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Burden of Pneumonia-Associated Hospitalizations:

United States, 2001-2014

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Abstract

BACKGROUND: The epidemiology of pneumonia has likely evolved in recent years, reflecting an aging population, changes in population immunity, and socioeconomic disparities.

METHODS: Using the National (Nationwide) Inpatient Sample, estimated numbers and rates of pneumonia-associated hospitalizations for 2001–2014 were calculated. A pneumonia-associated hospitalization was defined as one in which the discharge record listed a principal diagnosis of

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pneumonia or a secondary diagnosis of pneumonia if the principal diagnosis was respiratory failure or sepsis.

RESULTS: There were an estimated 20,361,181 (SE, 95,601) pneumonia-associated hospitalizations in the United States during 2001–2014 (average annual age-adjusted pneumonia-associated hospitalization rate of 464.8 per 100,000 population [95% CI, 462.5–467.1]). The average annual age-adjusted pneumonia-associated hospitalization rate decreased over the study period ($P < .0001$). In-hospital death occurred in 7.4% (SE, 0.03) of pneumonia-associated hospitalizations. Non-Hispanic American Indian/Alaskan Natives and non-Hispanic blacks had the highest average annual age-adjusted rates of pneumonia-associated hospitalization of all race/ethnicities at 439.2 (95% CI, 415.9–462.5) and 438.6 (95% CI, 432.5–444.7) per 100,000 population, respectively. During 2001–2014, the proportion of pneumonia-associated hospitalizations colisting an immunocompromising condition increased from 18.7% (SE, 0.2) in 2001 to 29.9% (SE, 0.2) in 2014. Total charges for pneumonia-associated hospitalizations in 2014 were over \$84 billion.

CONCLUSIONS: Pneumonia is a major cause of morbidity and mortality in the United States. Differences in rates and outcomes of pneumonia-associated hospitalizations between sociodemographic groups warrant further investigation. The immunocompromised population has emerged as a group experiencing a disproportionate burden of pneumonia-associated hospitalizations.

Keywords

epidemiology; pneumonia; respiratory failure; sepsis

Together, pneumonia and influenza rank as the eighth leading cause of death in the United States.¹ While a pathogen is not identified even after extensive diagnostic evaluation in the majority of cases, influenza virus is known to be an important contributor to pneumonia.^{2,3}

Factors such as an aging population, changes in population immunity (such as through vaccination and immunosuppressive comorbidities), and persisting socioeconomic disparities might be contributing to a shift in the national burden of pneumonia.^{4,5} While pneumonia disproportionately affects older adults, the mortality rate from pneumonia among older adults is declining.^{6–9} Among children, the very young face the greatest burden of pneumonia, though the introduction of the pneumococcal vaccine (eg, the 7-valent pneumococcal conjugate vaccine [PCV7] in 2000) has had an impact.^{10–12} People who are immunocompromised are at increased risk of pneumonia, but the national burden of pneumonia-associated hospitalizations among the immunocompromised has not been fully characterized.^{13–18} Finally, disparities have been noted in pneumonia death rates by race/ethnicity.¹⁹

To characterize the national burden of pneumonia after the introduction of PCV7, we analyzed hospital discharge data for pneumonia during 2001–2014.

Materials and Methods

Data Source

We used the National (Nationwide) Inpatient Sample (NIS) to retrospectively analyze hospital discharge data with a diagnosis of pneumonia for the general US population during 2001–2014.²⁰ The NIS is a nationally representative database of hospitalizations and is the largest all-payer inpatient database in the United States. The full NIS includes > 7 million unweighted hospitalizations per year. For each discharge record in the NIS, we pulled up to 15 diagnoses (principal diagnosis plus 14 secondary diagnoses) that were coded on the basis of the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM).

Study Approval

Use of the NIS specifically prohibits identification of individual patients. This investigation was determined by the Centers for Disease Control and Prevention and the New York City Department of Health and Mental Hygiene to be nonhuman subject research.

Definitions

We defined a pneumonia-associated hospitalization as a hospitalization with a principal diagnosis of pneumonia (ICD-9-CM code 480–486, 487.0, 488.01, 488.11, or 488.81), or a secondary diagnosis of pneumonia if the principal diagnosis was respiratory failure (ICD-9-CM code 518.81, 518.82, 518.84, or 799.1) or sepsis (ICD-9-CM code 038, 785.52, 995.91, or 995.92).⁷ Of note, ICD-9-CM codes 487.0, 488.01, 488.11, and 488.81 relate to “influenza with pneumonia”; we did not include other “influenza” ICD-9-CM codes within the 487 and 488 categories because they did not specify an associated “pneumonia.” Together, these four ICD-9-CM codes accounted for 1.1% (SE, 0.01) of all pneumonia-associated hospitalizations during the study period.

A pneumonia episode was considered to be of unspecified etiology if the discharge record contained a principal diagnosis of “bronchopneumonia, organism unspecified” or “pneumonia, organism unspecified” (ICD-9-CM codes 485 and 486, respectively); all other pneumonia-associated hospitalizations that listed a pneumonia diagnostic code as the principal diagnosis other than ICD-9-CM codes 485 or 486 were considered to have a specified etiology.

Pneumonia-associated hospitalizations of persons who were immunocompromised were identified if an ICD-9-CM code for an immunocompromising condition was colisted on the discharge record²¹ (e-Table 1).

Data Analysis

Estimates and standard errors of the number of pneumonia-associated hospitalizations were calculated from the NIS, using the Healthcare Cost and Utilization Project weighting methodology.^{20,22,23} The unit of analysis was a hospitalization; NIS data do not have person identifiers, and therefore any repeat pneumonia-associated hospitalizations of the same patient were included.

Average annual and annual hospitalization rates with 95% CIs were expressed as the weighted number of hospitalizations per 100,000 persons of the corresponding population. Age-adjusted rates with 95% CIs were calculated by the direct method, with the 2000 projected US population as the standard; crude weights were calculated for specific age groups and income quartiles. Denominators were taken from the National Center for Health Statistics annual bridged race population estimates for the study period.²⁴ We used Poisson regression to calculate rate ratios and 95% CIs, and test for trends over time. A *P* value < .05 was considered statistically significant.

Pneumonia-associated hospitalization records were examined by sex, age, race/ethnicity, region, ZIP code income quartile, month of admission, in-hospital death, colisting of immunocompromising conditions, and charges (in 2014 US dollars). Hospital charges reflected the amount that the medical facility billed for the hospitalization, but did not include professional (physician) fees. Income quartiles by ZIP code are consistent for the years 2003–2014 and were used in this study. To examine trends, we compared average annual rates for 2001–2003 to 2012–2014. Some discharge records had missing information on sex (0.1% [SE, < 0.01]), age (0.03% [SE, < 0.01]), race/ethnicity (19.0% [SE, 0.4]), and charges (1.7% [SE, 0.1]); adjustments were not made for missing data.

All analyses were generated with SAS, version 9.3. Weighted estimates and corresponding SEs were calculated with SUDAAN to account for the NIS sampling design.

Results

During 2001–2014, there were 463,384,760 (SE, 2,162,304) hospitalizations in the United States, including 20,361,181 (SE, 95,601) pneumonia-associated hospitalizations (4.4% [SE, 0.01]) (Table 1). This corresponds to an average of 1,454,370 (SE, 6,829) pneumonia-associated hospitalizations per year or an average annual age-adjusted pneumonia-associated hospitalization rate of 464.8 per 100,000 population (95% CI, 462.5–467.1). During 2001–2014, the annual age-adjusted rate of pneumonia-associated hospitalizations decreased (*P* < .0001) (Fig 1).

The majority of pneumonia-associated hospitalizations listed a pneumonia principal diagnosis (76.8% [SE, 0.1] of pneumonia-associated hospitalizations), corresponding to an average annual age-adjusted hospitalization rate of 358.3 per 100,000 population (95% CI, 356.4–360.1) (Table 2). The remaining pneumonia-associated hospitalizations listed a respiratory failure or sepsis principal diagnosis, corresponding to an average annual age-adjusted hospitalization rate of 106.6 per 100,000 population (95% CI, 105.8–107.3). The rate of pneumonia-associated hospitalizations with a pneumonia principal diagnosis decreased over the study period (*P* < .0001) while the rate for those with a respiratory failure or sepsis principal diagnosis increased (*P* < .0001) (Fig 1).

The majority of pneumonia-associated hospitalizations with a pneumonia principal diagnosis were of unspecified pneumonia etiology (Table 2). The most common specified etiology among pneumonia-associated hospitalizations listing a pneumonia principal diagnosis was

nonpneumococcal bacteria (ICD-9-CM code 482), accounting for 7.6% (SE, 0.1) of overall pneumonia-associated hospitalizations.

In-Hospital Death

In-hospital death occurred in 7.4% (SE, 0.03) of pneumonia-associated hospitalizations (Table 1). From 2001–2003 to 2012–2014, there was no significant change in the proportion of pneumonia-associated hospitalizations with in-hospital death. In-hospital death occurred in 3.9% (SE, 0.02) of pneumonia-associated hospitalizations listing a pneumonia principal diagnosis, vs 19.0% (SE, 0.1) of pneumonia-associated hospitalizations listing a respiratory failure or sepsis principal diagnosis.

Hospitalizations by Sex, Age Group, Race/ Ethnicity, Region, and Income Quartile

Male subjects had a higher average annual age-adjusted rate of pneumonia-associated hospitalization than female subjects (Table 1). Average annual age-adjusted rates of hospitalization decreased for both male and female subjects from 2001–2003 to 2012–2014 (Table 3).

The average annual rate of pneumonia-associated hospitalization was highest in those aged < 1 year and those aged ≥ 65 years (Table 1). The proportion of pneumonia-associated hospitalizations with in-hospital death was highest among people aged ≥ 65 years. The rate of pneumonia-associated hospitalizations decreased from 2001–2003 to 2012–2014 for all age groups except for the 20- to 44-year and 45- to 64-year age groups (Table 3).

Non-Hispanic American Indian/Alaskan Natives and non-Hispanic blacks had the highest average annual age-adjusted rates of pneumonia-associated hospitalization of all race/ethnicities; non-Hispanic Asian/Pacific Islanders had the lowest average annual age-adjusted rate (Table 1). The proportion of pneumonia-associated hospitalizations with in-hospital death was highest among non-Hispanic Asian/Pacific Islanders, whereas it was lowest among non-Hispanic American Indian/Alaskan Natives and Hispanics. Both non-Hispanic Asian/Pacific Islanders and Hispanics saw a decrease in the average annual age-adjusted rate of pneumonia-associated hospitalizations from 2001–2003 to 2012–2014; the average annual age-adjusted rate of pneumonia-associated hospitalization increased among non-Hispanic whites and non-Hispanic blacks (Table 3).

The South had the highest rate of pneumonia-associated hospitalizations of all regions, though in-hospital death occurred more often in the Northeast (Table 1). All regions experienced a decrease in the rate of pneumonia-associated hospitalizations from 2001–2003 to 2012–2014 (Table 3).

The average annual rate of pneumonia-associated hospitalization decreased as income quartile increased (Table 1). The proportion of pneumonia-associated hospitalizations with in-hospital death increased with increasing income quartile. The mean age at in-hospital death was lowest in the lowest income quartile (73.1 years [95% CI, 72.9–73.2]) and highest (76.4 years [95% CI, 76.2–76.6]) in the highest income quartile.

Hospitalizations by Immune Status

During 2001–2014, the proportion of pneumonia-associated hospitalizations colisting an immunocompromising condition increased from 18.7% (SE, 0.2) in 2001 to 29.9% (SE, 0.2) in 2014 (Fig 2, and e-Figs 1–3). In-hospital death occurred in 10.9% (SE, 0.1) of pneumonia-associated hospitalizations colisting an immunocompromising condition compared with 6.3% (SE, 0.03) among those not colisting an immunocompromising condition ($P < .0001$).

Seasonality

Age-adjusted pneumonia-associated hospitalization rates were highest from December through March (Fig 3A). The proportion of pneumonia-associated hospitalizations with in-hospital death was highest for those with an admission month of July (8.2% [SE, 0.1]) and lowest in March (7.1% [SE, 0.1]), April (7.1% [SE, 0.1]), and May (7.1% [SE, 0.1]) (Fig 3B).

Charges

Total charges for pneumonia-associated hospitalizations in 2014 were \$84,392,702,156 (SE, 1,285,930,398).

Discussion

This study underscores the large burden of pneumonia-associated hospitalizations in the United States, particularly among infants, older adults, those of lower socioeconomic status, certain race/ethnicities, and the immunocompromised. On average, approximately 1.5 million pneumonia-associated hospitalizations occurred per year, resulting in over \$84 billion in charges in 2014.

We focused on a period after the introduction of PCV7, and observed that the average annual age-adjusted rate of pneumonia-associated hospitalizations and the proportion with in-hospital death decreased during the study period. This downward trend, largely driven by a downward trend in pneumonia principal diagnoses, may be related to several factors, including PCV7 introduction, changes in coding practices, and changes in health-care delivery, among others. While these trends are reassuring, the rate of pneumonia-associated hospitalizations that involved a principal diagnosis of respiratory failure or sepsis tripled from 2001–2003 to 2012–2014. This is consistent with previously reported data, and likely reflects a coding bias.⁷

Consistent with previous studies, infants and adults aged ≥ 65 years experienced higher average annual rates of pneumonia-associated hospitalization than other age groups.^{6,12} Pneumococcal and influenza vaccination are a primary means of pneumonia prevention among these age groups, but the proportion of the population vaccinated for these conditions remains below target levels.^{25,26} Meanwhile, average annual rates of pneumonia-associated hospitalization decreased during the study period for all age groups except persons aged 20–44 and 45–64 years. The reasons for the rise in pneumonia-associated hospitalization rate among these particular age groups are unclear.

Also consistent with previous studies, male subjects experienced higher average annual age-adjusted pneumonia-associated hospitalization rates than female subjects.²⁷ Several lifestyle, behavioral, and socioeconomic factors may play a role in this difference.²⁸ Male subjects also had a higher percentage of pneumonia-associated hospitalizations with in-hospital death than female subjects. Previous research has shown that differences in mortality persist even after adjusting for behavior and comorbidities, and sex-specific immune responses might play a role.²⁹

Although inroads have been made in quantifying and elucidating the cause of racial and ethnic health disparities in pneumonia, our data show that differences persist.^{30,31} Consistent with previous reports, non-Hispanic blacks had among the highest rates of pneumonia-associated hospitalization among all race/ethnicity groups—perhaps due to a higher prevalence of underlying pneumonia risk factors such as smoking and certain chronic conditions.^{31–34} Furthermore, we found that non-Hispanic American Indian/Alaskan Natives had a high rate of pneumonia-associated hospitalizations compared with other race/ethnicities.

These data are consistent with other studies that have examined health disparities among non-Hispanic American Indian/Alaskan Natives.^{35,36} Though non-Hispanic whites did not have as high a rate of pneumonia-associated hospitalizations compared with other race/ethnicities, the apparent increase in age-adjusted hospitalization rates over time among this demographic and among non-Hispanic blacks is concerning. Differences by race/ethnicity in the proportion of pneumonia-associated hospitalizations with in-hospital death (eg, 6.2% in Hispanics vs 9.6% in non-Hispanic Asian/Pacific Islanders) were also identified.

The association between income quartile and pneumonia-associated hospitalization rates that we found is consistent with data from other investigations.³³ Lower income is associated with multiple pneumonia risk factors such as smoking, worse access to health care, and lower pneumococcal and influenza vaccination rates.^{25,34,37} There are likely additional effects of race/ethnicity and income; however, without population denominators of the distribution of race/ethnicity within each of the US income quartiles, we were unable to create rates to describe this relationship. Paradoxically, the proportion of pneumonia-associated hospitalizations with in-hospital death increased with income quartile. We suspect that this might be an artifact of age, given that mean age at in-hospital death also increased with income quartile.

The proportion of pneumonia-associated hospitalizations listing an ICD-9-CM code for an immunocompromising condition almost doubled from 2001 to 2014. Part of our findings may be explained by persons with immunocompromising conditions living longer.^{38,39} While the data we present highlight the importance of monitoring pneumonia among immunocompromised individuals, caution should be taken in their interpretation for multiple reasons. First, it is possible that our data related to immune status are subject to some unrecognized bias, as the codes we used have not been validated through chart review. Furthermore, the median number of secondary diagnoses listed on the discharge record for any hospitalization (not just pneumonia-associated hospitalizations) almost doubled from 3.8 (SE, 0.03) during 2001–2003 to 7.5 (SE, 0.02) during 2012–2014 ($P < .05$). Thus, there

is likely a bias over time to list secondary diagnoses on the discharge record, and this might explain why the proportion of pneumonia-associated hospitalizations colisting an immunocompromising condition increased during the study period. Second, some of the ICD-9-CM codes we used to identify immunocompromising conditions include a wide spectrum of severity in which the early stages of disease might not greatly impair the immune system, thus potentially overestimating the proportion of pneumonia-associated hospitalizations involving immunocompromised people. Third, chronic kidney disease, a condition that can suppress the immune system, was purposely excluded from our analysis because additional subdiagnoses were added to the ICD-9-CM code for this condition in 2005.⁴⁰ When we tested the impact of including this ICD-9-CM code in our analysis, we observed a dramatic inflation in the proportion of pneumonia-associated hospitalizations colisting an immunocompromising condition starting in 2005 (e-Fig 4). Fourth, our data do not capture outpatient treatment of pneumonia, and pneumonia in an immunocompetent person is more likely to be treated in the outpatient setting⁴¹.

Understanding the etiology of pneumonia can help with targeting specific therapies for individual patients and with focusing public health interventions, but we found that > 60% of pneumonia-associated hospitalizations with a pneumonia principal diagnosis had no specified etiology. This is consistent with data from previous studies showing that a pneumonia etiology is often not identified even after extensive investigation.^{2,3}

While hospital discharge data are useful for estimating trends in pneumonia-associated hospitalizations, there are limitations. The data presented reflect hospitalizations, not patients, and a single patient may be hospitalized more than once. As a sizeable proportion of patients with pneumonia are treated in the outpatient setting, our study estimates the more severe cases. We may have incorrectly estimated disease burden, due to use of nonspecific ICD-9-CM codes that included nonpneumonia illnesses and because we do not know the accuracy of the diagnoses listed on the discharge record. As administrative data can be affected by external factors such as reimbursement policies, the selection and distribution of principal and secondary diagnostic codes could be biased.⁴² However, to overcome a well-documented selection bias in coding for pneumonia, we chose to define “pneumonia-associated hospitalizations” as discharge records in which there was either a pneumonia principal diagnosis or a pneumonia secondary diagnosis in combination with a principal diagnosis of respiratory failure or sepsis.⁷

In conclusion, pneumonia causes significant morbidity and mortality in the United States. Populations such as the very young and older persons have historically faced the greatest risk, which is still the case today. Persons who are immunocompromised have emerged as a group representing an increasing proportion of pneumonia-associated hospitalizations. Understanding the burden of pneumonia-associated hospitalizations can potentially inform clinical treatment and public health interventions, and should continue to be monitored.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS:

ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
NIS	National (Nationwide) Inpatient Sample
PCV7	7-valent pneumococcal conjugate vaccine

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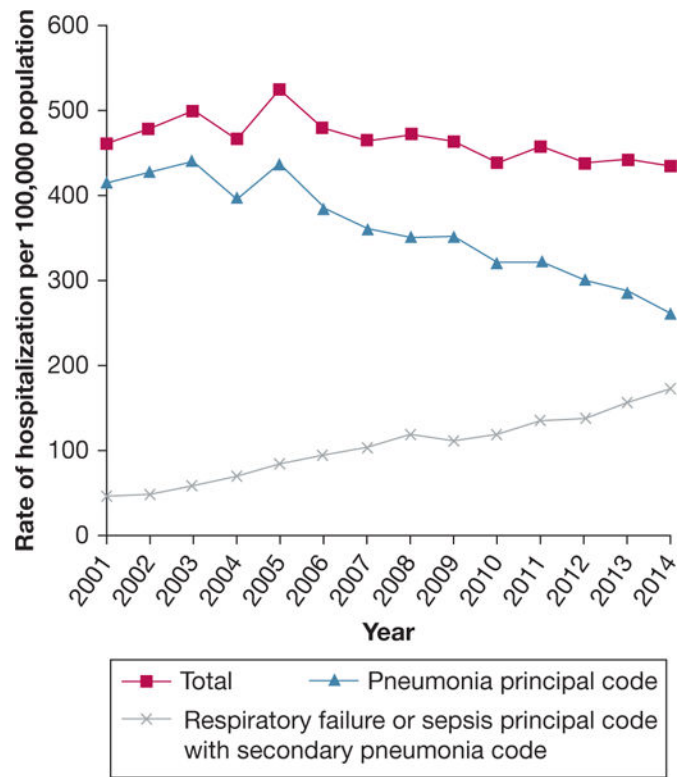


Figure 1- Annual age-adjusted rates of pneumonia-associated hospitalizations: United States, 2001–2014.

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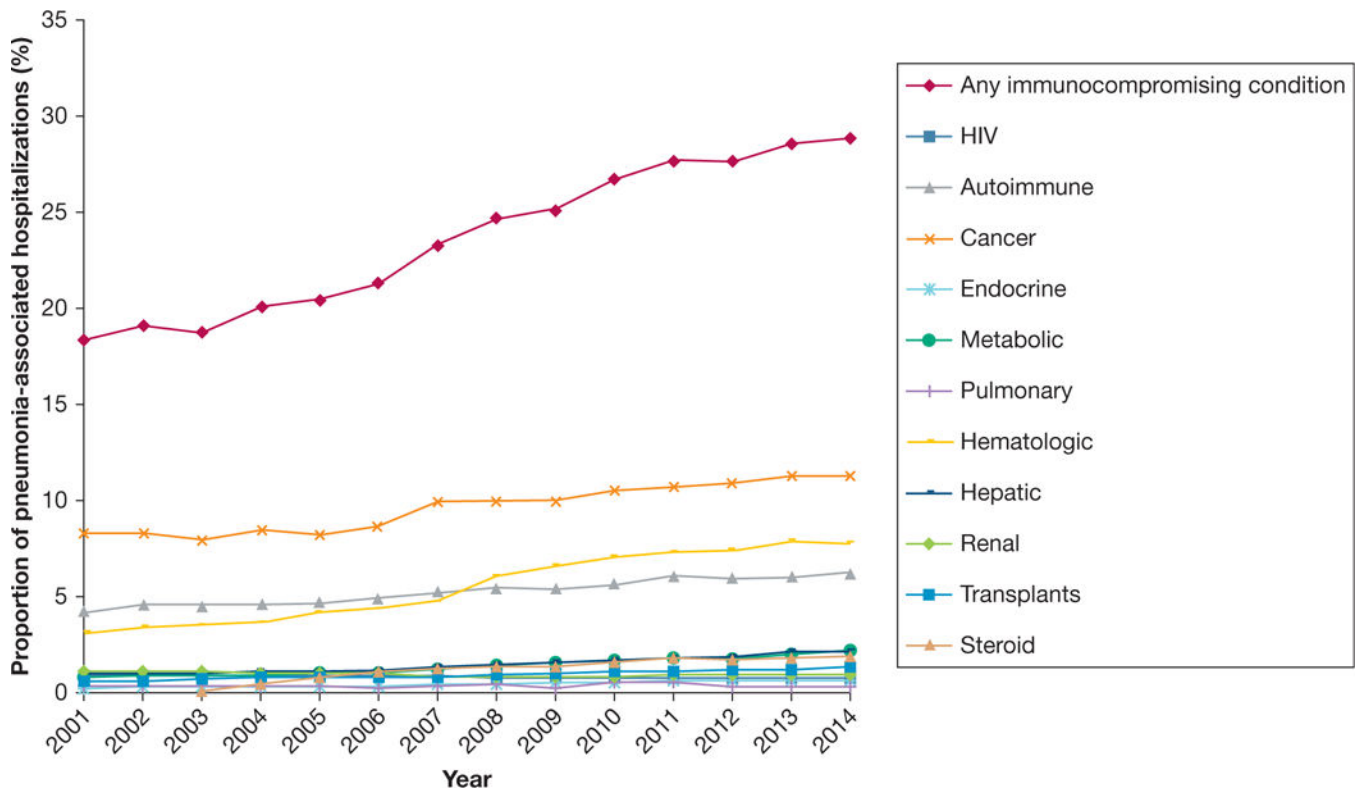


Figure 2- Proportion of pneumonia-associated hospitalizations colisting an immunocompromising condition: United States, 2001–2014.

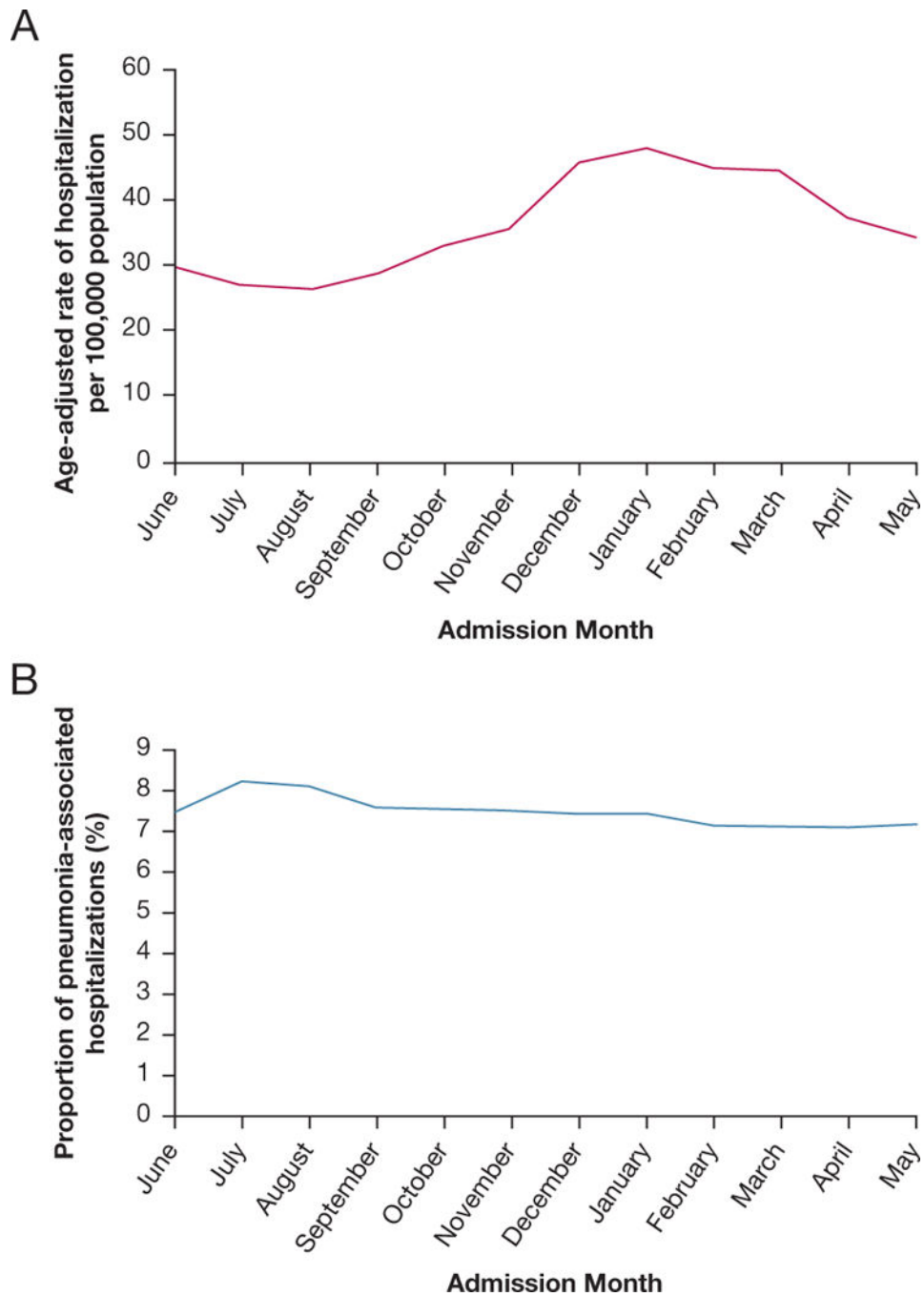


Figure 3-
 A, Age-adjusted rate of pneumonia-associated hospitalizations by month of admission: United States, 2001–2014. B, Proportion of pneumonia-associated hospitalizations with in-hospital death by month of admission: United States, 2001–2014

Pneumonia-Associated Hospitalizations by Sex, Age Group, Race/Ethnicity, Region, and Income: United States, 2001–2014

TABLE 1 J

Characteristics	No. of Pneumonia-Associated Hospitalizations (SE)	Average Annual Age-Adjusted Pneumonia-Associated Hospitalization Rate per 100,000 Population (95% CI) ^a	Rate Ratio (95% CI)	Percentage of Pneumonia-Associated Hospitalizations With in-Hospital Death (SE)	Total No. of Hospitalizations for Any Cause (SE)	Percentage of Total Hospitalizations for Any Cause That Were Pneumonia-Associated (SE)
Total	20,361,181 (95,601)	464.8 (462.5–467.1)	NA	7.4 (0.03)	463,384,760 (2,162,304)	4.4 (0.01)
Sex						
Male	9,790,653 (46,203)	512.5 (510.0–515.1)	1.2 (1.2–1.2)	7.8 (0.03)	186,938,629 (928,295)	5.2 (0.02)
Female	10,550,300 (50,676)	432.1 (430.0–434.3)	Reference	7.1 (0.03)	275,523,617 (1,316,296)	3.8 (0.01)
Age group, y						
<1	488,712 (8,186)	872.6 (844.0–901.3)	11.1 (10.6–11.6)	0.3 (0.02)	7,680,876 (167,980)	6.4 (0.1)
1–4	933,630 (14,699)	419.4 (406.4–432.3)	5.3 (5.1–5.6)	0.2 (0.01)	6,939,908 (152,249)	13.5 (0.2)
5–19	688,216 (11,541)	78.8 (76.2–81.4)	Reference	0.7 (0.03)	22,736,621 (290,644)	3.0 (0.03)
20–44	1,716,761 (10,764)	117.4 (116.0–118.9)	1.5 (1.4–1.5)	2.9 (0.03)	125,349,016 (768,145)	1.4 (0.01)
45–64	4,623,712 (24,591)	432.3 (427.8–436.8)	5.5 (5.3–5.7)	5.9 (0.03)	120,942,503 (655,416)	3.8 (0.01)
65–74	3,720,715 (19,383)	1,268.0 (1,255.0–1,280.9)	16.1 (15.5–16.6)	7.9 (0.04)	69,136,959 (373,526)	5.4 (0.02)
75–84	4,702,338 (25,625)	2,566.3 (2,538.9–2,593.7)	32.6 (31.4–33.7)	9.7 (0.04)	70,337,015 (403,148)	6.7 (0.02)
85	3,477,158 (19,590)	4,820.6 (4,767.4–4,873.8)	61.2 (59.0–63.3)	12.4 (0.1)	39,861,257 (234,155)	8.7 (0.03)
Race/ethnicity						
Non-Hispanic white	12,085,487 (92,577)	362.3 (359.7–364.8)	1.6 (1.5–1.7)	7.9 (0.03)	256,399,001 (2,119,606)	4.7 (0.02)
Non-Hispanic black	1,999,268 (30,548)	438.6 (432.5–444.7)	1.9 (1.8–2.1)	7.1 (0.1)	53,689,041 (815,539)	3.7 (0.02)
Hispanic	1,515,369 (32,123)	370.6 (362.8–378.5)	1.6 (1.5–1.8)	6.2 (0.1)	43,277,116 (855,647)	3.5 (0.03)
Non-Hispanic AI/AN	114,426 (6,081)	439.2 (415.9–462.5)	1.9 (1.6–2.2)	5.8 (0.2)	2,233,117 (114,545)	5.1 (0.1)
Non-Hispanic A/PI	360,096 (10,393)	230.1 (222.5–237.8)	Reference	9.6 (0.2)	8,862,428 (218,170)	4.1 (0.1)
Non-Hispanic other	415,654 (12,880)	NA	NA	7.4 (0.1)	11,647,646 (341,393)	3.6 (0.1)
Region						
Northeast	3,608,110 (40,867)	423.7 (418.7–428.6)	1.1 (1.1–1.2)	8.9 (0.1)	91,272,669 (1,011,020)	4.0 (0.03)
Midwest	4,903,744 (43,160)	495.5 (490.9–500.2)	1.3 (1.2–1.3)	6.3 (0.1)	106,770,549 (927,325)	4.6 (0.03)
South	8,188,107 (65,995)	515.7 (511.5–519.9)	1.3 (1.3–1.4)	7.2 (0.04)	178,179,742 (1,480,548)	4.6 (0.03)
West	3,661,220 (35,375)	384.6 (380.4–388.8)	Reference	8.0 (0.1)	87,161,800 (775,528)	4.2 (0.03)

Characteristics	No. of Pneumonia-Associated Hospitalizations (SE)	Average Annual Age-Adjusted Pneumonia-Associated Hospitalization Rate per 100,000 Population (95% CI) ^a	Rate Ratio (95% CI)	Percentage of Pneumonia-Associated Hospitalizations With in-Hospital Death (SE)	Total No. of Hospitalizations for Any Cause (SE)	Percentage of Total Hospitalizations for Any Cause That Were Pneumonia-Associated (SE)
Income quartile ^b						
0–25th percentile	5,574,810 (52,859)	609.4 (598.0–620.7)	1.8 (1.7–1.9)	7.0 (0.04)	113,831,029 (1,142,892)	4.9 (0.03)
26–50th percentile	4,743,812 (43,929)	518.5 (509.1–527.9)	1.5 (1.5–1.6)	7.2 (0.04)	101,491,744 (870,978)	4.7 (0.02)
51–75th percentile	3,877,074 (39,034)	423.8 (415.4–432.2)	1.3 (1.2–1.3)	7.5 (0.1)	91,975,009 (840,911)	4.2 (0.02)
76–100th percentile	3,082,668 (48,339)	337.0 (326.6–347.3)	Reference	8.3 (0.1)	81,649,261 (1,292,464)	3.8 (0.02)

AI/AN = American Indian or Alaskan Native; A/Pi = Asian or Pacific Islander; NA = not applicable.

^a Age and income quartile rates are not age-adjusted.

^b Income quartile includes only data during 2003–2014.

Pneumonia-Associated Hospitalizations by Discharge ICD-9-CM Category: United States, 2001–2014

TABLE 2]

Disease Category (ICD-9-CM Code)	No. (SE)	Percent (SE) ^a
Pneumonia principal code	15,638,813 (75,243)	76.8 (0.1)
Noninfluenza viral pneumonia (480)	334,129 (4,863)	1.6 (0.02)
Pneumococcal pneumonia (481)	335,198 (2,860)	1.7 (0.01)
Nonpneumococcal bacterial pneumonia (482)	1,539,852 (13,006)	7.6 (0.1)
Pneumonia due to other specified organism (483)	106,553 (3,217)	0.5 (0.02)
Pneumonia in infectious diseases classified elsewhere (484)	279 (38)	<0.01
Bronchopneumonia, organism unspecified (485)	222,553 (4,267)	1.1 (0.02)
Pneumonia, organism unspecified (486)	12,876,224 (64,035)	63.2 (0.1)
Influenza virus (487.0, 488.01, 488.11, or 488.81)	224,026 (2,602)	1.1 (0.01)
Respiratory failure or sepsis principal code with secondary pneumonia code	4,722,369 (32,528)	23.2 (0.1)
Respiratory failure (518.81, 518.82, 518.84, 799.1)	1,510,290 (13,044)	7.4 (0.1)
Sepsis (038, 785.52, 995.91, 995.92)	3,212,078 (24,030)	15.8 (0.1)
Total	20,361,181 (95,601)	100

ICD-9-CM = *International Classification of Diseases, 9th Revision, Clinical Modification*; NA = not applicable.^aPercentage of pneumonia-associated hospitalizations.

TABLE 3 |
Trend Analysis for Pneumonia-Associated Hospitalizations: United States, 2001–2014

Characteristics	2001–2003 Average Annual Age-Adjusted Hospitalization Rate per 100,000	2012–2014 Average Annual Age-Adjusted Hospitalization Rate per 100,000 Population (95% CI) ^d	Rate Ratio (95% CI) ^b
Total	480.1 (475.0–485.2)	438.5 (435.8–441.1)	0.9 (0.9 to 0.9)
Sex			
Male	540.9 (534.9–546.9)	477.3 (474.2–480.3)	0.9 (0.9 to 0.9)
Female	441.5 (436.6–446.3)	411.2 (408.6–413.9)	0.9 (0.9 to < 1.0)
Age, y			
< 1	1,095.1 (1,019.4–1,170.9)	567.6 (542.7–592.5)	0.5 (0.5 to 0.6)
1–4	470.9 (441.3–500.5)	314.5 (300.2–328.9)	0.7 (0.6 to 0.7)
5–19	80.7 (75.0–86.3)	68.8 (65.5–72.1)	0.9 (0.8 to 0.9)
20–44	113.5 (110.6–116.5)	119.1 (117.5–120.8)	1.0 (> 1.0 to 1.1)
45–64	392.8 (383.9–401.7)	463.1 (457.4–468.8)	1.2 (1.1 to 1.2)
65–74	1,308.3 (1,278.9–1,337.7)	1,187.1 (1,171.8–1,202.4)	0.9 (0.9 to 0.9)
75–84	2,697.7 (2,635.3–2,760.2)	2,381.6 (2,351.7–2,411.5)	0.9 (0.9 to 0.9)
85	5,502.8 (5,368.2–5,637.4)	4,304.8 (4,247.9–4,361.7)	0.8 (0.8 to 0.8)
Race/Ethnicity			
Non-Hispanic white	320.6 (314.9–326.2)	412.1 (409.0–415.1)	1.3 (1.2 to 1.4)
Non-Hispanic black	413.4 (397.9–429.0)	479.7 (472.9–486.4)	1.2 (> 1.0 to 1.3)
Hispanic	412.1 (389.3–434.9)	346.2 (338.4–353.9)	0.8 (0.7 to < 1.0)
Non-Hispanic AI/AN	188.4 (156.3–220.6)	480.3 (451.7–509.0)	2.6 ^c
Non-Hispanic A/PI	268.4 (242.9–293.9)	218.2 (210.6–225.8)	0.8 (0.6 to < 1.0)
Non-Hispanic other	NA ^d	NA ^d	NA ^d
Region			
Northeast	433.6 (421.8–445.4)	398.2 (392.8–403.7)	0.9 (0.9 to < 1.0)
Midwest	502.0 (491.6–512.4)	465.5 (460.2–470.7)	0.9 (0.9 to < 1.0)
South	540.4 (531.4–549.4)	487.3 (482.5–492.2)	0.9 (0.9 to < 1.0)
West	399.9 (389.8–409.9)	363.9 (359.0–368.9)	0.9 (0.8 to < 1.0)
Income quartile ^e			

Characteristics	2001–2003 Average Annual Age-Adjusted Hospitalization Rate per 100,000		2012–2014 Average Annual Age-Adjusted Hospitalization Rate per 100,000 Population (95% CI) ^d		Rate Ratio (95% CI) ^b
	Population (95% CI) ^d	Rate per 100,000	Rate per 100,000 Population (95% CI) ^d	Rate Ratio (95% CI) ^b	
0–25th percentile	617.0 (591.2–642.8)		610.1 (597.0–623.2)		1.0 (0.9 to 1.0)
25–50th percentile	542.7 (520.5–564.8)		514.7 (504.8–524.5)		0.9 (0.9 to < 1.0)
50–75th percentile	434.1 (415.8–452.5)		414.8 (406.5–423.1)		1.0 (0.9 to 1.0)
75–100th percentile	355.4 (331.8–379.0)		321.7 (311.9–331.4)		0.9 (0.8 to < 1.0)
Pneumonia principal code	428.4 (423.9–433.0)		282.8 (281.0–284.6)		0.7 (0.6 to 0.7)
Respiratory failure or sepsis principal code with secondary pneumonia code	511.6 (50.7–52.6)		155.7 (154.4–156.9)		3.0 (2.9 to 3.2)

AI/AN = American Indian or Alaskan Native; A/PI = Asian or Pacific Islander; NA = not applicable.

^aAge and income quartile rates are not age-adjusted.

^bRate ratio with 95% CI, using 2001–2000 as reference group.

^cUnreliable estimate: the relative standard error is too high.

^dNo rate calculated as there is no corresponding census denominator.

^eIncome quartile includes only data during 2003–2014. Therefore, the comparison years are 2003–2005 and 2012–2014.