload and pulmonary edema, when comparing albumin dosing strategies.

Conclusion

An institutional transition from a fixed-dose to an IBW-based dosing strategy for albumin infusion in the treatment of AKI in hospitalized patients with cirrhosis was not associated with a significant change in cumulative albumin exposure or AKI response when compared to fixed dose albumin. These findings support the safety and feasibility of IBW-based albumin dosing as a reasonable institutional protocol. Larger prospective studies are warranted to evaluate safety outcomes, including pulmonary edema and volume overload, and to define optimal weight-based albumin dosing strategies in this population

List of abbreviations:
AKI: Acute Kidney Injury
HRS: Hepatorenal syndrome
AASLD: American Association for the Study of Liver Disease
IBW: Ideal Body Weight
IV: Intravenous
MELD 3.0: Model for End-Stage Liver Disease 3.0
SCr: Serum Creatinine
KDIGO: Kidney Disease Improving Global Outcomes
NSAIDs: Non-steroidal anti-inflammatory medications
ACE: Angiotensin-converting enzyme
ARB: Angiotensin receptor blocker
MAP: Mean Arterial Pressure
IQR: Interquartile range
AIH: Autoimmune Induced Hepatitis
MASH: Metabolic Dysfunction-Associated Steatohepatitis
PBC: Primary Biliary Cholangitis
PSC: Primary Sclerosing Cholangitis

References

1. Russ K, Stevens T, Singal A. Acute Kidney Injury in Patients with Cirrhosis. *J Clin Transl Hepatol*2015;33):195-204. doi:10.14218/JCTH.2015.00015

2. Biggins SW, Angeli P, Garcia-Tsao G, et al. Diagnosis, Evaluation, and Management of Ascites, Spontaneous Bacterial Peritonitis and Hepatorenal Syndrome: 2021 Practice Guidance by the American Association for the Study of Liver Diseases. *Hepatology*.2021;74(2):1014-1048. doi:10.1002/hep.31884

3. Ge PS, Runyon BA. Treatment of Patients with Cirrhosis. Campion EW, ed. *N Engl J Med*. 2016;375(8):767-777. doi:10.1056/NEJMra1504367

4. De Mattos ÂZ, Simonetto DA, Terra C, et al. Albumin administration in patients with cirrhosis: Current role and novel perspectives. *World J*

Gastroenterol. 2022;28(33):4773-4786. doi:10.3748/wjg.v28.i33.4773

5. Angeli P, Gines P, Wong F, et al. Diagnosis and management of acute kidney injury in patients with cirrhosis: revised consensus recommendations of the International Club of Ascites. *Gut*. 2015;64(4):531-537. doi:10.1136/gutjnl-2014-308874

6. China L, Freemantle N, Forrest E, et al. A Randomized Trial of Albumin Infusions in Hospitalized Patients with Cirrhosis. *N Engl J Med*. 2021;384(9):808-817. doi:10.1056/NEJMoa2022166

7. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208. doi:10.1016/j.jbi.2019.103208

8. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377-381. doi:10.1016/j.jbi.2008.08.010

9. Gines P. Is there still a need for albumin infusions to treat patients with liver disease? *Gut*. 2000;46(5):588-590. doi:10.1136/gut.46.5.588

Corresponding Author:
Essilvo Sulejmani, PharmD
Department of Pharmacy, The Ohio State University Wexner Medical Center, 410 W 10th St, Columbus, OH, 43210
614-814-1718

Original Article

Preoperative Antibiotic Prescribing for Appendectomy and Cholecystectomy at a Community Hospital in West Texas

Amany A. Iskander, Pharm.D.[1]; Eric J. MacLaughlin, Pharm.D., FASHP, FCCP, BCPS[1]; Taryn B. Bainum, Pharm.D.[2]; Grace M. Kuo, PharmD, MPH, PhD, FCCP, FNAP[1]

Abstract

Background: Guidelines for appendectomy and cholecystectomy surgery recommend a first- or second-generation cephalosporin with anaerobic coverage to prevent infection. Despite this recommendation, broad-spectrum antibiotics are often used.

Objectives:
The primary objective of this study was to determine the frequency of alignment of pre-operative antibiotics with guideline-recommended regimens for appendectomy and cholecystectomy. Secondary objectives included assessing therapy duration, penicillin allergy, costs, and prescriber factors.

Methods:
This retrospective observational cohort study included patients undergoing appendectomy or cholecystectomy between January 1, 2024, and July 31, 2024, at a community hospital in West Texas. Data collected included patient demographics, procedure type, antibiotics, duration of therapy, costs, and prescriber type. Statistical analyses included descriptive statistics for demographics and costs; chi-square or Fisher's Exact tests to compare antibiotic prescribing by procedure type; and logistic regression to identify factors associated with guideline adherence and antibiotic costs.

Results:
Of the 239 subjects identified, 169 were included. Alignment of pre-operative antibiotics with guideline-recommended therapy was 36.7% (12.5% appendectomy; 58.4% cholecystectomy). The average duration of antibiotic therapy varied by antibiotic (range: 1-11 days). Many patients (49.7%) received >1 pre-operative dose. Documented penicillin allergy was noted in 11.8%. Prescriber patterns varied by provider specialty and clinical setting.

Conclusions:
Alignment of pre-operative antibiotics prescribing with guideline-recommended regimens for appendectomy and cholecystectomy was relatively low. Quality improvement measures should be initiated to improve prescribing.

Keywords: antimicrobial stewardship; pre-operative antibiotics; appendectomy, cholecystectomy

Corresponding Author:
Eric J. MacLaughlin, Pharm.D., FASHP, FCCP, BCPS1
TTUHSC, Jerry H. Hodge School of Pharmacy
Email: Eric.MacLaughlin@ttuhsc.edu

Introduction

Approximately 160,000 to 300,000 surgical site infections (SSIs) occur in the United States each year.[1] Pre-operative antibiotics prior to commonly performed surgeries, such as appendectomies and cholecystectomies, are critical to avoid infections, which can lead to increased hospital stay, costs, and morbidity and mortality.[1]

The 2013 American Society of Health-System Pharmacists (ASHP), the Infectious Disease Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA), along with the 2025 World Society Emergency Surgery guidelines, recommend pre-operative intravenous antibiotics for all patients with suspected appendicitis, even uncomplicated cases, to prevent SSI.[2,3] For uncomplicated appendicitis, appropriate prophylaxis includes a single dose of a first-generation cephalosporin (e.g., cefazolin) with metronidazole or a second-generation cephalosporin with anaerobic activity (i.e., cefoxitin or cefotetan).[2] Most SSIs after appendectomy involve anaerobic and aerobic gram-negative bacteria, with *Bacteroides fragilis* and *E. coli* being the most common. Other organisms may include *streptococci*, *Staphylococcus* species, *Enterococcus*, and, infrequently, *Pseudomonas aeruginosa*.[2]

Biliary tract procedures, such as cholecystectomy, typically involve a sterile biliary tract.[2] A single dose of cefazolin is recommended for open biliary procedures; alternatives include ampicillin-sulbactam and other cephalosporins (cefoxitin, ceftriaxone, and cefotetan).[2,4-7] Current guidelines state pre-operative antibiotics are not generally needed for low-risk elective laparoscopic cholecystectomy but are advised for higher-risk cases, such as patients with diabetes, longer procedures (>120 min), risk of gallbladder rupture, or patients over 70 years of age.[2] Common organisms post-procedure are *E. coli, Klebsiella*, and *enterococci*, with less frequent reports of other gram-negatives, streptococci, staphylococci, and sometimes anaerobes like *Clostridium*.[2,4,5]

Despite guideline recommendations to use narrow-spectrum antibiotics to target common organisms, the available literature indicates that many patients receive broad-spectrum antibiotics.[8] Ideally, an antimicrobial agent used pre-operatively should prevent SSI, reduce SSI-related morbidity and mortality, lower the duration and cost of healthcare, produce no adverse effects, and have no negative impact on the microbial flora.[2] Antibiotics can predispose patients to *Clostridium difficile*-associated colitis. Risk factors for developing *C. difficile*-associated colitis include longer durations of pre-operative therapy and the use of multiple antimicrobial agents. Limiting the duration of pre-operative antibiotics to a single dose can reduce the risk of *C. difficile* disease.[9]

Objectives

The primary objective of this study was to determine the frequency of alignment between preoperative antibiotic prescribing and guideline-recommended regimens for appendectomy and cholecystectomy at a community hospital in West Texas. Secondary objectives included evaluating the duration of antibiotic therapy, examining the frequency of penicillin allergy and its impact on antibiotic selection, estimating costs of antibiotic treatments, and exploring factors influencing prescribers' antibiotic choices.

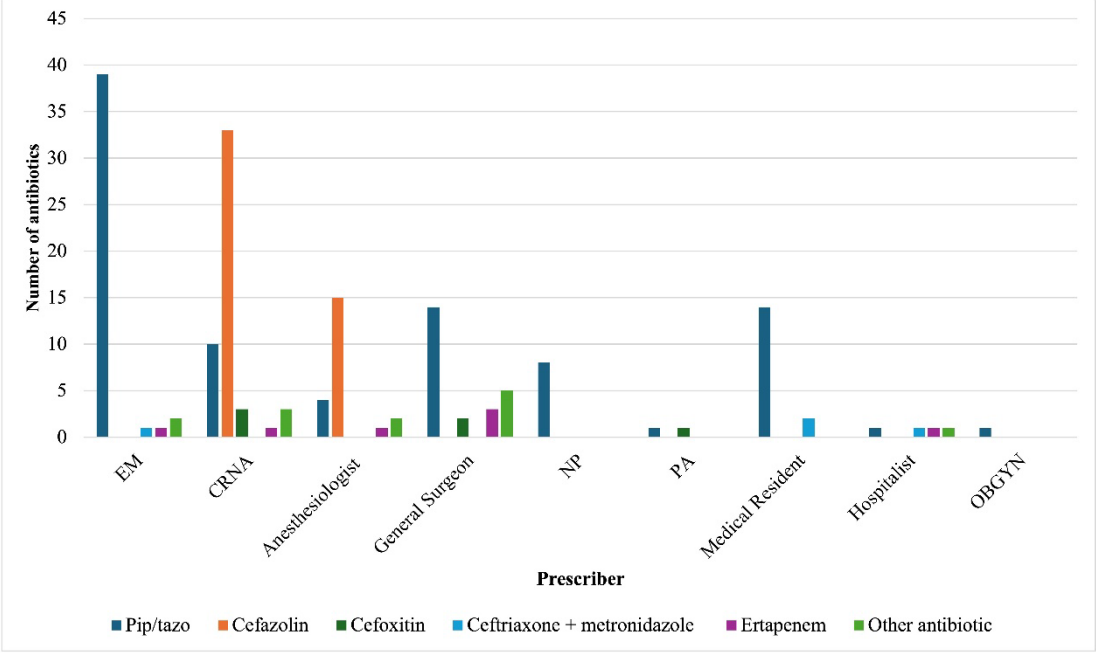
Methods

Study Design and Participants

This retrospective observational cohort study included adult and pediatric patients admitted to a tertiary care hospital in West Texas who underwent appendectomy or cholecystectomy between January 1, 2024, and July 31, 2024. The study setting and time frame were defined a priori. Based on institutional surgical volume data, the average monthly number of these surgeries was approximately 35, and it was anticipated that approximately 200 medical records would be available for review over a seven-month period. This study was reviewed and deemed exempt by the Texas Tech University Health Sciences Center Institutional Review Board.

Eligible participants included all adults and pediatric patients undergoing

Figure 1. Pre-operative Antibiotics Prescribed Across Type of Providers



EM, Emergency Medicine; CRNA, Certified Registered Nurse Anesthetists; NP, Nurse Practitioner; PA, Physician Assistant; Pip/tazo; Piperacillin/Tazobactam; OBGYN, Obstetrics and Gynecology

appendectomy and cholecystectomy procedures during the study period. Patients were excluded if they had a positive pregnancy test, given the unique physiological considerations that may complicate outcome interpretation; experienced post-operative complications, to maintain a more homogeneous cohort for comparison; had active or residual infections; or had complicated appendicitis (e.g., perforated or gangrenous disease), as these cases typically require broad-spectrum antibiotics and longer treatment durations. In addition, prisoners or wards of the state were excluded to prevent the inclusion of vulnerable populations that require extra protections beyond the scope of this study.

Data collection

Data were collected through a retrospective manual review of electronic medical records using a standardized data abstraction process. Patient information was initially stored in a password-protected file on a secure hospital server accessible only to authorized hospital personnel. Following data abstraction, all patient identifiers were removed, and de-identified data were transferred to an encrypted, password-protected Microsoft Excel spreadsheet stored on a secure network server with access limited to study investigators.

Collected variables included a unique study identification number; de-identified patient demographic characteristics (i.e., age, sex, race, height, weight, calculated BMI); surgical procedure type (appendectomy or cholecystectomy); admission date, procedure date, discharge date, and hospital length of stay. Clinical variables included antibiotic agents prescribed; number of doses administered; duration of antibiotic therapy; use of additional antimicrobial agents; penicillin allergy status and documented reaction type; and the cost of antibiotics. Prescriber characteristics, including provider type (e.g., MD/DO, NP, PA) and specialty, were also collected to evaluate prescribing patterns.

Statistical Analysis

All analyses were conducted using STATA/IC15.1 (StataCorp, College Station, TX) and Microsoft Excel. Descriptive analyses were used to summarize patient demographics,

surgical characteristics, antibiotic prescribing patterns, rates of guideline adherence, therapy durations, penicillin allergy status, costs, and prescriber type. Categorical variables were summarized using frequencies and percentages, while continuous variables were summarized using means and standard deviations, or medians and interquartile ranges, as appropriate.

Comparative analyses were performed to evaluate the associations between patient and prescriber characteristics and guideline-recommended antibiotic prescribing. Chi-square or Fisher's Exact tests were used for categorical values, as appropriate. Logistic regression models were constructed to identify factors independently associated with guideline adherence and antibiotic-related costs. Variables included in multivariable models were selected based on clinical relevance and univariable associations. Statistical significance was defined as a two-sided p-value <0.05. Analyses were conducted using complete-case data.

Table 1. Demographics and Baseline Characteristics (n=169)

Characteristics of Adult Patients (n=145)		
Sex		
	Male — no. (%)	48 (33)
	Female — no. (%)	97 (67)
Race		
	White — no. (%)	84 (58)
	Black or African American — no. (%)	6 (4)
	Asian — no. (%)	1 (1)
	Other — no. (%)	54 (37)
Penicillin Allergy — no. (%)		18 (12)
Age, mean ± SD (range)		42 ± 16 (18-89)
BMI, mean ± SD (range)		30.7 ± 7.4 (14.2-51.4)
Characteristics of Pediatric Patients (n=24)		
Sex		
	Male — no. (%)	11 (46)
	Female — no. (%)	13 (54)
Race		
	White — no. (%)	11 (46)
	Black or African American — no. (%)	0 (0)
	Asian — no. (%)	1 (4)
	Other — no. (%)	12 (50)
Penicillin Allergy — no. (%)		2 (8)
Age, mean ± SD (range)		12 ± 4 (2-17)
BMI, mean ± SD (range)		22.2 ± 7.1 (14.2 – 42)

BMI, Body Mass Index; SD, Standard Deviation

Results

From January 1, 2024, to July 31, 2024, a total of 239 patient charts were identified for possible inclusion. Seventy charts were excluded, including 64 with suppurative or perforation disease identified postoperatively and 4 patients

who received antibiotic therapy for an active infection (urinary tract infection, pneumonia, or bacteremia). Two pregnant patients were also excluded. The final study population consisted of 169 patients. Most patients were adult females with a mean body mass index (BMI) in the obesity range. Pediatric patients comprised a small proportion of the cohort. Baseline demographics are depicted in Table 1.

Of the 169 patients included in the analysis, alignment between prescribed pre-operative antibiotics and guideline recommendations was 36.7% of cases when both procedures were considered together ($p<0.001$). When stratified by procedure, guideline alignment was 12.5% for appendectomy ($p<0.001$) and 58.4% for cholecystectomy ($p<0.001$). Piperacillin-tazobactam was the most frequently prescribed antibiotic, used in 92 cases (54.4%). Antibiotics received and the duration of therapy during hospital stay are listed in Table 2.

For appendectomy, among the 80 cases included, the guideline-recommended agents were prescribed as follows: cefazolin plus metronidazole in 6.3% of cases and ceftriaxone plus metronidazole in 1%. The remaining guideline-recommended agents, including cefoxitin, cefotetan, or ampicillin-sulbactam, were not prescribed in the appendectomy cases. The remaining agents not recommended by guidelines, including piperacillin-tazobactam, were prescribed in 64 cases (80%), cefazolin in 2 cases (2.5%), ertapenem in 4 cases (5%), and other antibiotics, including cefepime, ciprofloxacin plus metronidazole, or levofloxacin plus metronidazole, in 4 cases (5%).

For cholecystectomy, of the 89 cases, the guideline-recommended agent, cefazolin, was prescribed in 46 cases (51.7%). The remaining patients (48.3%) received broader-spectrum antibiotics, including piperacillin-tazobactam (31.5%), cefoxitin (1%), ceftriaxone plus metronidazole (3%), ertapenem (2%), and other antibiotics (10.1%), such as meropenem, ciprofloxacin plus metronidazole, or clindamycin in patients with a documented penicillin allergy.

The duration of antibiotic therapy varied among agents. Approximately half of the patients (n=84; 49.7%) received more than one preoperative dose, either before or after surgery. Among these patients, 26 (15.4% of the total cohort) were discharged on oral antibiotics, most commonly for 7 days, using either amoxicillin-clavulanate or ciprofloxacin plus metronidazole. Among patients who received more than one dose, the mean duration of antibiotic therapy was 3 days (range, 1-11 days). One patient who received 11 days of oral antibiotics following discharge had blood cultures positive for *Staphylococcus epidermidis* in two sets; no repeated blood cultures were obtained.

Twenty subjects (12%) had a documented penicillin allergy in their medical record. Among patients with a documented penicillin allergy, 40% received beta-lactam antibiotics, including piperacillin-tazobactam, ceftriaxone, cefazolin, or ceftriaxone plus metronidazole, regardless of the reaction type. The remaining 60% received alternative regimens, including a fluoroquinolone plus metronidazole, ertapenem, or clindamycin. Alignment between antibiotic selection and guideline recommendations among patients with a documented penicillin allergy is presented in Table 3.

The mean acquisition cost of antibiotics was $9.30 (range, $0.12-$50.30). At this institution, the cost per vial was $2.37 for piperacillin-tazobactam and $3.31 for cefazolin. Patients who received piperacillin-tazobactam frequently received multiple doses, whereas patients who received cefazolin typically received a single pre-operative dose. A formal pharmacoeconomic analysis was not conducted in this stuFactors associated with antibiotic prescribing differed by prescriber type. Figure 1 illustrates differences in pre-operative antibiotic selection across prescriber groups. Emergency medicine physicians prescribed piperacillin-tazobactam more frequently than internal medicine residents (23.1% vs. 8.3%). In contrast, certified registered nurse anesthetists and anesthesiologists most commonly prescribed cefazolin (19% and 9%, respectively). General surgeons demonstrated greater variability in antibiotic selection, including piperacillin-tazobactam (8%), cefoxitin (1%), and ertapenem (2%). Orders from nurse

Table 2. Antibiotics Received During Hospital Stay of Appendectomy and Cholecystectomy

Antibiotic Agents Received (n=169)	
Pip/Tazo — no. (%)	92 (54.4)
Cefazolin — no. (%)	48 (28.4)
Cefoxitin — no. (%)	6 (3.6)
Ceftriaxone + metronidazole — no. (%)	4 (2.4)
Ertapenem — no. (%)	6 (3.6)
Other — no. (%)	13 (7.7)
Extended beyond one dose — no. (%)	84 (49.7)
Total doses of antibiotic received, mean ± SD (range)	4 ± 6.31 (1-57)
Duration of therapy of total antibiotic received, mean ± SD (range)	3 ± 2 (1-11)

practitioners (5%), physician assistants (0.6%), hospitalists (0.6%), and obstetrician/gynecologists (0.6%) were less frequent overall. However, when antibiotics were prescribed by these providers, piperacillin-tazobactam was most commonly selected.

Discussion

This retrospective observational study found that the alignment of pre-operative antibiotic prescribing with guideline-recommended regimens was relatively low for appendectomies (12.5%) and cholecystectomies (58.4%) at a community hospital in West Texas. Despite the recommendation to use cefazolin plus metronidazole for appendectomies, no patient received this therapy, and the broad-spectrum antibiotic piperacillin-tazobactam was the most frequently used antibiotic. Notably, the susceptibility rate for E. coli to cefazolin has declined in recent years, with a susceptibility rate of 72% using the local antibiogram as of 2024. It's now low enough that cefazolin should not be recommended as first-line for intra-abdominal procedures or infections. Instead, cefoxitin, cefuroxime, or ceftriaxone plus metronidazole should be recommended due to high susceptibility (> 90%). The low selection of cefazolin plus metronidazole could be due to the resistance rate at our facility. However, broad-spectrum antibiotics were still used rather than simply using another cephalosporin. Thus, the problem remains. Ertapenem, a broad-spectrum carbapenem, is recommended for complicated appendectomy cases such as intra-abdominal infections, none of which had documented complications, indicating that broad-spectrum therapy was used in the absence of documented complications. While ertapenem is an appropriate option for complicated appendicitis, its use in uncomplicated cases may present an opportunity for antimicrobial stewardship intervention.[10] While guideline-recommended therapy was more commonly followed for cholecystectomies (cefazolin monotherapy), rates of guideline adherence were still suboptimal based on established surgical antimicrobial prophylaxis guidelines (e.g., ASHP/IDSA/SIS/SHEA).[2,3]

Our findings are similar to those from previous research. In a multisite quality improvement project at 17 surgical sites ranging from a small 15-bed critical access hospital to a large 1,265-bed quaternary care center, a multi-step intervention was implemented to decrease the use of piperacillin-tazobactam for treating uncomplicated acute appendicitis without increasing surgical site infections.[8] This quality improvement study was similar to ours in that it was performed retrospectively through review of Electronic Health Records (EHR), included uncomplicated acute appendicitis, and used piperacillin-tazobactam as the commonly prescribed antibiotic. In this study, the authors implemented two quality improvement components. The first was updating electronic health record orders to promote preoperative administration of narrow-spectrum antibiotics and creating an antibiotic panel specifically for appendicitis, with ceftriaxone/metronidazole as

the default regimen. Second, they educated surgeons and emergency department clinicians about selecting appropriate antibiotic therapy for acute appendicitis through a virtual 30-minute education session focused on antibiotic stewardship. Through this multi-pronged approach, they were able to significantly decrease the use of broad-spectrum piperacillin-tazobactom use by approximately 30% (51.4% preintervention period vs 20.1% postintervention period, $P < 0.001$), with no significant increase in surgical site infections.

To our knowledge, there are no quality improvement studies evaluating the optimization of pre-operative antibiotics in patients undergoing cholecystectomy. However, most studies available on cholecystectomy focused on whether prophylactic antibiotics reduce the risk of surgical site infection. In a retrospective quality improvement study testing the efficacy of preoperative antibiotics before cholecystectomy at a single tertiary academic institution, the incidence of surgical site infections was compared between those who received preoperative antibiotics and those who did not.[11] The study found that preoperative antibiotics for elective cholecystectomy were not beneficial, though patients with co-morbidities that are known to predispose to surgical site infection were included in mild cases. However, the efficacy of preoperative in high-risk patients remains unanswered.[11] On the other hand, a systematic review assessing the effects of preoperative antibiotics versus placebo or no preoperative antibiotics found insufficient evidence to support or refute the use of preoperative antibiotics to reduce surgical site infections.[12]

Regarding the duration of therapy, approximately half of the patients received more than one dose with an average duration of three days ranging from one to eleven days of either pre-operative or post-operative antibiotics. In some cases, patients who received multiple doses before surgery received them earlier than 60 minutes before the procedure, which may explain why an additional pre-operative dose was administered. However, most cases involved receiving more than a single dose. One possible explanation is that when an antibiotic order is entered, it is automatically set for a seven-day course unless the order is modified. This may have contributed to the administration of multiple doses. Similarly, the reasons for continuation of antibiotics postoperatively are unclear; however, this may reflect transitions in care, whereby antibiotics initiated by one prescriber are continued by subsequent providers after transfer to the inpatient ward. Additionally, in one case, prolonged antibiotic therapy was prescribed after two blood cultures tested positive for *Staphylococcus epidermidis*, a coagulase-negative staphylococci that is a common blood culture contaminant, without repeat cultures; therefore, this was not true bacteremia. This may have led to unnecessary continuation of antibiotics and highlights the importance of careful interpretation of blood culture results to prevent overtreatment.

Patients with reported penicillin allergies showed variability in antibiotic prescribing. Reported reactions included throat swelling, loss of consciousness, rash, hives, difficulty breathing, or unspecified reactions. In our study, there was no association between the documented penicillin allergy and adherence to guideline-recommended therapy. Nearly half of the patients received beta-lactam antibiotics despite documented reactions, while the rest were prescribed fluoroquinolone plus metronidazole, ertapenem, or clindamycin. Among these patients, some had severe allergy symptoms, such as “closed throat” documented in their chart prior to receiving preoperative antibiotics, while others had unknown allergic reactions documented. The lack of correlation suggests that antibiotic prescribing in patients with a documented allergy may depend on the prescriber's judgment.[13] Penicillin allergies are often mislabeled, which may lead to the use of less-preferred alternative antibiotics, contributing to antibiotic resistance and resulting in adverse outcomes. Penicillin allergy is a public health issue; however, less than 10% of reported penicillin allergy is confirmed by formal testing.[13] Various clinical decision-making tools for penicillin allergy have been developed to guide antibiotic selection and delabeling strategies. However, some of these tools are limited by their

generalizability and lack of external validation. PEN-FAST is a clinical decision-making tool with a high negative predictive value that can be used to identify patients with low-risk penicillin allergy who do not require skin testing prior to oral penicillin challenge.[14] It is a user-friendly tool that has been successfully validated, with a negative predictive value of 93% to 100% in identifying patients with a low-risk history of penicillin allergy who can safely discontinue antibiotics and be unlabeled.

In addition to concerns regarding unnecessary antibiotic exposure and adverse effects associated with broad-spectrum antibiotic use, there are also fiscal concerns. While a formal pharmacoeconomic analysis was not conducted in this study, the total costs related to antibiotic therapy, including preparation and infusion supplies, nursing and pharmacy labor, and downstream costs, were likely much higher for patients who received piperacillin-tazobactam. In addition, the potential morbidity associated with broad-spectrum antibiotic use and development of *C difficile* infections may contribute to increased costs and adverse effects. According to CDC Antimicrobial Stewardship's four core elements guidelines, “Action”—the implementation of interventions to optimize antibiotic use—is essential for reducing costs.[15] These findings reinforce the importance of strengthening antimicrobial stewardship practices to promote guideline-recommended therapy and cost-effective antibiotics.

The variability of antibiotic choice by prescriber type suggests that antibiotic selection is influenced not only by provider specialty but also by the clinical setting in which prescribing occurs. Emergency medicine physicians more frequently prescribed broader empiric coverage, whereas certified registered nurse anesthetists and anesthesiologists commonly use cefazolin in alignment with guideline-recommended therapy for cholecystectomy. Surgeons demonstrate mixed prescribing patterns, likely reflecting intraoperative decision-making and variability in practice habits. While prescribing volumes were lower among other provider groups, the predominance of piperacillin-tazobactam across multiple settings highlights a consistent tendency toward broad-spectrum use.

Limitations

While our study demonstrates significant issues with guideline-concordant prescribing, there are limitations. First, the sample size was relatively small and from a single center. However, our study in a West Texas community-based hospital had similar findings as other studies.[8] Additionally, there were no data on the provider’s decision-making process when choosing antibiotics. Unmeasured confounders include patients’ comorbidities such as diabetes, which increases the risk of infection due to poor wound healing; obesity, related to poor tissue perfusion and a higher inoculum; previous infectious diseases and prior antibiotic exposure, which raise the likelihood of resistant organisms; immunosuppression, potentially increasing the infection risk; liver failure, due to a higher risk of surgical site infection; and tobacco use, which can impair wound healing, cannot be adequately assessed. The timing of antibiotic administration is also an important confounder, with the recommended preoperative timing being 60 minutes prior to the procedure. If patients do not receive the antibiotic within this timeframe, it may result in administering more than the

Table 3. Chi-Square Test for Alignment with Guideline-Recommended Therapy and Penicillin Allergy (n=169)

Alignment with Guidelines	Penicillin Allergy n (%)			P-value
	Yes	No	Total	
Yes	8 (40)	54 (36)	62 (37)	0.807
No	12 (60)	95 (64)	107 (63)	
Total	20 (100)	149 (100)	169 (100)	

recommended dose. Literature supports administering antibiotics at least 30 minutes but no more than 60 minutes before skin incision for optimal preoperative administration.[15] Additional limitations are the possibility of other unmeasured cofounders, such as surgical technique, including maintaining sterility to avoid the need for additional antibiotics, and the provider's experience, such as confidence in using broad-spectrum antibiotics for broader coverage to prevent complications.

Conclusion

The frequency of alignment of pre-operative antibiotic prescribing with guideline-recommended regimens for appendectomy and cholecystectomy in a community-based West Texas hospital was low, with lower alignment for appendectomy than for cholecystectomy. Results from this study suggest several challenges related to the appropriate use of pre-operative antibiotics, including the type of antibiotics, duration of therapy, considerations for patients with penicillin allergy, and prescriber patterns in antibiotic choice. Targeted antimicrobial stewardship interventions, particularly standardized order-sets and prescriber education, represent actionable opportunities to improve guideline-concordant prescribing.

References

1. Garner BH, Anderson DJ. Surgical site infections: an update. *Infect Dis Clin North Am*. 2016;30(4):909-929. doi:10.1016/j.idc.2016.07.010

2. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. *Am J Health Syst Pharm*. 2013;70(3):195-283. doi:10.2146/ajhp120568

3. Podda M, Ceresoli M, De Simone B, et al. Diagnosis and treatment of acute appendicitis: 2025 edition of the World Society of Emergency Surgery Jerusalem guidelines. *JAMA Surg*. 2026;161(3):283-295. doi:10.1001/jamasurg.2025.6218

4. Chang WT, Lee KT, Chuang SC, et al. The impact of prophylactic antibiotics on postoperative infection complication in elective laparoscopic cholecystectomy: a prospective randomized study. *Am J Surg*. 2006;191(6):721-5. doi:10.1016/j.amjsurg.2006.01.050

5. Den Hoed PT, Boelhouwer RU, Veen HF, Hop WC, Bruining HA. Infections and bacteriological data after laparoscopic and open gallbladder surgery. *J Hosp Infect*. 1998;39(1):27-37. doi:10.1016/s0195-6701(98)90240-7

6. Krajden S, Yaman M, Fuksa M, et al. Piperacillin versus cefazolin given perioperatively to high-risk patients who undergo open cholecystectomy: a double-blind, randomized trial. *Can J Surg*. 1993;36(3):245-50.

7. Pasquali S, Boal M, Griffiths EA, et al. Meta-analysis of perioperative antibiotics in patients undergoing laparoscopic cholecystectomy. *Br J Surg*. 2016;103(1):27-34; discussion 34. doi:10.1002/bjs.9904

8. Beckermann J, Linnaus ME, Swartz H, et al. Optimizing antibiotic management for patients with acute appendicitis: A quality improvement study. *Surgery*. 2024;175(5):1352-1357. doi:10.1016/j.surg.2024.01.010

9. Johnson S, Lavergne V, Skinner AM, et al. Clinical practice guideline by the Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA): 2021 focused update guidelines on management of Clostridioides difficile infection in adults. *Clin Infect Dis*. 2021;73(5):755-757. doi:10.1093/cid/ciab718

10. Solomkin JS, Mazuski JE, Bradley JS, et al. Diagnosis and management of complicated intra-abdominal infection in adults and children: guidelines by the Surgical Infection Society and the Infectious Diseases Society of America. *Surg Infect (Larchmt)*. 2010;11(1):79-109. doi:10.1089/sur.2009.9930

11. Smith JP, Samra NS, Ballard DH, Moss JB, Griffen FD. Prophylactic antibiotics for elective laparoscopic cholecystectomy. *Am Surg*. 2018;84(4):576-580.

12. Sanabria A, Dominguez LC, Valdivieso E, Gomez G. Antibiotic prophylaxis for patients undergoing elective laparoscopic cholecystectomy. *Cochrane Database Syst Rev*. 2010;2010(12):CD005265. doi:10.1002/14651858.CD005265.pub2

13. Castells M, Khan DA, Phillips EJ. Penicillin allergy. *N Engl J Med*. 2019;381(24):2338-2351. doi:10.1056/NEJMra1807761

14. Su C, Belmont A, Liao J, Kuster JK, Trubiano JA, Kwah JH. Evaluating the PEN-FAST clinical decision-making tool to enhance penicillin allergy delabeling. *JAMA Intern Med*. 2023;183(8):883-885. doi:10.1001/jamainternmed.2023.1572

15. Centers for Disease Control and Prevention. Core elements of hospital antibiotic stewardship programs. U.S. Dept of Health and Human Services. Updated 2019. Accessed April 27, 2026,https://www.cdc.gov/antibiotic-use/hcp/core-elements/hospital.html

Affiliations:
[1] TTUHSC, Jerry H. Hodge School of Pharmacy, Amarillo, TX
[2] Northwest Texas Healthcare System, Amarillo, TX

Letter to the Editor

Unplugged and Overwhelmed: The New Reality of Medical Training

Amber Hernandez, BS[1]; Ariel P. Santos, MD, MPH, FRCSC, FACS, FCCM[1]

Introduction

A typical morning for a surgical resident begins with logging into the electronic medical record (EMR) to extract patient information in preparation for rounds and before heading to the operating room. It is a critical platform that residents have become reliant on. But what happens when this system goes dark? Not for minutes, but for days, weeks, or even months.

Cyberattacks on healthcare institutions are escalating. It is no longer hypothetical. If you personally haven't been a part of a system that has been attacked, then you are probably aware of other healthcare institutions that have fallen

victim. Ransomware attacks on US hospitals more than doubled from 43 to 91 annually between 2016 and 2021, with 44% causing operational disruptions including electronic system downtime.[1] When one academic Level 1 trauma center experienced a 25-day total EMR downtime following a cyberattack, operative time decreased by 53%.[2] However, while literature primarily focuses on the operational and financial impacts of cyberattacks, a critical question remains unaddressed. In September 2024, our own institution at Texas Tech University Health Sciences Center experienced a cyberattack, reinforcing the urgency of this issue. This is a patient safety crisis. Surgical residents prepare for many things, but how much of their training consists of how to safely and effectively treat patients while experiencing EMR downtime?

The Training Gap

The transition from paper to electronic records has created a world where the next generation of physicians have primarily never practiced medicine without digital support. Through our own experience, it was surprising to discover the inexperience residents had in writing medical notes without a standardized online template. One institution agreed that it is critical to warn other institutions that residents need to understand everything down to the basics, even things as simple as using black ink and drawing a single line through errors.[3] Most residents graduate medical school with very little training on a paper-based system, and they must understand what to do when the EMR fails them.

This deficit extends beyond basic documentation. Surgical residents must manage complex perioperative workflows. They are responsible for tracking laboratory values, managing drains and lines, adjusting medications, and ensuring seamless handoffs between teams. In the digital era, these tasks are mitigated using the EMR. During downtime, these tasks can be disrupted, posing issues in the provision of clinical care and causing patient safety issues.

To put things into perspective, season 2 episode 8 of The Pitt offers a clear example of how a cyberattack can disrupt patient care in real time. While there were things that worked, many of the challenges arose from a lack of prior hands-on training, in which things could have run more smoothly. The hospital administration and department heads clearly had a cyberattack plan in place; however, the staff that keeps the hospital running were not properly prepared for

Corresponding Author:
Amber Hernandez, BS
Texas Tech University Health Sciences Center School of Medicine, Lubbock, TX
Email: amber00132@gmail.com

the situation. Staff were trained on the spot, leading to confusion and unclear expectations.[4] This highlights a critical gap between having a plan and being able to implement it.

The 2024 CrowdStrike outage, caused by a faulty software update, led to widespread system failures across many health care institutions. It demonstrated that even benign causes of EMR downtime can significantly impact patient care.[5] Healthcare systems are not only vulnerable to attack, but also unexpected technological failure.

Impact on Surgery

Surgery is uniquely vulnerable to EMR downtime. Unlike outpatient clinics that can reschedule appointments, patients coming in with trauma, emergent surgical conditions, and those who are critically ill must be attended to expediently. Reports of prolonged EMR outages in perioperative settings describe disruptions ranging from operating room scheduling to failures in patient identification, each posing risks to patient safety.[6] During the 25-day cyberattack at an academic trauma center, the dramatic reduction in operative capacity was attributed to multiple factors, but the role of resident preparedness was never examined.[2] How much of that 53% decrease in operative time resulted from residents struggling with unfamiliar paper workflows?

Consider the large realm of tasks a surgical resident must complete for a single postoperative patient without EMR access. The list is endless. They must handwrite admission orders, manually track intake and output, communicate lab results verbally rather than automated alerts, write legible operative notes that other teams can interpret, and coordinate care transitions without electronic handoff tools. Each step introduces opportunities for error when residents lack experience with manual workflows.

A Call to Action

It is crucial for residency programs to take action with structured steps to ensure residents can safely deliver care without an EMR. Programs should consider implementing a structured EMR downtime preparedness training into their curriculum. This is about patient safety and systems-based practice, which are part of the core competencies of the Accreditation Council for Graduate Medical Education (ACGME).

First, programs should implement simulation-based downtime training. Residents should participate in structured exercises that replicate prolonged EMR outages, requiring them to write admission orders, document operative notes, track laboratory data, and coordinate care using paper-based systems. These simulations should reflect real-world complexity. Simulation training allows residents to perform routine clinical tasks without reliance on the EMR, serving both as a teaching tool and a systems test. This training not only helps residents develop competence in paper-based systems but also reveals institutional weaknesses in contingency planning when protocols are put into action.[7] One study evaluated surgical residents completing a simulation several weeks after a didactic session and found that participants reported improved skills and greater confidence in managing adverse scenarios. [8] Demonstrating that even one review can establish confidence in putting paper-based systems to use. Although some may argue this adds to an already demanding training burden in residency, this does not have to be a time-consuming preparation. Even brief instruction on expectations for paper-based documentation can provide meaningful benefit.[8,9]

Second, competency in fundamental paper-based workflows should be established as a core training expectation. Residents should demonstrate the ability to write clear orders, maintain accurate patient lists, track intake and output, and perform safe handoffs without reliance on electronic tools. Simple structured systems can support this, such as placing clipboards at each bedside with updated labs, vital signs, intake and output, along with a communication chart in each room to keep providers and adjunct services aware of ongoing tasks. These are not outdated skills, but essential safeguards during system failures.

Third, institutions should incorporate residents and medical students into downtime

preparedness planning. Residents are frontline providers during these events. Defining resident roles, communication pathways, and escalation processes during EMR outages is critical to maintaining continuity of care. As demonstrated in The Pitt, having a plan in place is not enough if frontline staff are unfamiliar with how to execute it in real time.[4] Incorporating all members of the care team, including residents, into preparedness planning ensures that protocols are usable in practice. Communication between teams and staff is essential; it is a crucial part of downtime preparedness. The procedures for communication should not only be planned but also be practiced.[10]

Finally, downtime preparedness should be standardized throughout the institution. When unexpected EMR downtime occurs, there should be standardized procedures for all residents to follow. This should include providing standardized templates for writing orders, notes, and prescriptions with examples to eliminate any confusion on expectations.[3] These paper-based templates should be regularly refined based on real-world use to improve efficiency when implemented.[11]It is also recommended to establish a meeting point, such as the chief medical resident office, to create a primary place where residents can receive updates and written templates.[3] Additionally, the use of whiteboards for tracking patients and maintaining updated patient lists, along with alternative communication methods such as faxing information to lab and radiology, can help maintain workflow during downtime.

Conclusion

As a medical student applying to general surgery residency, I recognize that my generation has grown up with technology as an extension of our clinical practice. But technology is a tool, not a replacement. When that tool fails, we must be prepared to deliver safe and effective surgical care using whatever systems remain available. The increasing reliance on the EMR has created a vulnerability that needs to be protected. Current residency education does not adequately prepare residents to function safely during EMR downtime, putting clinical workflow, communication, and patient care at risk.

Direct evidence from real-world downtime events and illustrative scenarios, such as those from The Pitt, demonstrates that even when institutional plans exist, patient care can be compromised if staff on the frontline are not adequately trained to execute them. Delays in care, miscommunication, and unclear roles are not only inconvenient but also a threat to patient safety.

The next cyberattack is not hypothetical. As healthcare systems invest in technological defenses, equal attention must be given to preparing the physicians who will deliver care when those systems fail. Cyberattacks are becoming more common; the downtime is disruptive, and residents lack experience with paper-based workflows. What remains missing is action. This gap in training is both identifiable and correctable. Surgical education must evolve to address this gap before the next ransomware attack causes preventable patient harm. Residents should be prepared to deliver safe and effective care no matter the EMR system availability. Without deliberate action, we risk placing both residents and patients in preventable danger during the next inevitable cyberattack. As with most things in medicine, an ounce of prevention is worth more than a pound of cure.

References

1. Neprash HT, McGlave CC, Cross DA, et al. Trends in Ransomware Attacks on US Hospitals, Clinics, and Other Health Care Delivery Organizations, 2016-2021. JAMA Health Forum. 2022;3(12):e224873. doi:10.1001/jamahealthforum.2022.4873
2. Tarka M, Blankstein M, Schottel P. The crippling effects of a cyberattack at an academic level 1 trauma center: An orthopedic perspective. Injury. 2023 Apr;54(4):1095-1101. doi: 10.1016/j.injury.2023.02.022. Epub 2023 Feb 10. PMID: 36801172.
3. Paul C, Bilger E, Kango G, Reyes JA, Catalanotti JS. Residency Program Preparedness for Prolonged Downtime: Lessons Learned From a Cyberattack. J Grad Med Educ. 2021 Oct;13(5):626-630. doi: 10.4300/JGME-D-21-00253.1. Epub

2021 Oct 15. PMID: 34721788; PMCID: PMC8527927.
4. "2:00 PM." In: The Pitt. Season 2, Episode 8. HBO Max; 2026
5. Tully JL, Rao S, Straw I, Gabriel RA, Longhurst CA, Savage S, Voelker GM, Dameff CJ. Patient Care Technology Disruptions Associated With the CrowdStrike Outage. JAMA Netw Open. 2025 Jul 1;8(7):e2530226. doi: 10.1001/jamanetworkopen.2025.30226. Erratum in: JAMA Netw Open. 2025 Aug 1;8(8):e2531871. doi: 10.1001/jamanetworkopen.2025.31871. PMID: 40682764; PMCID: PMC12276631.
6. Cheon EC, Shaffer S, McCarthy K, Leavitt O, Mukerji S, Hardy C. Continuing Anesthesia Services in the Face of a Prolonged Digital Health System Outage. Anesthesiology. 2025 Aug 1;143(2):266-274. doi: 10.1097/ALN.0000000000005508. Epub 2025 Jun 10. PMID: 40493406.
7. Abbou B, Kessel B, Ben Natan M, Gabbay-Benziv R, Dahan Shriki D, Ophir A, Goldschmid N, Klein A, Roguin A, Dudkiewicz M. When all computers shut down: the clinical impact of a major cyber-attack on a general hospital. Front Digit Health. 2024 Feb 16;6:1321485. doi: 10.3389/fdgth.2024.1321485. PMID: 38433989; PMCID: PMC10904636.
8. Nguyen N, Watson WD, Dominguez E. Simulation-Based Communication Training for General Surgery and Obstetrics and Gynecology Residents. J Surg Educ. 2019 May-Jun;76(3):856-863. doi: 10.1016/j.jsurg.2018.10.014. Epub 2019 Feb 28. PMID: 30826262.
9. Zhao JY, Kessler EG, Yu J, Jalal K, Cooper CA, Brewer JJ, Schwaitzberg SD, Guo WA. Impact of Trauma Hospital Ransomware Attack on Surgical Residency Training. J Surg Res. 2018 Dec;232:389-397. doi: 10.1016/j.jss.2018.06.072. Epub 2018 Jul 19. PMID: 30463746.
10. Stowman AM, Cacciatore LS, Cortright V, McConnell J, Wilburn C, Bryant B, Frisch N, Kalof AN. Anatomy of a Cyberattack: Part 3: Coordination in Crisis, Development of an Incident Command Team, and Resident Education During Downtime. Am J Clin Pathol. 2022 Jun 7;157(6):814-822. doi: 10.1093/ajcp/aqab162. PMID: 35188562.
11. Larsen E, Fong A, Wernz C, Ratwani RM. Implications of electronic health record downtime: an analysis of patient safety event reports. J Am Med Inform Assoc. 2018 Feb 1;25(2):187-191. doi: 10.1093/jamia/ocx057. PMID: 28575417; PMCID: PMC7647128.

Affiliations:
[1]Texas Tech University Health Sciences Center, School of Medicine, Lubbock, TX

West Texas Journal *of* Medicine



Original Article

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

Ronald G Hall[1], PharmD, MSCS; Grace Kuo, PharmD, MPH, PhD[1]; Miguel Carrasco, MS[2]; Cole Johnson, JD[3]

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

Corresponding Author:
Ronald G Hall, PharmD, MSCS
Jerry H. Hodge School of Pharmacy
Texas Tech University Health Sciences Center
Email: Ronald.hall@ttuhsc.edu

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

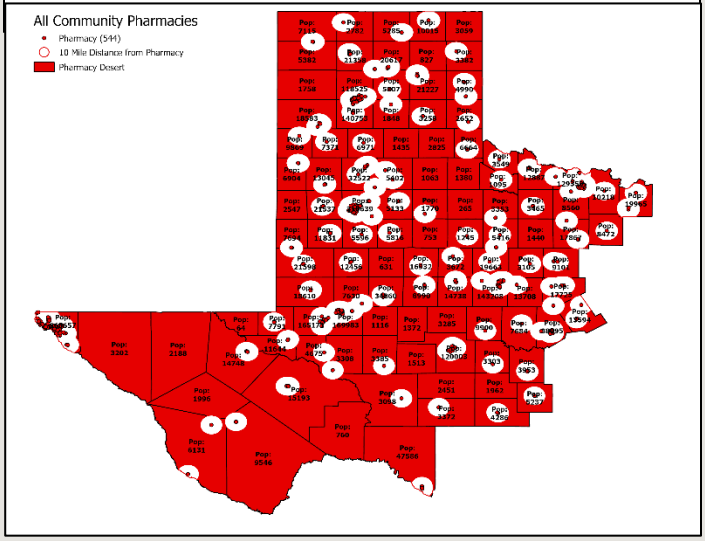
There were 544 community pharmacies located within the 108 westernmost counties of Texas (Figure 1). The majority (68%) were in counties with populations greater than 50,000, clustering around metropolitan hubs including El Paso, Lubbock, Amarillo, Abilene, Midland, and Odessa. Large portions of the 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



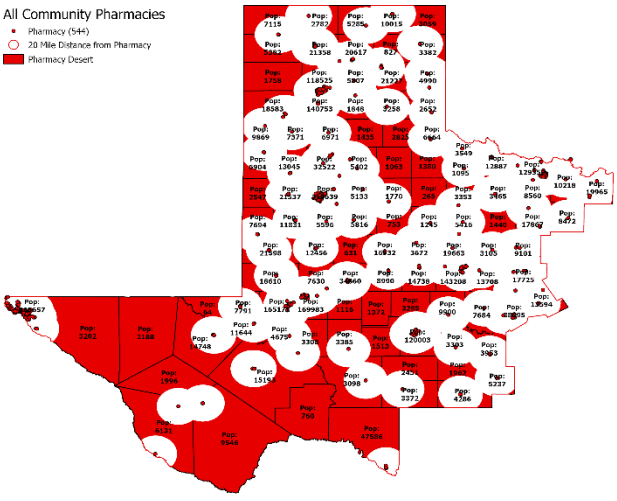
20-Mile Distance Threshold:

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



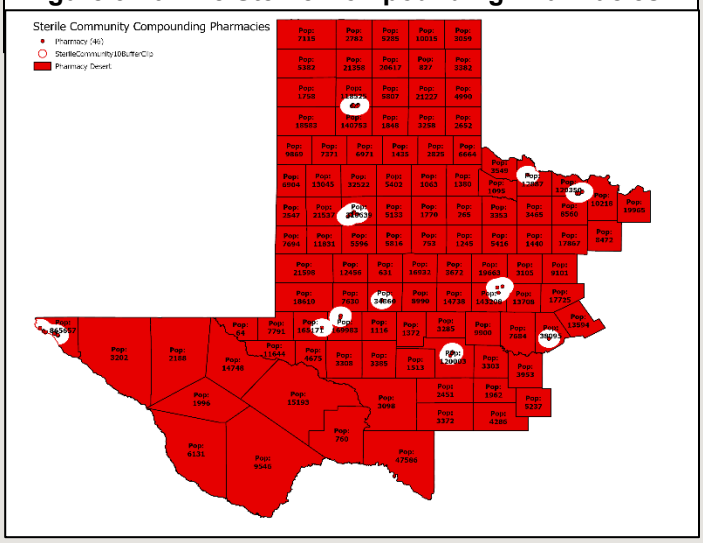
Non-Sterile Compounding Pharmacies:

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

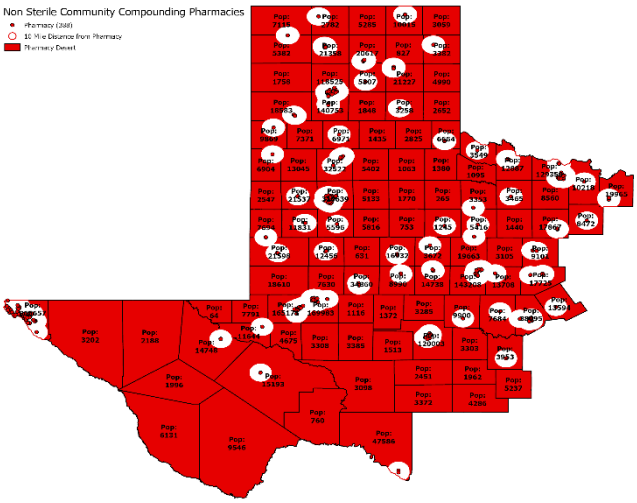


Sterile Compounding Pharmacies:
Geographic access to community pharmacies offering sterile compounding services was markedly limited, with only 46 such pharmacies across the 108-county region (Figure 3). Using a 10-mile threshold, sterile compounding pharmacies covered just 4,295 square miles (3.3%), 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



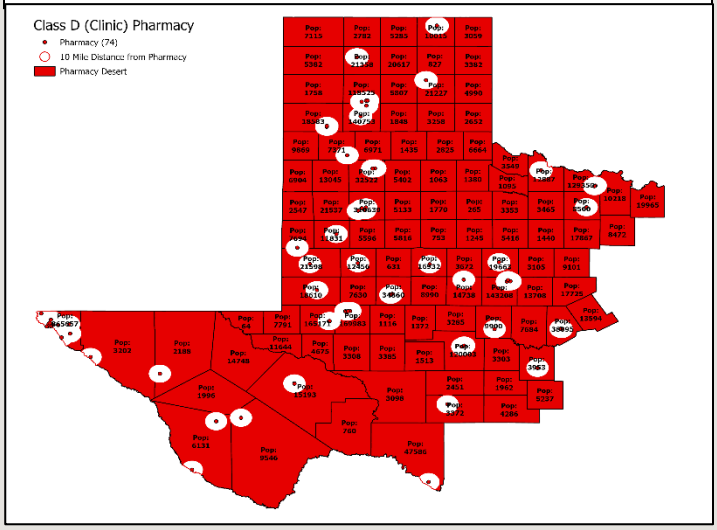
Class D (Charitable/Clinic) Pharmacies:
There were 74 Class D pharmacies located in 36 of the 108 counties (33%) (Figure 4). Using a 10-mile threshold, Class D pharmacies covered 12,319 square miles, leaving 119,521 square miles (90.66%) of land area without access within this distance (Figure 5.) At 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.

Acknowledgements

The authors gratefully acknowledge the support of the Rural Research Core within the Division of Rural Affairs at Texas Tech University Health Sciences Center. The authors also thank Diana Vargas-Gutierrez, PhD, and Grace Fosu, MS, MA, for comprehensive literature review and data analysis; and Amber Parker, BA, for manuscript editing and proofreading. Their expertise and collaborative support contributed significantly to the quality and presentation of this work.

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

Affiliations:
[1]Jerry H. Hodge School of Pharmacy - Texas Tech University Health Sciences Center, Dallas, TX

[2]The F. Marie Hall Institute for Rural and Community Health - Texas Tech University Health Sciences Center, Lubbock, TX

[3]Texas Tech University Health Sciences Center - Associate Vice Chancellor for Governmental Relations, Lubbock, TX

West Texas Journal *of* Medicine

Case Report

Surgical Repair of an Isolated Superior Mesenteric Vein Aneurysm: Case Report

Lauren A. Puig BS[1], Mackenzie L. Coffin BS[1], Grace E. McCrea MD[1], Edwin Onkendi MB.ChB[1,2], Mohamad Sidani, MD[1,2] Tyler J. Mouw MD[1,2]

Abstract

We present the case of a 71-year-old female who was incidentally diagnosed with a superior mesenteric vein (SMV) aneurysm while being evaluated for lower back pain. Computed tomography (CT) imaging revealed a 3.2 cm right upper quadrant mass characterized as a saccular SMV aneurysm. Given the aneurysm size and potential risk of rupture, the patient chose to undergo elective exploratory laparotomy with tangential aneurysmectomy and primary repair. Intraoperative ultrasonography confirmed patency and flow without narrowing or thrombus formation. The patient's postoperative course was uncomplicated, and surveillance imaging at six months confirmed resolution without recurrence. This case contributes to the limited literature on VVAs and supports considering elective surgical repair for asymptomatic but anatomically significant venous aneurysms.

Introduction

Visceral venous aneurysms (VVAs) are rare vascular malformations, with superior mesenteric vein (SMV) aneurysms accounting for approximately 8.5% of all the reported cases[1]. These lesions pose diagnostic and therapeutic challenges because of their deep anatomical location and nonspecific clinical presentation. SMV aneurysms are particularly uncommon, with a few cases documented in literature[2]. Continued case reporting remains essential to guide clinical decision-making and management in the absence of established treatment guidelines.

Patients with SMV aneurysms often present with vague abdominal symptoms, most commonly right upper quadrant (RUQ) discomfort. However, serious complications have been reported, such as gastrointestinal bleeding from rupture, portal hypertension, biliary obstruction, and thrombosis[2,3]. Physical examination is often noncontributory given the retroperitoneal location of the SMV, making imaging the primary diagnostic modality. On cross-sectional imaging, these aneurysms may present in saccular, fusiform, or diverticular forms and are often located near the splenic vein confluence[4].

Case Presentation

A 71-year-old female with a medical history of arthritis and congenital Müllerian agenesis was referred to the surgical oncology clinic following incidental imaging findings concerning a pancreatic lesion. She was initially being evaluated for lower back pain when a lumbar spine MRI revealed a 3.4 × 3.3 cm hypointense mass-like structure in the right upper quadrant. For reference, the normal size range for the SMV is 0.4–1.3 cm[5]. Follow-up computed tomography (CT) imaging nine days later (Figure 1A-C) characterized the lesion as a 4 cm SMV aneurysm. It noted a 0.6 cm cystic area in the pancreatic body favoring a side branch intraductal papillary mucinous neoplasm (IPMN). The patient was referred to the clinic twelve weeks later, and further evaluation with CT pancreas protocol demonstrated a 3.2 cm SMV aneurysm with no evidence of pancreatic lesions or ductal dilatation (Figure 1D-F).

At her initial surgical oncology clinic visit four

Corresponding Author:
Tyler Mouw MD,
Texas Tech University Health Sciences Center – Division of Surgical Oncology, Department of Surgery
Lubbock, Texas
Email Address: tyler.mouw@ttuhsc.edu

days after the CT with pancreas protocol, the patient was asymptomatic, with no reported abdominal pain, gastrointestinal symptoms, weight loss, or constitutional symptoms. She also had no medical history of gastrointestinal bleeding, portal hypertension, liver disease, pancreatitis, or abdominal trauma.

The initial plan was for observation with repeat imaging within six months. However, after the case was reviewed at the hepatobiliary multidisciplinary conference, concerns about the lesion's size and potential risk of rupture prompted a decision to offer the patient surgical repair. After discussion with the patient, they elected to proceed with surgical repair.

After approximately seven months from initial presentation, the patient underwent exploratory laparotomy with aneurysmectomy of the proximal SMV and primary venous repair. Intraoperatively, a 3 cm saccular aneurysm was found at the proximal SMV, closely associated with the superior mesenteric artery, which was successfully dissected (Figure 2A). Intraoperative Doppler ultrasound confirmed aneurysmal dilation and preserved venous flow (Figure 2B). The aneurysm was then isolated using a Satinsky clamp (Figure 2C), excised via tangential aneurysmectomy, and the resulting venous defect was closed primarily with a 5-0 Prolene suture (Figure 2D).

Her postoperative course was notable for a decrease in hemoglobin from 11.0 g/dL on postoperative day one to 7.3 g/dL on day two, which was managed with transfusion of two units of packed red blood cells. A CT angiogram of the abdomen and pelvis revealed a small hematoma within the anterior abdominal wall and a large subcapsular hematoma of the liver, without evidence of active extravasation. A hypodense lesion in the pancreatic head and uncinate process, corresponding to the previously identified small cystic lesion, was again visualized but showed no enhancement, suggesting residual blood flow. The remainder of her recovery was uneventful, and she was discharged in stable condition on postoperative day five.

At her postoperative six-month follow-up, the patient remained asymptomatic. Repeat CT of the abdomen/pelvis with liver protocol showed complete resolution of the aneurysm. Vessel caliber was normal; no evidence of recurrence was observed. She is currently undergoing surveillance imaging every six months.

Discussion

A 3.2 cm SMV aneurysm was incidentally discovered in a 71-year-old female during an evaluation for lower back pain. Despite being asymptomatic and lacking risk factors, such as portal hypertension, liver disease, pancreatitis, or abdominal trauma, she underwent elective aneurysmectomy with primary repair due to concern for rupture. Her postoperative course

was notable for a hepatic subcapsular hematoma and hemoglobin drop requiring transfusion; however, she recovered uneventfully and remained asymptomatic, with complete resolution of the aneurysm on follow-up imaging seven months postoperatively.

Although VVAs are rare, those involving the SMV are particularly uncommon. A 2009 systematic review identified 176 patients with 198 VVAs across 93 case reports, with only 17 (8.5%) localized to the SMV[1]. More recent data suggest an even lower frequency, with SMV involvement accounting for 4.83% of all portal venous aneurysms[6]. The most common locations for VVAs are within the portal venous system, including the extrahepatic portal vein, splenic vein, and splenic-SMV confluence[1].

Patient presentation of VVAs varies widely and is often nonspecific. In the same 2009 review, 44.7% of patients reported abdominal pain, while gastrointestinal bleeding occurred in 7.3%[1]. Notably, 38.2% of the cases were entirely asymptomatic and identified incidentally during imaging, consistent with our patient's presentation[1]. Back pain on presentation was attributed to a musculoskeletal origin. Because of their retroperitoneal location, SMV aneurysms are typically difficult to detect on physical examination, emphasizing the importance of cross-sectional imaging. Morphologically, VVAs may appear as saccular, fusiform, or diverticular. In our case, the aneurysm exhibited a saccular configuration, with focal dilation of the SMV in a single direction (Figure 2A).

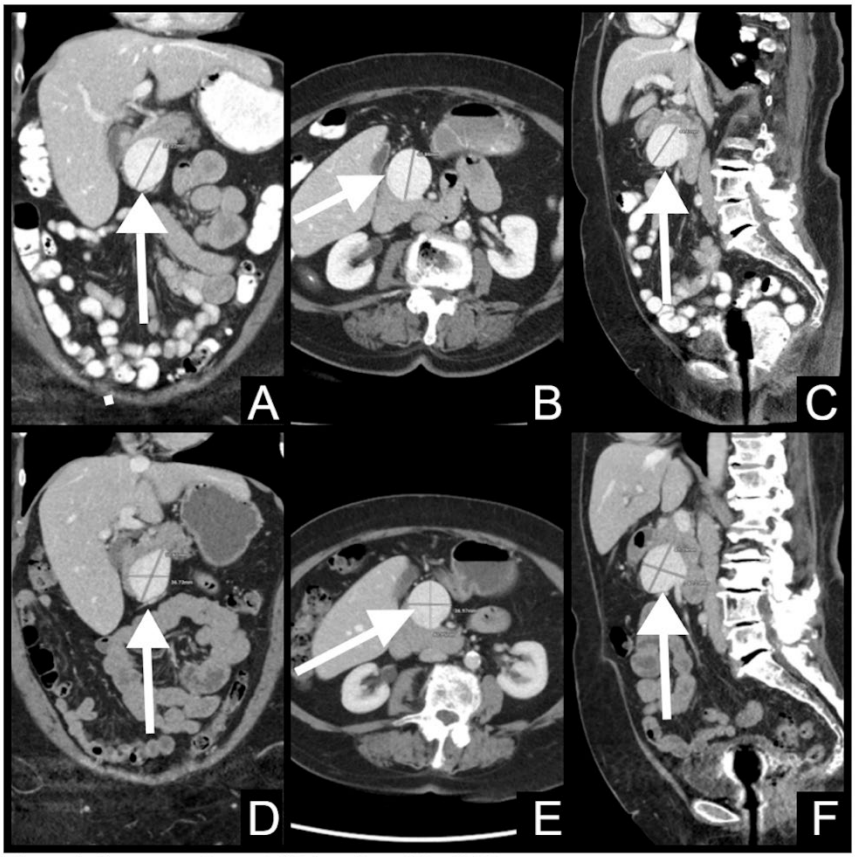


Figure 1: **Contrast-enhanced CT imaging of the SMV aneurysm.**
(A-C) Initial CT: Coronal **(A)**, axial **(B)**, and sagittal **(C)** views showing a 4.0 cm saccular aneurysm at the junction of the middle colic vein. **(D-F)** Subsequent 12-week pancreatic protocol CT: Coronal **(D)**, axial **(E)**, and sagittal **(F)** views demonstrating interval size reduction to 3.2 cm.

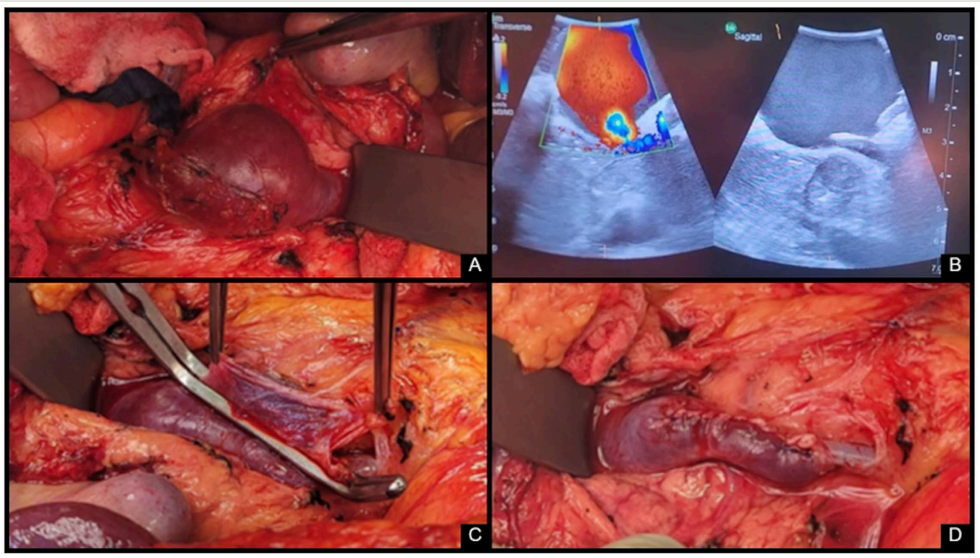


Figure 2: Intraoperative Photos and Ultrasound.
(A) Intraoperative view of the superior mesenteric vein (SMV) aneurysm before resection, measuring approximately 3.2 cm in diameter. **(B)** Intraoperative Doppler ultrasound confirming aneurysmal dilation and preserved venous flow. **(C)** Satinsky clamp applied across the SMV to facilitate tangential aneurysmectomy. **(D)** Completed primary closure of the SMV following aneurysm resection, demonstrating intact vessel continuity.

The etiology of VVAs remains incompletely understood but is broadly categorized as acquired or congenital. Acquired causes are more common and include portal hypertension, cirrhosis, pancreatitis, trauma, or prior abdominal surgery[7]. However, our patient did not exhibit any of these risk factors. This supports a congenital etiology, possibly linked to embryologic vascular anomalies. One proposed theory suggests that incomplete regression of the caudal segment of the right vitelline vein can result in a small diverticulum at the caudal-ventral intervitelline anastomosis, which may enlarge over time and evolve into an aneurysm[2,3].

The decision to proceed with elective surgical repair was based on the aneurysm size and concern for rupture. Laurenzi et al. noted that in patients without portal hypertension, saccular or fusiform aneurysms can be treated with aneurysmorrhaphy or aneurysmectomy[7]. In contrast, patients with portal hypertension often require decompressive shunt procedures or liver transplantation in advanced cases[7].

Conservative management with imaging surveillance is sometimes appropriate for small, asymptomatic lesions; larger aneurysms (> 3 cm) and those with evidence of mural thrombus are considered for intervention due to the risk of rupture, compression of surrounding structures, or complications of thrombosis[7,8]. In patients with thrombosed aneurysms, anticoagulation can also be considered to prevent embolization[6].

In this case, the patient's asymptomatic but anatomically significant SMV aneurysm, greater than 3 cm in size and located adjacent to the superior mesenteric artery, was reviewed at a hepatobiliary multidisciplinary conference. Consensus favored operative management, given the risk of rupture and thrombosis. The patient underwent tangential aneurysmectomy with primary repair, a technique that maintains venous continuity without the need for grafting.

Postoperative bleeding and hepatic subcapsular hematoma, while concerning, were conservatively managed. The absence of active extravasation and the patient's clinical stability supported non-operative management.

Resolution of the aneurysm with preserved vessel patency on follow-up imaging confirmed the success of the procedure (Figure 3A-C).

Despite the favorable outcomes, this case highlights several limitations in the current VVA management. The rarity of SMV aneurysms makes it difficult to establish evidence-based protocols, and treatment decisions must rely heavily on individual patient factors and surgeon

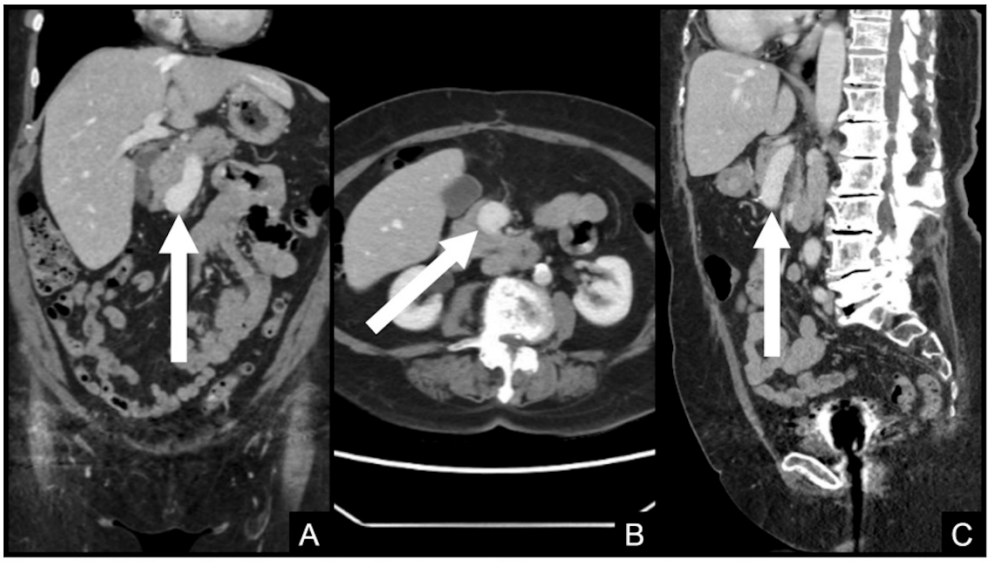


Figure 3: CT imaging 12 months after tangential aneurysmectomy of the complete resolution of the SMV aneurysm.

(A) Coronal, **(B)** axial, and **(C)** sagittal views showing a patent superior mesenteric vein with preserved vessel caliber at the repair site. No evidence of aneurysm recurrence, stenosis, or thrombosis.

experience. Additionally, the long-term durability of the repair remains unknown, as our current follow-up period extends only to seven months. Furthermore, because this patient underwent surgical intervention, our report does not provide insight into the conservative management of SMV aneurysms.

Conclusions SMV aneurysms are rare and potentially life-threatening. Although often clinically silent, complications such as thrombosis and rupture may develop without warning. Early detection through imaging, multidisciplinary evaluation, and appropriate surgical planning can lead to excellent outcomes. This case adds to the limited body of literature supporting tangential aneurysmectomy with primary repair as a safe and effective strategy for selecting patients with anatomically significant, asymptomatic SMV aneurysms.

References

1. Sfyroeras GS, Antoniou GA, Drakou AA, Karathanos C, Giannoukas AD. Visceral venous aneurysms: clinical presentation, natural history and their management: a systematic review. *Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg*. 2009;38(4):498-505. doi:10.1016/j.ejvs.2009.05.016

2. Nitesh P, Biju P, Kalayarasan R. Superior Mesenteric Vein Aneurysm With Arteriovenous Communication and Portal Vein Thrombosis: A Rare Presentation in Non-cirrhotic Portal Hypertension. *Cureus*. 2023;15(7):e42595. doi:10.7759/cureus.42595

3. Carneiro C, Brito J, Bilreiro C, et al. All about portal vein: a pictorial display to anatomy, variants and physiopathology. *Insights Imaging*. 2019;10(1):38. doi:10.1186/s13244-019-0716-8

4. Wolosker N, Zerati AE, Nishinari K, de Melo Galvão Filho M, Wolosker AMB. Aneurysm of superior mesenteric vein: case report with 5-year follow-up and review of the literature. *J Vasc Surg*. 2004;39(2):459-461. doi:10.1016/j.jvs.2003.08.008

5. Lechowicz R, Elwertowski M. Standards of the Polish Ultrasound Society. Ultrasound examination of the portal system and hepatic vessels. *J Ultrason*. 2015;15(61):208-226. doi:10.15557/JoU.2015.0018

6. Kurtcehajic A, Zerem E, Alibegovic E, Kunosic S, Hujdurovic A, Fejzic JA. Portal vein aneurysm-etiology, multimodal imaging and current management. *World J Clin Cases*. 2023;11(4):725-737. doi:10.12998/wjcc.v11.i4.725

7. Laurenzi A, Ettorre GM, Lionetti R, Meniconi RL, Colasanti M, Vennarecci G. Portal vein aneurysm: What to know. *Dig Liver Dis Off J Ital Soc Gastroenterol Ital Assoc Study Liver*. 2015;47(11):918-923. doi:10.1016/j.dld.2015.06.003

8. Moreno JA, Fleming MD, Farnell MB, Gloviczki P. Extrahepatic portal vein aneurysm. *J Vasc Surg*. 2011;54(1):225-226. doi:10.1016/j.jvs.2010.05.113

Affiliations:
[1] Texas Tech University Health Sciences Center - School of Medicine
[2] Texas Tech University Health Sciences Center – Division of Surgical Oncology, Department of Surgery

West Texas Journal *of* Medicine

Case Report

Acute urinary hesitancy associated with buprenorphine in a young adult treated for kratom use disorder: a case report

Jedidiah Feyisetan[1], Gniewko Więckiewicz, MD, PhD3, Wali Yousufzai, MD[2], Regina Baronia, MD[2], Poorvanshi Alag, MD, DABOM[2]

Abstract

Background: Acute urinary hesitancy and retention are rare adverse effects of opioid use, including buprenorphine, and may require urgent intervention. While urinary hesitancy occurs in up to 26 percent of patients treated with buprenorphine, acute retention is uncommon.

Case: A 20-year-old Hispanic male college student with kratom dependence, PTSD, depression, and anxiety was started on buprenorphine naloxone 2 mg 0.5 mg sublingually for withdrawal management. Two days later, he presented to the emergency department with lower abdominal discomfort and an inability to urinate. The post-void bladder scan showed 58 mL of residual urine, which is below the threshold for acute retention but consistent with functional hesitancy. He declined Foley catheterization, and a straight catheter was used. Buprenorphine was discontinued at the patient's request.

Discussion: Symptom onset closely followed buprenorphine initiation, suggesting a causal relationship. Possible mechanisms include mu-opioid receptor-mediated detrusor relaxation, increased sphincter tone, and interaction with concomitant fluoxetine and clonidine. Early identification and management may prevent treatment interruption.

Conclusion: Even subclinical urinary dysfunction can significantly affect adherence in opioid use disorder treatment. Clinician awareness is critical, particularly in young patients without urologic risk factors.

Introduction

Acute urinary hesitancy and retention involve impaired bladder emptying and can require emergent intervention such as catheterization. If left untreated, retention may lead to pain, infection, hydronephrosis, and post-renal kidney injury. Medication-induced urinary symptoms account for approximately 2% to 10% of acute urinary retention cases [1,2]. Kratom (*Mitragyna speciosa*) is a tropical tree native to Southeast Asia whose leaves are traditionally used for their stimulant and opioid-like properties. At low doses, kratom acts as a stimulant, increasing energy and alertness, while at higher doses it produces sedative and analgesic effects similar to opioids. Though some individuals use kratom to self-manage pain or opioid withdrawal, it has increasingly gained attention for its potential for abuse, dependence, and adverse effects. Global regulatory approaches vary widely, reflecting ongoing debates regarding their safety and potential for misuse [3].

Corresponding Author:
Dr. Poorvanshi Alag MD, DABOM, Texas Tech University Health Sciences Center, Email: Poorvanshi.Alag@ttuhsc.edu

Buprenorphine, a partial mu opioid receptor agonist, is FDA-approved for opioid use disorder and pain management and is increasingly used off-label for kratom withdrawal [4,5]. While well tolerated in most patients, buprenorphine has been associated with urinary dysfunction, most often hesitancy and less commonly acute retention [6,7,8]. The likely mechanism involves impaired detrusor contractility, increased urethral sphincter tone, and reduced afferent bladder signaling [7, 8, 9].

Case Presentation

A 20-year-old Hispanic male college student presented for evaluation of kratom dependence, reporting daily use for approximately three years for stress relief and mood regulation. He also had a history of PTSD, recurrent major depressive disorder, and unspecified anxiety disorder. He was taking fluoxetine 40 mg daily and clonidine ER 0.1 mg twice daily, which had been partially effective for mood, anxiety, and withdrawal-related symptoms.

Family history was notable for anxiety, depression, and substance use. Mental status examination revealed a restless appearance, anxious mood, racing thoughts, and limited judgment regarding substance use. Buprenorphine naloxone 2 mg 0.5 mg sublingual film was initiated with counseling on common side effects [4].

Two days after initiation, he presented to the emergency department with lower abdominal discomfort and an inability to urinate. A bladder scan revealed a post-void residual of 58 mL, which is well below the threshold of greater than 300 mL used to diagnose acute urinary retention [10], confirming that this case represents urinary hesitancy rather than proper retention. He declined Foley catheter placement, and a straight catheter was used for urine sampling. No infectious or obstructive cause was found. Symptoms resolved after buprenorphine discontinuation per patient preference. He did not return for the scheduled follow-up.

Discussion

This case illustrates buprenorphine-associated urinary hesitancy in a young adult without structural urological disease. The temporal relationship between buprenorphine initiation and symptom onset supports causality. Opioids may impair bladder emptying through mu receptor-mediated detrusor muscle relaxation, increased urethral sphincter tone through sympathetic stimulation, and suppression of bladder afferent signaling [7,8,9,11].

The potential intersection between kratom and buprenorphine in contributing to acute urinary hesitancy warrants clinical attention, particularly given their shared action as partial agonist of the mu opioid receptors [12]. While buprenorphine has established opioid associated side effects, emerging evidence suggests kratom may induce similar effects at higher doses due to its opioid-like properties. A recent case series involving individuals with kratom use disorder treated with long-term buprenorphine maintenance highlighted overlapping pharmacodynamics but did not assess urologic outcomes [5]. This overlap suggests a plausible risk of compounded urinary hesitancy in patients transitioning between or co-using these agents. Further investigation is needed to evaluate the prevalence and severity of urinary adverse effects in this population.

Fluoxetine and clonidine can independently contribute to urinary symptoms, and their concomitant use may potentiate their effects [9,13,14]. Although the patient's post-void residual confirmed urinary hesitancy rather than acute retention, the discomfort was significant enough to prompt discontinuation. This shows that even mild or subclinical urinary dysfunction can disrupt adherence.

Management options may include dose reduction, temporary cessation, or the use of pharmacologic agents such as bethanechol [15], an M3 receptor agonist. Multidisciplinary collaboration between psychiatry, primary care, and urology may help optimize care when multiple medications affecting autonomic function are involved.

Beyond the physiological mechanisms, it is essential to frame opioid related urinary effects in a way that promotes awareness without creating fear. For younger patients with substance use disorders, including those using off-label buprenorphine for kratom withdrawal, fear-based messaging can lead to premature discontinuation or reluctance to begin treatment. Clear and non-alarmist counseling that urinary hesitancy is manageable and may encourage early reporting of symptoms and help maintain adherence [16].

Conclusions

Opioid induced urinary hesitancy should be considered in patients taking buprenorphine who develop voiding symptoms, even when residual volumes are below acute retention thresholds. Early recognition and dose adjustment may help maintain treatment adherence. This case also highlights the importance of considering polypharmacy effects in young adults with psychiatric comorbidities and ongoing kratom use.

Authors' contributions

JF, PA, GW contributed to case conceptualization, literature review, and manuscript drafting. WY, RB, and PA contributed to clinical interpretation, critical revisions, and supervision. All authors read and approved the final manuscript.

References

1. Verhamme KM, et al. Drug induced urinary retention: incidence, management and prevention. Drug Saf. 2008.
2. Roehrborn CG. Acute urinary retention: risks and management. Rev Urol. 2005.
3. Prozialeck WC. Update on the Pharmacology and Legal Status of Kratom. J Am Osteopath Assoc. 2016.
4. Weiss ST, Douglas HE. Buprenorphine naloxone for kratom withdrawal. J Addict Med. 2021.
5. Broyan VR, et al. Long term buprenorphine treatment for kratom use disorder. Subst Abuse. 2022.
6. Varma A, et al. Buprenorphine induced urinary hesitancy. J Alcohol Drug Depend. 2017.
7. Altunsoy N, et al. Acute urinary retention with sublingual buprenorphine. Klinik Psikofarmakoloji Bulteni. 2016.
8. Edwards RT, et al. Acute urinary retention secondary to buprenorphine. Am J Emerg Med. 2013.
9. Dobrek L. Lower urinary tract disorders as adverse drug reactions. Pharmaceuticals. 2023.
10. Halbgewachs C, Domes T. Postobstructive diuresis. Can Fam Physician. 2015.
11. Pergolizzi JV Jr, et al. Urinary retention and opioid therapy. J Clin Pharm Ther. 2019.
12. Pangarkar S, Pham QG, Eapen BC. Pain and Addiction. Pain Care Essentials and Innovations. Elsevier. 2021.
13. Elsamra SE, Ellsworth P. Effects of analgesic and anesthetic medications on the bladder. Urol Nurs. 2012.
14. Perrin Terrin A, et al. Drugs associated with urinary retention. Eur J Clin Pharmacol. 2014.
15. Varma A, et al. Bethanechol for buprenorphine related hesitancy. J Addict Med. 2011.
16. Volkow ND, et al. Stigma and the public health response to the opioid crisis. N Engl J Med. 2021
17. Verhamme KM, et al. Drug induced urinary retention: incidence, management and prevention. Drug Saf. 2008.
18. Roehrborn CG. Acute urinary retention: risks and management. Rev Urol. 2005.

19. Prozialeck WC. Update on the Pharmacology and Legal Status of Kratom. J Am Osteopath Assoc. 2016.
20. Weiss ST, Douglas HE. Buprenorphine naloxone for kratom withdrawal. J Addict Med. 2021.
21. Broyan VR, et al. Long term buprenorphine treatment for kratom use disorder. Subst Abuse. 2022.
22. Varma A, et al. Buprenorphine induced urinary hesitancy. J Alcohol Drug Depend. 2017.
23. Altunsoy N, et al. Acute urinary retention with sublingual buprenorphine. Klinik Psikofarmakoloji Bulteni. 2016.
24. Edwards RT, et al. Acute urinary retention secondary to buprenorphine. Am J Emerg Med. 2013.
25. Dobrek L. Lower urinary tract disorders as adverse drug reactions. Pharmaceuticals. 2023.
26. Halbgewachs C, Domes T. Postobstructive diuresis. Can Fam Physician. 2015.
27. Pergolizzi JV Jr, et al. Urinary retention and opioid therapy. J Clin Pharm Ther. 2019.
28. Pangarkar S, Pham QG, Eapen BC. Pain and Addiction. Pain Care Essentials and Innovations. Elsevier. 2021.
29. Elsamra SE, Ellsworth P. Effects of analgesic and anesthetic medications on the bladder. Urol Nurs. 2012.
30. Perrin Terrin A, et al. Drugs associated with urinary retention. Eur J Clin Pharmacol. 2014.
31. Varma A, et al. Bethanechol for buprenorphine related hesitancy. J Addict Med. 2011.
32. Volkow ND, et al. Stigma and the public health response to the opioid crisis. N Engl J Med. 2021

Affiliations:
[1]Texas Tech University Health Sciences Center School of Medicine, Lubbock, Texas, USA
[2]Department of Psychiatry, Texas Tech University Health Sciences Center, Lubbock, Texas, USA
[3] Medical University of Silesia, Poland