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Interstitial lung disease hospitalization patterns between U.S. states from 2016-2020

Eva Ma, Niranjan Jeganathan
Division of Pulmonary, Critical Care, Hyperbaric, and Sleep Medicine, Department of Medicine, Loma Linda University Health, Loma Linda, California, USA

To the editor,

Interstitial lung diseases (ILDs) constitute a group of conditions characterized by shared clinical, radiological, and pathophysiological traits (1, 2). All ILDs are associated with significant morbidity and substantial financial strain (3-5). Studies have reported notable variability in ILD prevalence across states (6). However, differences in ILD-related hospitalizations and outcomes between states have not been explored. Examining regional discrepancies in ILD hospitalization patterns could reveal unique risk factors and disparities within healthcare infrastructure, providing valuable insights for broader public health interventions. Therefore, our study aims to compare the current trends in ILD hospitalizations (focusing on patients with a principal diagnosis of severe ILD), outcomes, and costs across U.S. states.

This retrospective cohort study utilized the Nationwide Inpatient Sample (NIS) Database, the largest publicly available all-payer inpatient database in the U.S. Data from 2016 to 2020 were extracted for analysis, yielding comprehensive information on hospitalization rates, length of stay (LOS), routine discharges (indicates a patient's return home rather than transfer to another facility or discharge due to mortality), hospitalization rates, and costs by state. ILD hospitalizations were identified using specific Medicare Severity Diagnosis-Related Groups (MS-DRG) codes, with a focus on MS- DRG code 196, representing a principal diagnosis of ILD with major complications and comorbidities (MCC). Additional details about DRG assignment are available in the Figure 1 footnotes and were previously published (7). By focusing on MCC codes, the analysis is weighted more heavily towards patients with severe ILD, enabling a nuanced assessment of its impact on outcomes while minimizing confounding from less severe conditions. We applied the Spearman's Rho correlation coefficient to explore associations between ILD hospitalization rates and state health variables (smoking prevalence, air pollution, environmental indicator, economic hardship index, and uninsured percent) obtained from the *America's Health Rankings* (AHR) published by the United Health Foundation (8). A p-value of $\leqslant 0.05$ was considered statistically significant, and analyses were conducted using SPSS 27.0 (IBM Corp., Armonk, NY, USA). From 2016 to 2020, the U.S. had an estimated median of 18,603 annual hospitalizations with a principal diagnosis of severe ILD (Figure 1). California topped the list with 1,562 cases, while Wyoming had the fewest, with 18. The national crude hospitalization rate was 5.5 per 100,000 individuals. Delaware had the highest rate of severe ILD hospitalizations at 7.9 per 100,000, followed by Pennsylvania (7.3), Michigan (7.2), and Massachusetts (6.9). In contrast, Utah (2.1), Hawaii (2.3), and Alaska (3.3) reported the lowest rates. Heat maps in Figure 2 illustrate ILD hospitalization rates,

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Correspondence:
Niranjan Jeganathan MD, MS, FCCP, ATSF
Department of Medicine, Division of Pulmonary, Critical Care, Hyperbaric, and Sleep Medicine
Loma Linda University Health, 11234 Anderson Street, Loma Linda, CA 92354
E-mail: njeganathan@llu.edu
ORCID : 0000-0001-5533-5105

State	Hospitalizations/ Year Median (IQR)	Hospitalization Rates (Per 100,000 Population) (95% CI)
United States	18603 (17725-18744)	5.5 (4.8-6.2)
Alaska	25 (22-26)	3.3 (1.7-4.8)
Arizona	342 (300-391)	4.7 (4.1-5.3)
Arkansas	187 (174-215)	6.8 (5.7-7.8)
California	1562 (1399-1781)	4.1 (3.2-5.1)
Colorado	226 (216-268)	4.0 (3.5-4.6)
Delaware	70 (63-81)	7.9 (7.3-8.4)
Florida	1403 (1252-1568)	6.6 (5.5-7.6)
Georgia	631 (591-643)	5.8 (4.7-7.0)
Hawaii	34 (28-39)	2.3 (1.9-2.7)
Illinois	699 (645-798)	6.2 (5.3-7.1)
Indiana	377 (338-396)	5.6 (5.2-6.0)
Iowa	145 (128-169)	4.9 (4.3-5.6)
Kansas	129 (109-138)	*4.3(3.5-5.1)
Kentucky	259 (230-287)	6.1 (5.7-6.4)
Louisiana	260 (259-264)	5.6 (5.3-5.8)
Maine	90 (73-106)	*6.7 (5.1-8.2)
Maryland	308 (296-328)	5.5 (5.3-5.6)
Massachusetts	483 (462-548)	6.9 (5.6-8.1)
Michigan	628 (616-776)	7.2 (5.9-8.4)
Minnesota	293 (283-324)	5.4 (4.8-5.9)
Mississippi	179 (177-181)	6.0 (5.8-6.2)
Missouri	368 (344-427)	*6.2 (5.2-7.3)

State	Hospitalizations/ Year Median (IQR)	Hospitalization Rates (Per 100,000 Population) (95% CI)
Montana	54 (53-80)	*6.0 (4.2-7.8)
Nebraska	59 (59-82)	4.0 (3.5-4.6)
Nevada	106 (99-136)	4.0 (3.6-4.3)
New Jersey	502 (478-588)	6.6 (5.5-7.6)
New Mexico	71 (51-93)	4.1 (3.2-5.0)
New York	1087 (1014-1314)	*5.9 (4.6-7.1)
North Carolina	608 (594-659)	5.9 (5.5-6.3)
North Dakota	34 (26-62)	4.8 (1.0-8.8)
Oklahoma	158 (148-169)	4.5 (3.9-5.0)
Oregon	151 (145-193)	4.0 (3.2-4.8)
Pennsylvania	965 (909-974)	7.3 (6.0-8.6)
Rhode Island	62 (38-63)	5.3 (5.0-5.7)
South Carolina	255 (244-297)	5.9 (5.1-6.7)
South Dakota	46 (37-50)	*4.9 (1.2-8.6)
Tennessee	381 (344-455)	5.8 (5.0-6.6)
Texas	1419 (1233-1568)	5.0 (4.2-5.8)
Utah	76 (61-81)	2.1 (1.8-2.3)
Vermont	28 (21-31)	*4.3 (3.2-5.4)
Washington	290 (270-342)	4.3 (3.9-4.6)
West Virginia	89 (77-89)	5.7 (5.4-6.0)
Wisconsin	294 (263-333)	5.2 (4.1-6.4)
Wyoming	18 (15-24)	4.9 (2.7-7.1)

Figure 1. Interstitial lung disease-related hospitalizations rates by U.S. States, 2016-2020

Abbreviations: IQR – interquartile range, CI – confidence interval. * Statistic is not reliable because the reporting cell draws from fewer than 2 hospitals, contains fewer than 11 discharges, has a relative standard error (standard error / weighted estimate) greater than 0.30 or equal to 0, or if the region is missing 2% or more of total discharges in the HCUP State Inpatient Database when compared to the Medicare Hospital Service Area File. Source: Community-Level Statistics (CLS) are from the Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), State Inpatient Databases (SID), based on data collected by individual States and provided to AHRQ by State Partners. Weighted national estimates are from the HCUP National (Nationwide) Inpatient Sample (NIS). All data are de-identified and publicly available, thus exempt from institutional review board approval Patients hospitalized for severe ILD were identified according to Medicare Severity Diagnosis-Related Groups (MS- DRG) codes 196, ILD with major complications and comorbidities (MCC). U.S.hospitals are reimbursed based on DRG codes, assigned at discharge based on the primary reason for hospitalization and associated complications or comorbidities. Hospitals have invested in clinical improvement programs to enhance documentation of complications and comorbidities. The primary factor in DRG assignment is the principal diagnosis, defined by the Centers for Medicare & Medicaid Services as "the condition established after study to be chiefly responsible for the admission." Even if another diagnosis is more severe, the principal diagnosis takes precedence. DRG assignment is typically automated, based on electronic health records and coding information.

average length of stay (LOS), average costs, and routine discharges from 2016 to 2020. Figure 2.a shows lower ILD hospitalization rates along the West Coast compared to the Eastern Seaboard. The mean LOS in the U.S. was 6.4 days (Figure 2.b), ranging from 5.2 to 7.6 days. New York had the longest average LOS at 7.6 days, followed by Washington and Oklahoma (7.0 days). In contrast, Vermont had the shortest LOS at 5.2 days, followed closely by Minnesota, Nebraska, and Maine. Figure 2.c highlights the average hospital cost per ILD-related stay by state, with a national average of $17,155. Alaska and California had the highest costs at $24,563 and $22,954, respectively, while Arkansas and Tennessee had the lowest. Figure 2.d shows routine discharge rates by state, ranging from 29.8% to 61.3%, with Massachusetts (29.8%) and Delaware (30.1%) having the lowest rates, and Montana (61.3%) and Nevada (60.0%) the highest. Overall, ILD-related hospitalization rates remained stable from 2016 to 2020 across most states, with some exceptions. Significant increases were noted in Maine (+11%, confidence interval [CI] 29-58,

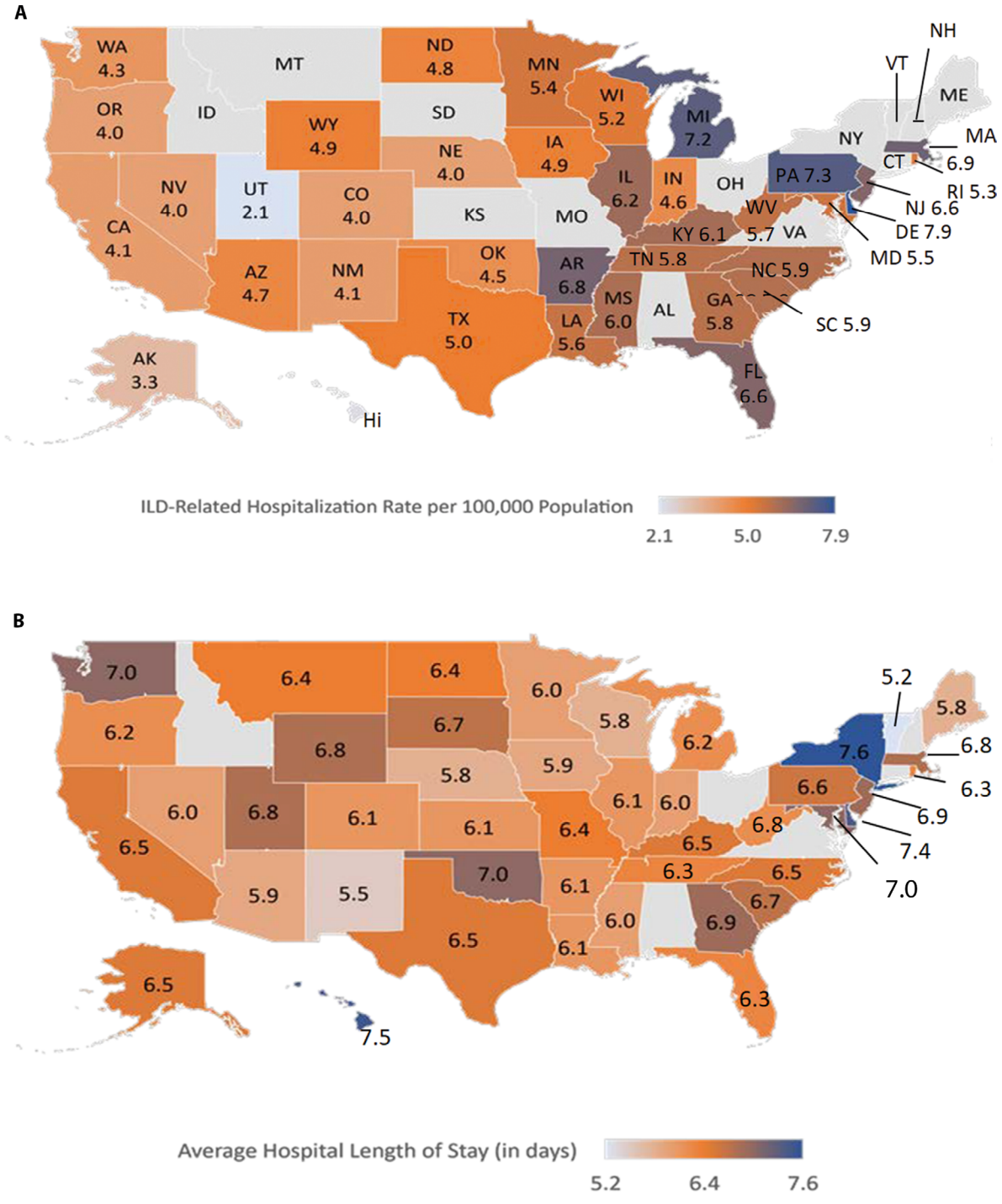

Figure 2. Average ILD hospitalization rates (per 100,000 persons) (a), hospital length of stay (b), hospital costs (c), and percent routine discharges (d) by states from 2016 to 2020. For states without a reported value, data were unavailable in the NIS database.

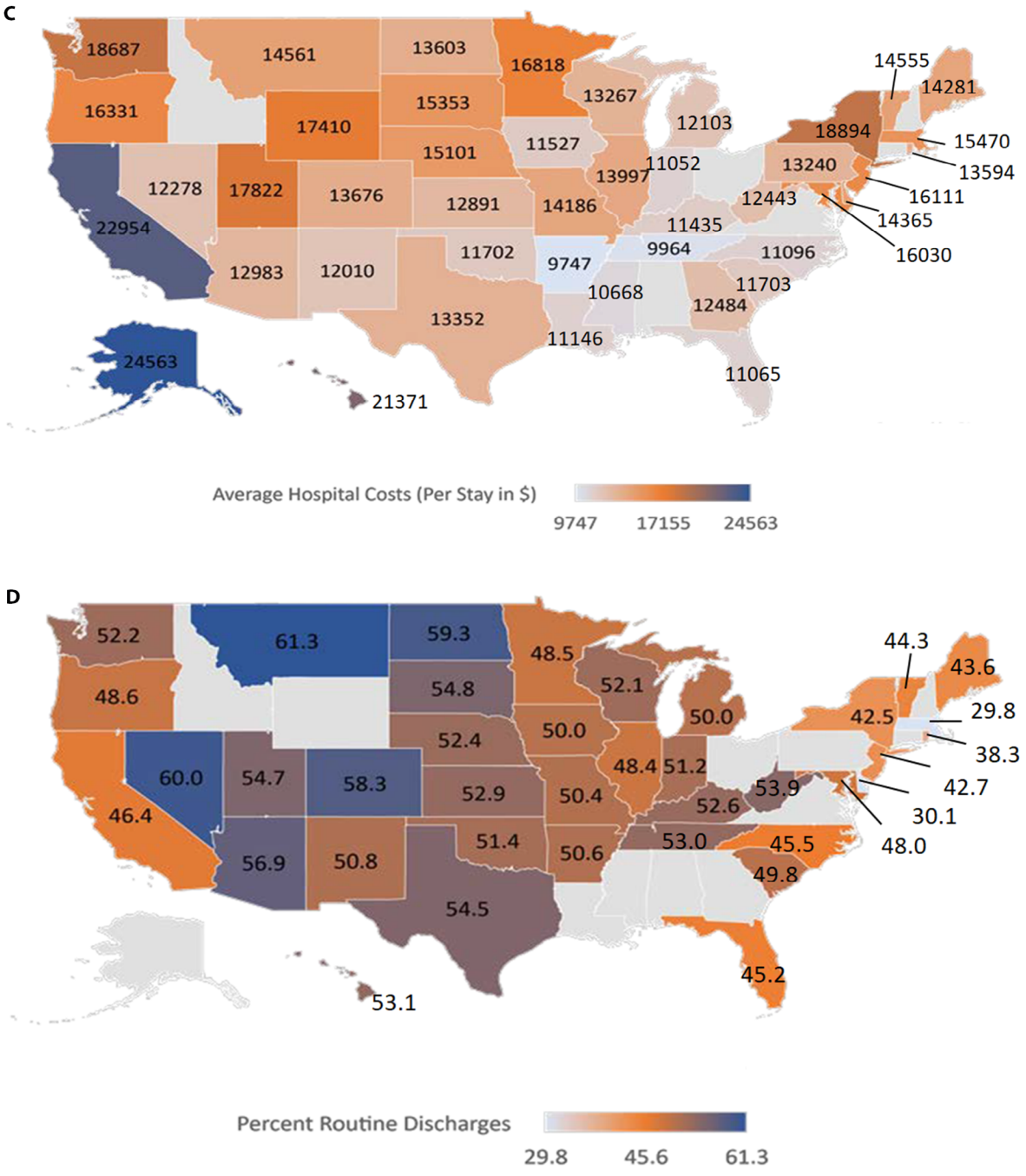

Figure 2. (*Continued*)

p = 0.007), North Dakota (+28%, CI 17-41, p < 0.001), and Nevada (+37%, CI 5-69, p = 0.02), while Illinois experienced a significant decrease (-15%, CI -6 to -24, p = 0.002).

This descriptive study provides a statewide comparison of severe ILD-related hospitalization rates, average LOS, costs, and routine discharges in the U.S. from 2016 to 2020. The median annual number of severe ILD-related hospitalizations in the U.S. was 18,603 with a crude hospitalization rate of 5.5 per 100,000 population, and only 45.6% resulted in routine discharge to home. Significant variations

in hospitalization rates and outcomes were evident across U.S. states, with the highest median hospitalizations observed in California, Florida, Texas, New York, and Pennsylvania, while the lowest were in Wyoming, North Dakota, Alaska, Vermont, and South Dakota. Delaware recorded the highest hospitalization rate, followed by Pennsylvania, Michigan, and Massachusetts (6.9-7.9 hospitalization per 100,000 persons), whereas Utah, Hawaii, and Alaska reported the lowest rates (2.1-3.3 hospitalizations per 100,000 persons). The mean ILD-related hospitalization rates across U.S. Census Bureau regions were as follows: Northeast (6.1, standard deviation [SD] 1.0), Midwest (5.3, SD 0.9), South (5.9, SD 0.8), and West (4.0, SD 1.1). Hospitalization rates in the West were significantly lower than those in the Midwest ($p = 0.01$), South ($p < 0.01$), and Northeast ($p = 0.06$), though no significant differences were found between the Midwest, South, and Northeast. These findings align with earlier reports of regional disparities in ILD prevalence (6).

We found a significant positive association between ILD prevalence and hospitalization rates, indicated by a Spearman's Rho correlation coefficient of 0.69 ($p < 0.001$). This suggests that demographic factors, environmental exposures, and healthcare access may influence hospitalization rates both directly and through their impact on ILD prevalence. Our analysis of state health variables from the AHR revealed significant correlations between hospitalization rates and several factors. Notably, we found correlations with smoking rates (0.36, $p = 0.02$), the risk screening environmental indicator score—an estimate of human health-related risks from exposure to over 600 toxic chemicals (0.38, $p = 0.01$), and state health rankings (0.32, $p = 0.03$). The latter indicates that states with lower health rankings experience higher ILD hospitalization rates. In contrast, no significant correlations were found with state air pollution levels, the economic hardship index (which reflects factors such as housing, dependency, education, income, poverty, and unemployment), or uninsured rates. Additionally, we found no correlation between hospitalization rates and the number of accredited Pulmonary Fibrosis Foundation centers, of which there were 68 during the study period (9). We calculated the number of centers per 100,000 population for each state and conducted a Spearman's correlation analysis. In our multivariate linear regression model, which included all significant variables, ILD prevalence emerged as the most significant predictor, explaining 54% of the variance in hospitalization rates ($R^2 = 0.540$, $p < 0.001$). Other variables did not show significant associations, further underscoring the importance of disease prevalence in influencing hospitalization rates. The average LOS for severe ILD-related hospitalizations was 6.4 days, compared to 5.5 days for the general ILD hospitalization (7). Routine discharge rates ranged from 29.8% to 60%, likely influenced by factors such as disease severity, care coordination, and available community resources. States with more advanced healthcare systems may experience shorter LOS due to efficient treatment and discharge processes. The average cost per ILD-related hospitalization was $17,155, ranging from $9,747 to $24,563. High costs in Alaska likely stem from the challenges of healthcare delivery in remote areas, while California's high costs may be attributed to its advanced medical centers and overall higher cost of living. Limitations of this study include missing data for some states, reliance on administrative datasets, and a focus solely on severe ILD hospitalizations Additionally, specific ILD subtypes, which may exhibit distinct hospitalization patterns, were not analyzed. Nonetheless, this approach allows for a focused evaluation of how institutions manage the most severe ILD patients, maintaining the specificity of the analysis and facilitating meaningful state comparisons. Although 2020 was impacted by COVID-19, our focus on hospitalizations with ILD as the principal diagnosis revealed consistent hospitalization rates in most states compared to prior years.

In conclusion, this study offers valuable insights into state-level ILD-related hospitalizations and outcomes in the U.S. from 2016 to 2020. Studying differences among states in ILD hospitalizations and outcomes provides valuable information for developing targeted interventions, allocating resources effectively, shaping public health policies, setting research priorities, and promoting health equity. Further research and collaboration are warranted to address the complex challenges posed by ILD and to enhance healthcare delivery for affected individuals.

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Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

References

1. Cottin V, Hirani NA, Hotchkin DL, et al. Presentation, diagnosis and clinical course of the spectrum of progressive-fibrosing interstitial lung diseases. Eur Respir Rev. 2018;27(150). doi: 10.1183/16000617.0076-2018.
2. Cottin V, Wollin L, Fischer A, Quaresma M, Stowasser S, Harari S. Fibrosing interstitial lung diseases: knowns and unknowns. Eur Respir Rev. 2019;28(151). doi: 10.1183/16000617.0100-2018.
3. Fan Y, Bender SD, Conoscenti CS, et al. Hospital-based resource use and costs among patients with idiopathic pulmonary fibrosis enrolled in the idiopathic pulmonary fibrosis prospective outcomes (IPF-PRO) registry. Chest. 2020;157(6):1522-1530. doi: 10.1016/j.chest.2019.12.041.
4. Frank AL, Kreuter M, Schwarzkopf L. Economic burden of incident interstitial lung disease (ILD) and the impact of comorbidity on costs of care. Respir Med. 2019;152:25-31. doi: 10.1016/j.rmed.2019.04.009.
5. Jeganathan N, Sathananthan M. The prevalence and burden of interstitial lung diseases in the USA. ERJ Open Res. 2022;8(1). doi: 10.1183/23120541.00630-2021.
6. Jeganathan N, Sathananthan M. Interstitial lung disease cases, prevalence rates and trends among states in the United States. Chest. 2023. doi: 10.1016/j.chest.2023.08.006.
7. Jeganathan N, Sathananthan M. Interstitial lung disease hospitalizations, outcomes, and costs in the United States from 2008 to 2018. Respir Med. 2024;221:107502. doi: 10.1016/j.rmed.2023.107502.
8. America's Health Rankings. Analysis of America's Health Rankings composite measure. United Health Foundation. Available from: https://www.americashealthrankings.org/. Accessed April 28, 2023.
9. Pulmonary Fibrosis Foundation. PFF Care Center Network. Available from: https://www.pulmonaryfibrosis.org/researchers-healthcare-providers/community-engagement/care-center-network. Accessed September 25, 2024.