Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

War-associated increase in pediatric respiratory infections in Western Ukraine: a regional study from Chernivtsi Oblast (2022–2025)

Olena Koloskova
Bukovinian State Medical University
Ksenia Rudan
xenia.rudan@gmail.com

Bukovinian State Medical University
Nataliya Bohutska
Bukovinian State Medical University
Khrystyna Buryniuk-Hloviak
Bukovinian State Medical University
Olena Vlasova
Bukovinian State Medical University
Kateryna Vlasova
Bukovinian State Medical University

Article

Keywords: epidemiological analysis, impact of war on child health, pneumonia, pediatric respiratory infections, respiratory hospitalization, internally displaced children

Posted Date: May 4th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9186042/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Acute respiratory infections remain a major cause of pediatric morbidity and hospitalization worldwide. Armed conflicts disrupt healthcare systems and living conditions, increasing the vulnerability of children to infectious diseases. Since 2022, the full-scale war in Ukraine has led to large-scale population displacement and significant pressure on regional healthcare systems. However, quantitative evidence on the impact of prolonged war on pediatric respiratory disease patterns remains limited. This is particularly important for regions hosting internally displaced populations. Here we show that the burden of pediatric respiratory infections in Chernivtsi Oblast increased substantially during 2022–2025, with a 53% rise in hospitalizations and a marked increase in disease severity. The proportion of pneumonia increased over time, accompanied by a more than twofold rise in severe and complicated cases, and strong associations with emergency care utilization. These findings indicate that pneumonia is a key driver of increased healthcare burden during wartime and that prolonged conflict contributes to more severe disease in children. Our results highlight the need for adaptive healthcare strategies and improved surveillance systems in conflict-affected regions.

INTRODUCTION

Acute respiratory infections are among the leading causes of morbidity and hospitalization in children worldwide. Their burden is particularly high in conditions associated with adverse social, environmental, and healthcare-related factors.

Armed conflicts are known to substantially affect population health, especially in vulnerable groups such as children. The full-scale war in Ukraine has led to large-scale internal displacement, overcrowding in temporary settlements, chronic psycho-emotional stress, disruption of access to primary healthcare, decreased vaccination coverage, and increased antibiotic use [1]. These factors may contribute to changes in the incidence, structure, and severity of pediatric respiratory infections [2, 3].

Chernivtsi Oblast, located near the European Union border, has become a major transit and settlement region for internally displaced populations since the beginning of the war. The region has experienced a significant influx of children from active conflict areas, including Donetsk, Kharkiv, Luhansk, Zaporizhzhia, Kherson, and Mykolaiv regions. These population movements have created additional pressure on the healthcare system and may have influenced epidemiological patterns of respiratory diseases [4, 5, 6].

Despite increasing attention to the health consequences of war, there is limited systematic evidence on long-term changes in the epidemiology of pediatric respiratory infections in regions hosting displaced populations [7, 8, 9, 10]. In particular, data on hospitalization rates, disease structure, and mortality remain insufficient.

The aim of this study was to conduct a retrospective epidemiological analysis of temporal changes in hospitalization, prevalence, mortality, and the structure of respiratory diseases among children in

Chernivtsi Oblast during the period of the full-scale war (2022–2025).

RESULTS

Pediatric Respiratory Hospitalizations During the War

During the first year of the full-scale war (2022) in Chernivtsi Oblast, a total of 29,739 pediatric hospitalizations were recorded, of which 27.4% were due to respiratory diseases. Across the 2022–2025 period, the total number of bed-days for children hospitalized with respiratory infections reached 60,141. Specifically, 1,040 children with community-acquired pneumonia spent 10,278 bed-days in hospital, representing 15.6% of total bed occupancy. Infants under one year accounted for 940 cases (11.5%) of respiratory hospitalizations, primarily due to acute bronchiolitis and community-acquired pneumonia. Over four years, pediatric hospitalizations due to respiratory diseases increased by 4,324 episodes, representing a 53.0% rise compared to the first year of the war (Fig. 1).

Trends in Community-Acquired Pneumonia

Severe and complicated forms of community-acquired pneumonia increased by 131.3% over the study period. The proportion of hospitalized pneumonia cases among emergency department visits grew from 76.6% in 2022 to 87.8% in 2025. The share of community-acquired pneumonia within respiratory hospitalizations also increased from 12.7% in 2022 to 19.3% in 2025, reflecting both rising prevalence and severity of disease (Fig. 2).

Hospital Burden and Internally Displaced Children

The majority of children hospitalized for respiratory infections presented with severe or complicated conditions requiring inpatient monitoring. Annual hospital visits for pediatric respiratory infections increased by 65.9% compared to pre-war levels, and hospitalizations rose by 47.1%. The average number of emergency department visits among internally displaced children (IDPs) was 1,018.25 per year, with hospitalization rates ranging from 76.6% in 2022 to 87.8% in 2025 (Fig. 3).

Correlation Between Hospitalization Variables

Correlation analysis using Pearson coefficients revealed strong positive associations between total pediatric respiratory hospitalizations (RespHosp) and pneumonia cases ($r = 0.93$), as well as with emergency department visits (EDvisits, $r = 0.82$) and hospitalizations following these visits (EDhosp, $r = 0.87$). Pneumonia cases alone were highly correlated with ED visits ($r = 0.90$) and ED hospitalizations ($r = 0.94$), underscoring the significant contribution of pneumonia to hospital workload. Hospitalizations of IDPs (IDPhosp) showed moderate positive correlation with total IDP visits (IDPvisits, $r = 0.62$) and moderate negative correlations with ED visits and ED hospitalizations (r from -0.46 to -0.57), reflecting a

gradual decline in the proportion of IDPs among total visits and hospitalizations over time. Overall, these analyses suggest that general trends in healthcare burden during the 2022–2025 war period were primarily driven by overall respiratory hospitalizations and pneumonia, whereas IDP-related variables exerted more localized effects (Fig. 4).

Given the limited number of annual observations, the correlation analysis was considered exploratory and intended to identify potential relationships between epidemiological indicators rather than to establish causal associations.

Regional Distribution of Hospitalized Internally Displaced Children

Children from Donetsk, Kharkiv, and Mykolaiv regions accounted for the largest numbers of hospitalizations, while fewer cases originated from Luhansk, Zaporizhzhia, and Kherson regions. The overall number of visits to the emergency department of Chernivtsi Regional Children's Clinical Hospital by internally displaced children was distributed across regions as follows (https://datawrapper.dwcdn.net/PBu18/3/): Donetsk (746 children), Kharkiv (541), Kyiv (861), Mykolaiv (206), Kherson (275), Zaporizhzhia (253), and Luhansk (119) regions (Fig. 5.). These numbers reflect pronounced regional variations in the impact of the conflict and internal displacement on pediatric healthcare utilization. These regional differences highlight the differential impact of displacement on pediatric hospital care within Chernivtsi Oblast.

Pediatric Respiratory Mortality

Over the four-year study period, 49 children aged 0–18 years died, with infants under one year accounting for 75.5% of deaths. The mortality rate due to respiratory diseases in pediatric patients was 14.3%.

DISCUSSION

This study provides a comprehensive assessment of hospitalizations of children with respiratory diseases in the Chernivtsi Oblast during the first four years of the full-scale war (2022–2025). The results indicate a significant increase both in the number and severity of hospitalizations. In 2022, the share of hospitalizations due to respiratory diseases among all pediatric admissions was 27.4%, rising by 53.0% to 32.4% in 2025 [11]. Notably, the number of severe and complicated cases of community-acquired pneumonia increased by 131.3% over the four-year period [11], with the average share of pneumonia among respiratory hospitalizations rising from 12.7% in 2022 to 19.3% in 2025 [12, 13].

Our data confirm that internally displaced children (IDCs) significantly impacted hospital workload. The average annual number of IDC visits to the emergency department of OKNP "Chernivtsi Regional Children's Clinical Hospital" was 1,018.25, with the share of hospitalizations ranging from 76.6% in 2022 to 87.8% in 2025 [14, 15]. Most hospitalizations involved children from Donetsk, Kharkiv, Mykolaiv,

Kherson, Zaporizhzhia, and Luhansk regions, highlighting regional differences in the effects of the war and migration on healthcare [16].

Correlation analysis revealed a strong positive relationship between the total number of pediatric hospitalizations for respiratory infections and cases of pneumonia (r = 0.93), as well as emergency department visits (EDvisits r = 0.82; EDhosp r = 0.87). IDC hospitalization indicators showed moderate positive correlations among themselves (r = 0.62) and moderate negative correlations with other indicators (r from − 0.46 to -0.57), indicating a gradual decrease in the proportion of IDCs among overall hospitalizations in later years of the war [17].

Over the four-year war period in the Chernivtsi Oblast, 49 children aged 0–18 years died, with 75.5% of deaths occurring in infants under one year of age. Mortality from respiratory diseases among all deceased children was 14.3%, consistent with UNHCR estimates for refugee children (14.0–20.0%) [18].

Comparison with international data confirms the consistency of the findings: among 47,851 refugee children in Romania, interstitial pneumonia was observed in 23.0% of cases, and severe acute respiratory distress in 19.0%, reflecting the significant impact of war on child health in border regions [19]. Experience from Syria also indicates a high burden of respiratory pathology among internally displaced children – 29.0% of respiratory disease cases, with chronic respiratory conditions in 14.0% of patients [20].

This study demonstrates that the war not only increased the incidence and severity of pediatric respiratory infections but also substantially increased the burden on the healthcare system, especially in inpatient settings. However, prolonged residence of IDCs in the rear regions was associated with stabilization of the frequency of visits and more rational hospitalization, suggesting adaptive processes and partial improvement of children's mental health [21, 22].

Thus, these findings expand the understanding of pediatric respiratory infection epidemiology during wartime, emphasize the importance of considering IDC status and regional factors in healthcare planning, and provide a basis for developing prevention strategies and optimizing treatment of children in crisis conditions [23].

Limitations

A limitation of the present study is the relatively small number of time points used for correlation analysis, which may influence the stability of correlation estimates. Therefore, these findings should be interpreted cautiously and confirmed in studies with longer observation periods.

METHODS

Study Design and Population

The study was conducted as a retrospective observational regional analysis using data from the Chernivtsi Oblast (Ukraine) during the period of the full-scale Russian-Ukrainian war (2022–2025). The study population included both local children and internally displaced persons (IDPs) from eastern regions affected by the ongoing conflict. According to these data, as of 1 March 2026, a total of 19,104 children aged 0 to 18 years were officially registered as and granted the status of “internally displaced persons” in the Chernivtsi Oblast. Hospitalization data were obtained from regional health records, and cases were classified according to the primary respiratory diagnosis, including pneumonia, bronchiolitis, and bronchial asthma. Children were stratified by age groups, with particular attention to those under one year of age.

Data Collection and Processing

Data on hospital admissions, age, and region of origin were collected in Microsoft Excel (Windows 11) for initial organization and cleaning. Descriptive statistics and inferential analyses were performed using Statistica 13.5 (TIBCO Software Inc., Palo Alto, CA, USA) and RStudio version 2023.06.1 + 524 (R version 4.3.1; https://www.r-project.org/) for statistical calculations, correlation analyses, and visualization of trends over time.

Statistical Analysis

Continuous variables were summarized using means and standard deviations or medians and interquartile ranges, as appropriate. Categorical variables were expressed as counts and percentages. Comparative analyses between groups were conducted using chi-square tests or Fisher’s exact tests for categorical variables and t-tests or Mann–Whitney U tests for continuous variables. Correlation analyses were performed using Pearson or Spearman coefficients, depending on data distribution. Adjusted odds ratios (aOR) were calculated to assess the effect of displacement status on hospitalization risk, controlling for age and primary diagnosis. Statistical significance was set at $p < 0.05$.

Data Visualization

Figures illustrating trends in hospitalizations, age distribution, and regional origin were generated in RStudio. A geographical map showing the distribution of hospitalized IDPs from different regions was created using Datawrapper (https://app.datawrapper.de/). All figures were formatted for clarity according to Scientific Reports standards.

Ethical Considerations

This study was conducted as a retrospective observational regional analysis of pediatric hospitalizations in the Chernivtsi Oblast (Ukraine) during the full-scale Russian-Ukrainian war (2022–2025). The study

protocol was reviewed and approved by the Ethics Committee of the Bukovinian State Medical University (protocol #4, 18.12.2025). All procedures were performed in accordance with relevant institutional and national guidelines, as well as the principles of the Declaration of Helsinki, ensuring the protection of patient confidentiality.

Informed consent

Due to the retrospective nature of the study and the use of anonymized, aggregated data derived from hospital records and publicly available statistics, the requirement for obtaining informed consent was waived by the Ethics Committee of the Bukovinian State Medical University.

Declarations

AUTHOR CONTRIBUTIONS

O.K.designed the study and drafted the manuscript. K.R. prepared all figures. N.B. collected and verified statistical data. K.B-H. performed data analysis. O.V. and K.V. assisted with data collection, literature review, and manuscript editing. All authors reviewed and approved the final manuscript.

Data availability statement

The datasets generated and analyzed during the current study are not publicly available due to patient confidentiality but are available from the corresponding author on reasonable request.

Additional Information (including a Competing Interests Statement)

Correspondence and requests for materials should be addressed to K.R. xenia.rudan@gmail.com

Competing Interests: The authors declare no competing interests.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethical Approval: The study was approved by the Ethics Committee of Bukovinian State Medical University (protocol #4 18.12.2025) and was conducted in accordance with relevant guidelines and regulations.

References

1. Armitage, R. War in Ukraine: The impacts on child health. Br. J. Gen. Pract. 72, 272–273 (2022).
2. Pluta, M. et al. Ukrainian war refugee children with particularly severe viral infections: A case series report. Pediatr. Infect. Dis. J. 43, e30–e36 (2024). https://doi.org/10.1097/INF.0000000000004162

3. Lavie, M., Maymon, D., Diamant, N. et al. Respiratory syncytial virus bronchiolitis among refugees and asylum seekers from war-torn countries. Pediatr. Pulmonol. 56, 2888–2892 (2021). https://doi.org/10.1002/ppul.25562
4. Page, B., Irving, D., Amalberti, R. & Vincent, C. Health services under pressure: A scoping review and development of a taxonomy of adaptive strategies. BMJ Qual. Saf. 33, 738–747 (2024).
5. Yoon, J. G. et al. Clinical characteristics and disease burden of respiratory syncytial virus infection among hospitalized adults. Sci. Rep. 10, 12106 (2020). https://doi.org/10.1038/s41598-020-69017-8
6. Chen, Z. et al. Contribution of respiratory syncytial virus to burden of lower respiratory tract infections: A global analysis of 204 countries and territories, 1990–2021. Trop. Med. Infect. Dis. 10, 223 (2025). https://doi.org/10.3390/tropicalmed10080223
7. de Alencar Rodrigues, J. A. R. et al. Ukraine: War, bullets, and bombs—Millions of children and adolescents are in danger. Child Abuse Negl. 128, 105622 (2022).
8. Awuah, W. A. et al. Vulnerable in silence: Paediatric health in the Ukrainian crisis. Ann. Med. Surg. 82, 104369 (2022).
9. Murray, C. J. et al. Armed conflict as a public health problem. BMJ 324, 346–349 (2002).
10. Cantor, D. et al. Understanding the health needs of internally displaced persons: A scoping review. J. Migr. Health 4, 100071 (2021). https://doi.org/10.1016/j.jmh.2021.100071
11. Becker, G. et al. Acute appendicitis in children during war conflict: Results from a multicenter study. J. Clin. Med. 14, 4615 (2025). https://doi.org/10.3390/jcm14134615
12. Terkawi, A. S. et al. Child and adolescent health in northwestern Syria: Findings from healthy-Syria 2017 study. Avicenna J. Med. 9, 94–106 (2019).
13. Dida, G. O. et al. Factors predisposing women and children to indoor air pollution in rural villages, Western Kenya. Arch. Public Health 80, 46 (2022). https://doi.org/10.1186/s13690-022-00791-9
14. Alhaffar, M. H. D. B. A. & Janos, S. Public health consequences after ten years of the Syrian crisis: A literature review. Glob. Health 17, 111 (2021). https://doi.org/10.1186/s12992-021-00762-9
15. van Berlaer, G. et al. Diagnoses, infections and injuries in Northern Syrian children during the civil war: A cross-sectional study. PLoS One 12, e0182770 (2017). https://doi.org/10.1371/journal.pone.0182770
16. Omer, A. T. et al. Child health in war crisis: Barriers to healthcare utilization among internally displaced Sudanese caregivers 2024–2025. BMC Public Health 25, 3376 (2025). https://doi.org/10.1186/s12889-025-24627-7
17. M. S. & Vaithilingan, S. Childhood pneumonia in low- and middle-income countries: A systematic review. Cureus 16, e57636 (2024). https://doi.org/10.7759/cureus.57636
18. Hershey, C. L. et al. Incidence and risk factors for malaria, pneumonia and diarrhea in children under 5 in UNHCR refugee camps: A retrospective study. Confl. Health 5, 24 (2011). https://doi.org/10.1186/1752-1505-5-24

19. Tătăranu, E. et al. Emergency care for refugee patients at Suceava Hospital, Romania: Challenges and insights from the first year of the Russian-Ukrainian conflict. Healthcare 13, 138 (2025). https://doi.org/10.3390/healthcare13020138
20. Basha, L. et al. Impact of the Syrian conflict and forced displacement on respiratory health. BMJ Open Respir. Res. 10, e001636 (2023). https://doi.org/10.1136/bmjresp-2023-001636
21. Khosravi, M. Mental health needs in war-affected refugee children: Barriers, gaps, and strategies for effective care. Child Adolesc. Psychiatry Ment. Health 18, 146 (2024). https://doi.org/10.1186/s13034-024-00840-x
22. Metersky, K. et al. Psycho-social stressors experienced by young war refugees in developed countries: A scoping review. Can. J. Nurs. Res. 56, 350–362 (2024). https://doi.org/10.1177/08445621241263459
23. Lewtak, K. et al. What do hospital admission data reveal about the health needs of Ukrainian child refugees in Poland? Eur. J. Public Health 35 (Suppl. 4), ckaf161.350 (2025). https://doi.org/10.1093/eurpub/ckaf161.350

Figures

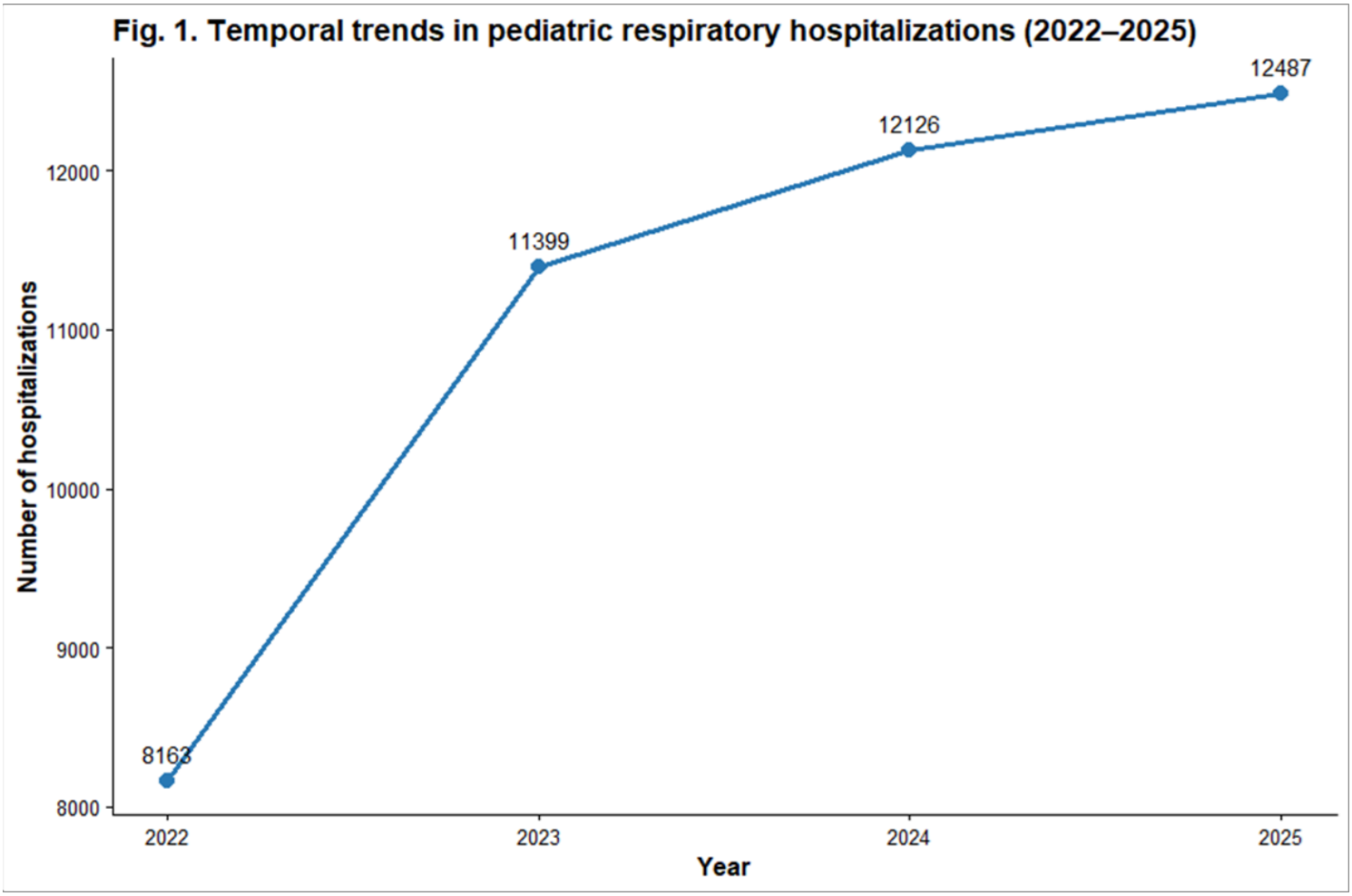


Figure 1

Temporal trends in pediatric respiratory hospitalizations (2022–2025).

Respiratory hospitalizations increased from 8,163 cases in 2022 to 12,487 cases in 2025.

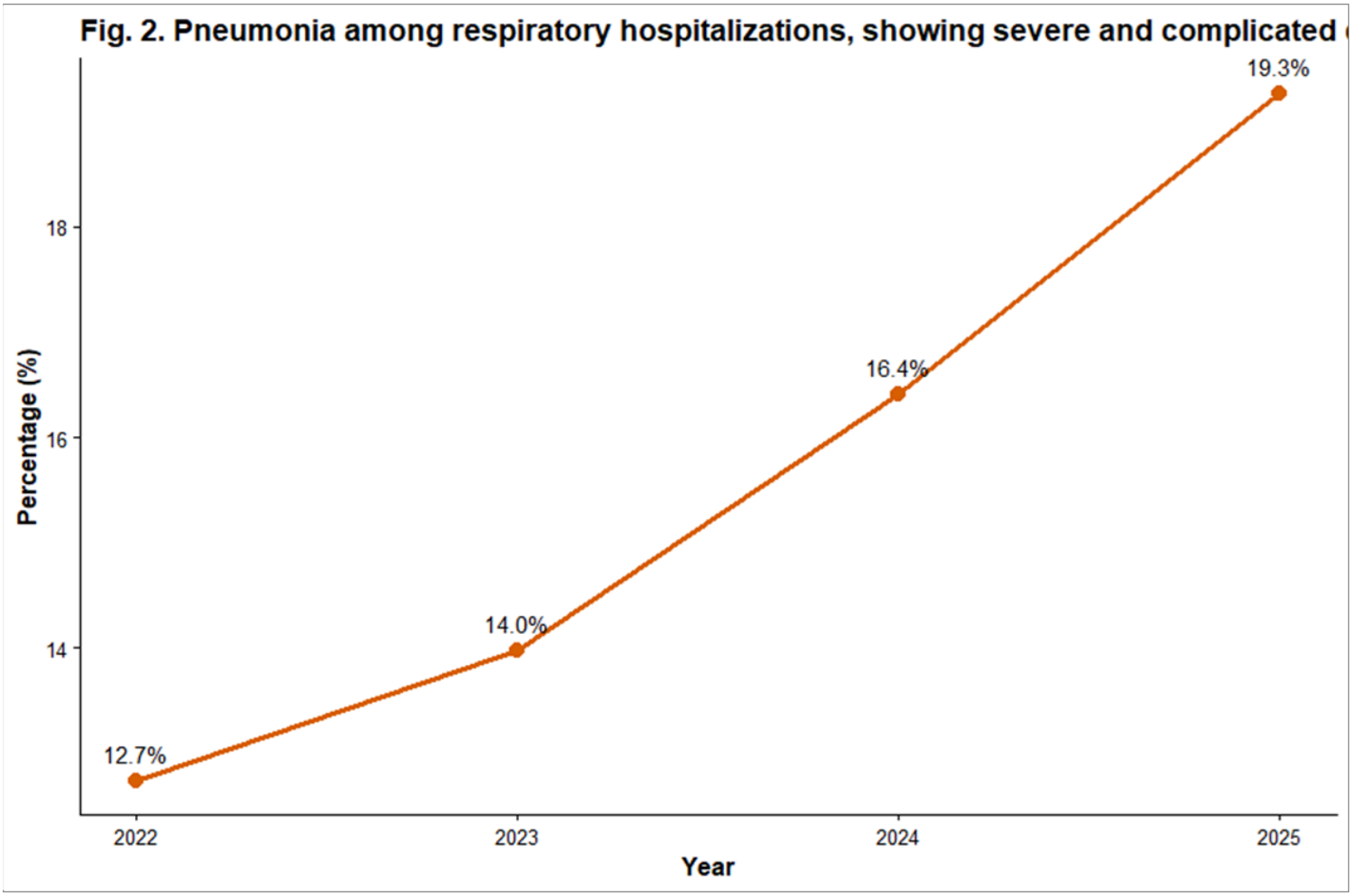


Figure 2

Pneumonia among respiratory hospitalizations.

Annual proportion of pneumonia cases among pediatric respiratory hospitalizations.

The proportion of pneumonia increased steadily from 12.7% in 2022 to 19.3% in 2025, suggesting a growing contribution of severe and complicated respiratory infections to overall hospitalizations.

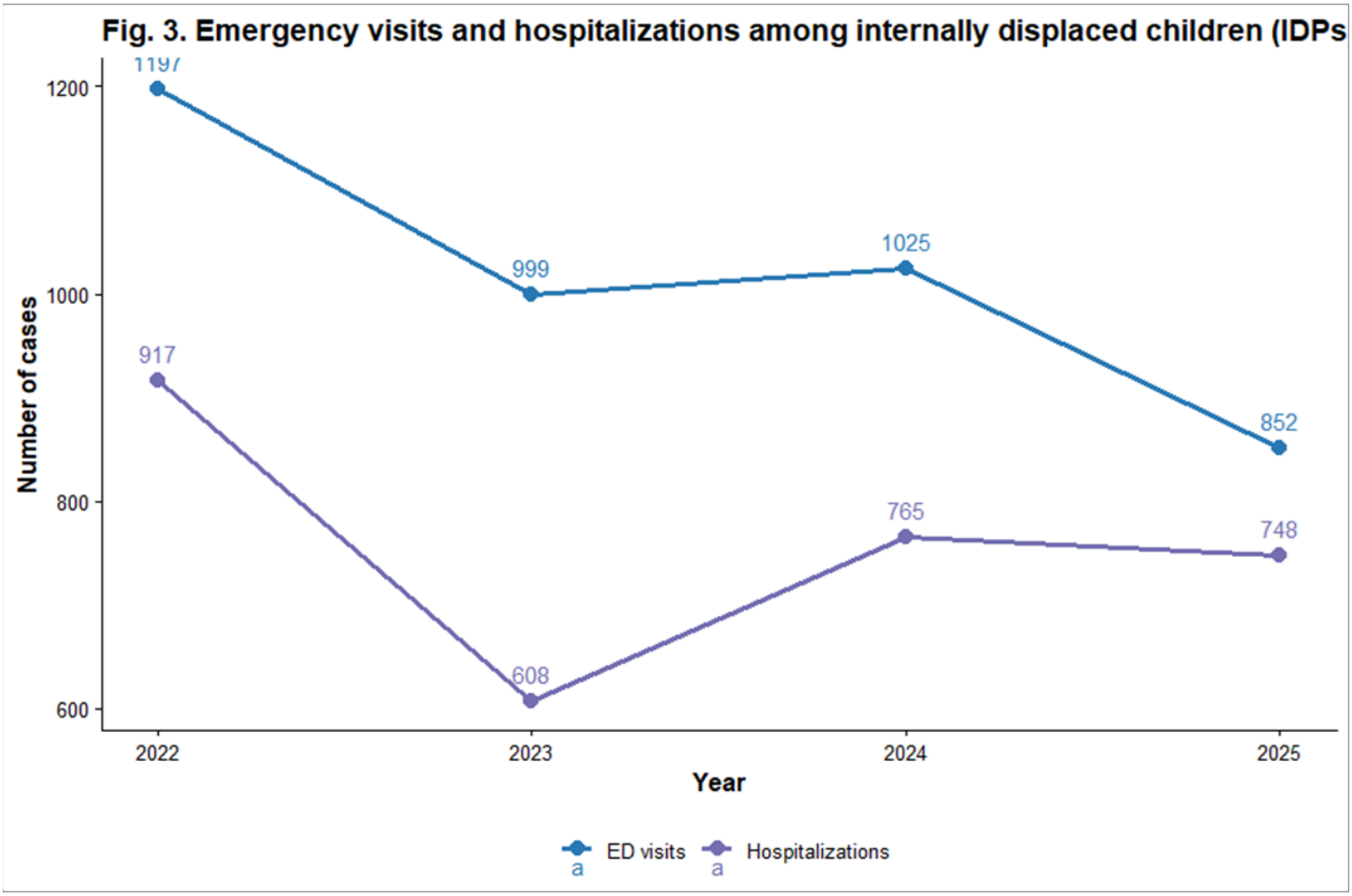


Figure 3

Emergency visits and hospitalizations among internally displaced children (IDPs).

Annual number of emergency department visits and hospitalizations among internally displaced children.

IDP-related emergency visits decreased from 1,197 cases in 2022 to 852 cases in 2025, while hospitalizations decreased from 917 to 748 cases. These findings indicate a reduction in the relative contribution of IDPs to pediatric healthcare utilization over time.

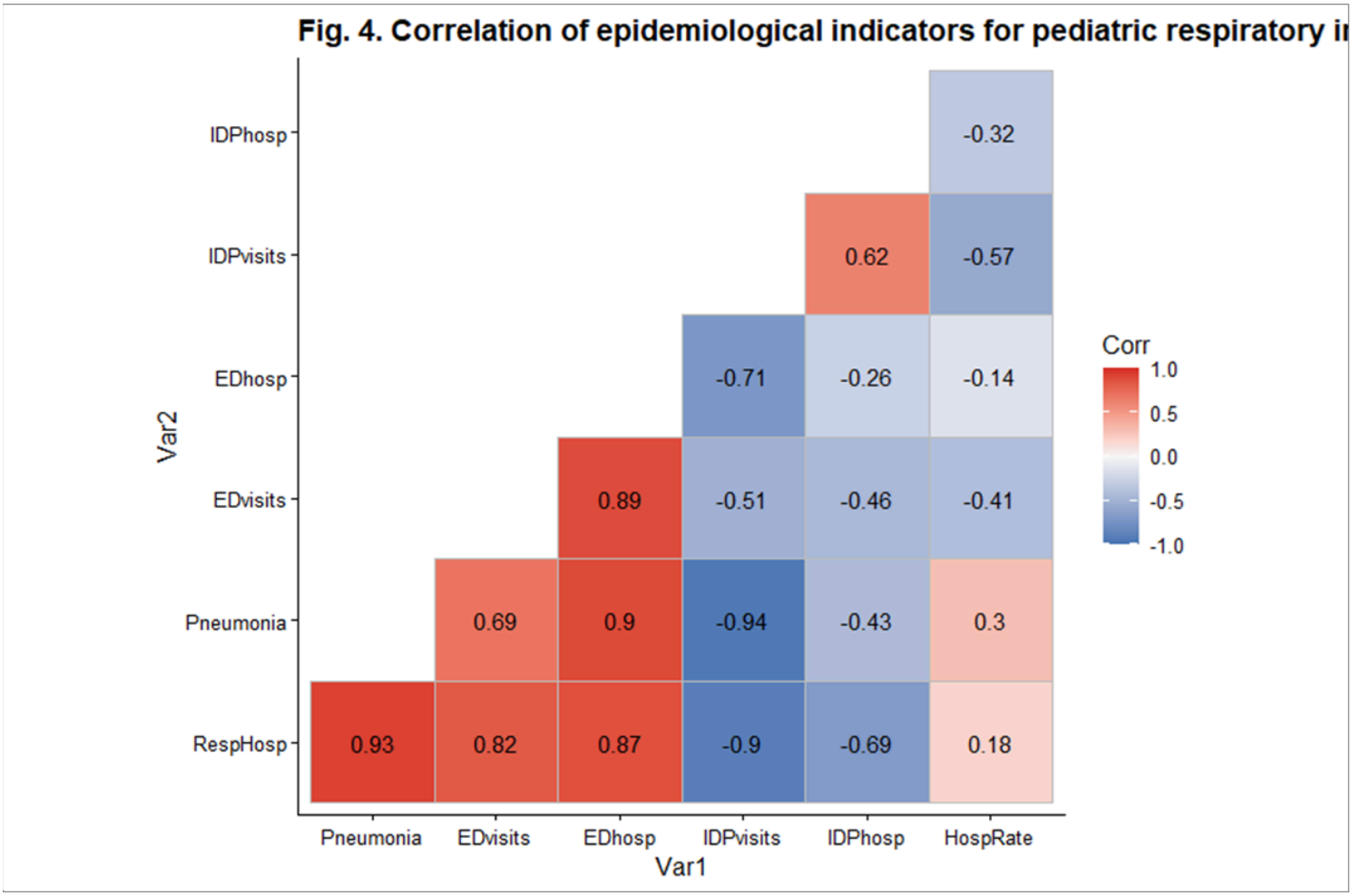


Figure 4

Correlation of epidemiological indicators for pediatric respiratory infections and IDP visits.

Correlation matrix showing pairwise associations between respiratory hospitalizations (RespHosp), pneumonia cases (Pneumonia), emergency department visits (EDvisits), hospitalizations through the emergency department (EDhosp), IDP-related visits (IDPvisits), IDP-related hospitalizations (IDPhosp), and hospitalization rate (HospRate).

Strong positive correlations were observed between respiratory hospitalizations and pneumonia (r = 0.93), as well as between hospitalizations and emergency department indicators. Pneumonia was also strongly correlated with emergency visits and hospitalizations. In contrast, IDP-related indicators demonstrated weaker or negative correlations with overall healthcare utilization metrics. The hospitalization rate showed relatively weak correlations with other variables.

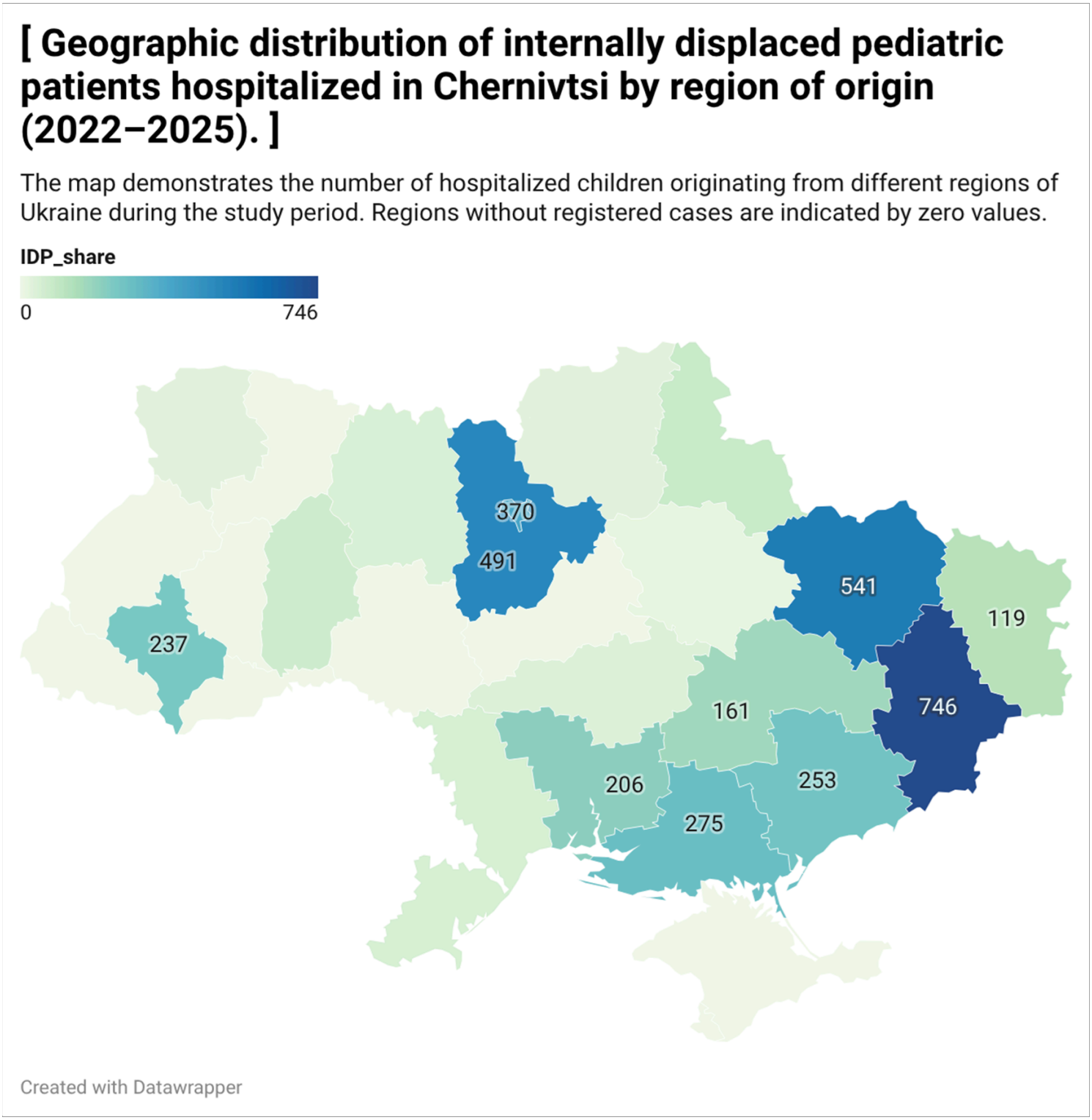


Figure 5

Geographic distribution of internally displaced pediatric patients hospitalized in Chernivtsi by region of origin (2022–2025).

The map (https://datawrapper.dwcdn.net/PBu18/3/) illustrates the number of hospitalized children originating from different regions of Ukraine during the study period. Regions with no registered cases are indicated by zero values.