Utilization Trends and Predictors of Non-invasive and Invasive Ventilation During Hospitalization Due to Community-Acquired Pneumonia

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Abstract

Background: Community-acquired pneumonia (CAP) is associated with significant morbidity and mortality. Non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV) are most important interventions for patients with severe CAP associated with respiratory failure. We analysed utilisation trends and predictors of non-invasive and invasive ventilation in patients hospitalized with CAP.

Methods: Nationwide Inpatient Sample and Healthcare Cost and Utilization Project data for years 2008-2017 were analysed. Adult hospitalizations due to CAP were identified by previously validated International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) and International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) codes. We then utilized the Cochran-Armitage trend test and multivariate survey logistic regression models to analyse temporal incidence trends, predictors, and outcomes. We used SAS 9.4 software (SAS Institute Inc., Cary, NC, USA) for analysing data.

Results: Out of a total of 8,385,861 hospitalizations due to CAP, ventilation assistance was required in 552,395 (6.6%). The overall ventilation use increased slightly; however, IMV utilization decreased, while NIV utilization increased. In multivariable regression analysis, males, Asian/others and weekend admissions were associated with higher odds of any ventilation utilization. Concurrent diagnoses of septicemia, congestive heart failure, alcoholism, chronic lung diseases, pulmonary circulatory diseases, diabetes mellitus, obesity and cancer were associated with increased odds of requiring ventilation assistance. Ventilation requirement was associated with high odds of in-hospital mortality and discharge to facility.

Conclusion: The use of NIV among CAP patients has increased while IMV use has decreased over the years. We observed numerous factors linked with a higher use of ventilation support. The requirement of ventilation support is also associated with very high chances of mortality and morbidity.

Introduction

Community-acquired pneumonia (CAP) refers to acute pulmonary parenchymal inflammation in a person who has not been hospitalized in the previous 14 days or is not living in a nursing home or long-term care facility [1]. CAP is estimated to occur in five million cases in the USA, leading to over one million hospitalizations and 60,000 deaths each year [2].

The indications of ventilation in CAP remain controversial. The American Thoracic Society and the Infectious Disease Society of America suggested cautious trial of non-invasive ventilation (NIV) while its application is still not a recommendation provided by the evidence-based clinical practice guidelines of CAP [3]. A study conducted in 2018 showed that the 30-day mortality was 33%, 16% and 6% in invasive mechanical ventilation (IMV), NIV and non-ventilation groups, respectively [4]. Based on this study, the use of IMV can be considered as an independent predictor of mortality in severe CAP patients.

Most of previous research studies on ventilation use among CAP patients were conducted on relatively small
sample sizes or in single centers. Therefore, lack of generalized statistics from large sample size impedes the accurate acknowledgement of utilization trends, predictors and outcomes. We used a large, nationally representative database to describe temporal trends, predictors and outcomes of invasive and non-invasive ventilation use in patients with CAP.

Materials And Methods

Data source
We extracted our study cohort from the National (Nationwide) Inpatient Sample (NIS) of the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ) [5]. NIS is one of the largest all-payer publicly available databases on inpatient discharges from U.S. hospitals maintained by the AHRQ [5]. The NIS approximates a 20% stratified sample of discharges from U.S. community hospitals, excluding rehabilitation and long-term acute care hospitals and contains more than seven million hospitalizations annually. With the established weights in NIS, this data could be weighted to represent the standardized U.S. population and obtain national estimates with high accuracy [6].

Study population and design
We queried the 2008-2017 NIS database using International Classification of Diseases, 9th Revision, Clinical Modification, and International Classification of Diseases, 10th Revision, Clinical Modification (ICD-9/10-CM) diagnose codes for CAP. These codes have been used by previously published articles from administrative databases such as NIS. We also identified IMV and NIV by ICD-9/10-CM procedural codes [7-11]. We extracted demographics, hospital-level characteristics (geographical region, size, and teaching status) and patient-level characteristics from the NIS [12]. We estimated comorbidities using Elixhauser Comorbidity Software and mortality risk using the validated All Patient Refined-Diagnosis Related Group (APR-DRG) Risk of Mortality score, which are also supplied by HCUP tools and software [13,14]. Specific concurrent medical conditions and procedures of interest were identified by ICD-9/10-CM diagnosis and procedure codes.

Statistical analysis
To establish the trend, we calculated the proportion of CAP hospitalizations that required IMV or NIV for each year and used the Cochran-Armitage trend test for analysis purpose. Descriptive statistics were performed to present the baseline difference in socio-demographics, comorbidities and hospital-level characteristics among those who did not require any ventilation, those who required IMV and those who required NIV. Categorical variables were compared with the chi-square test, and continuous variables were compared with Student’s t-test or Wilcoxon rank-sum test. To estimate the impact of IMV or NIV on CAP outcomes, we used logistic outcomes/variables (in-hospital mortality and discharge to a long-term facility) and adjusted them for potential confounders. We utilized SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for all analyses and included designated weight values to produce nationally representative estimates [6]. For regression models, we used survey procedures to account for the inherent survey design of NIS to produce more robust estimates [15]. We considered a two-tailed p-value <0.05 as statistically significant.

Results
We analysed a total of 8,585,861 hospitalizations due to CAP from 2008 to 2017. Out of the total, 267,774 (3.2%) required NIV and 284,621 (3.4%) required IMV during the hospitalization.

Temporal trends of NIV and IMV utilization during CAP hospitalizations
In trend analysis, we observed steady decline in yearly CAP hospitalizations from 965,170 in 2008 to 568,210 in 2017. The proportion of patients receiving NIV was increased from 1.7% in 2008 to 5.3% in 2017, while the trend of IMV declined from 3.6% in 2008 to 2.6% in 2017 (Figure 1).
Baseline characteristics of the study cohort

The median age (IQR) was 71 (56-81), 71 (60-80) and 66 (55-77) years in patients who received no ventilation, NIV and IMV, respectively. The proportion of females was higher among those who received NIV (52.5% vs 47.5%; p<0.001); however, the proportion of males was higher among the those who received IMV (52.0% vs 47.9%; p<0.001). White patients comprised 69.1% of total CAP hospitalizations followed by African Americans (10.5%) but the proportion of African Americans was 13.4% among those who required IMV. In patients who received NIV, the most common comorbidities were chronic pulmonary disease (68.5%), hypertension (68.4%), fluid and electrolyte abnormalities (45.4%) and congestive heart failure (42.8%). In patients who received IMV, the most common comorbidities were fluid and electrolyte disorders (59.9%), hypertension (56.4%), and chronic pulmonary disease (46.8%). The northeast region had a higher proportion of NIV (22.4%) and IMV (19.8%) as compared to no ventilation (17.5%) (p<0.001). A similar trend was observed in large-bed-size hospitals and urban teaching hospitals. A detailed description of baseline characteristics of the study cohort has been depicted in Table 1.

| Patient and hospital characteristics | No ventilation | Non-invasive ventilation | Invasive mechanical ventilation | Total | p value |
|-----------------------------------|----------------|--------------------------|-------------------------------|-------|---------|
| Overall                           | 7,833,466      | 267,774                  | 284,621                      | 8,385,861 |       |
| Age in years (mean±SE)            | 68.4 (0.5)     | 69.6 (0.8)               | 65.2 (0.1)                   | <0.001 |
| Age in years (median [q1-q3])     | 71 (56-81)     | 71 (60-80)               | 66 (55-77)                   | <0.001 |
| Age in years (%)                  |                |                          |                              | <0.001 |
| 18-34                             | 5.0            | 2.6                      | 5.6                          | 4.98   |
| 35-49                             | 9.9            | 7.1                      | 10.3                         | 9.77   |
| 50-64                             | 21.7           | 23.3                     | 28.0                         | 21.96  |
| 65-79                             | 31.2           | 37.8                     | 35.2                         | 31.52  |
| ≥80                               | 32.2           | 29.2                     | 21.0                         | 31.76  |
| Gender (%)                        |                |                          |                              | <0.001 |
| Male                              | 46.8           | 47.5                     | 52.0                         | 47.03  |
| Female                            | 53.1           | 52.5                     | 47.9                         | 52.94  |
| Race (%)                          |                |                          |                              | <0.001 |
| White                             | 69.2           | 72.0                     | 64.3                         | 69.09  |
| Black                             | 10.4           | 10.4                     | 13.4                         | 10.51  |
| Hispanic                          | 6.9            | 6.8                      | 8.2                          | 6.89   |
| Comorbidities (%)                                      | 2021 Shah et al. Cureus 13(9): e17954. DOI 10.7759/cureus.17954 |
|-------------------------------------------------------|------------------------------------------------------------------|
| Others                                                | 4.6                                                              |
| Missing                                               | 9.0                                                              |
| Comorbidities (%)                                     | 4.6                                                              |
| Obesity                                               | 10.2                                                             |
| Hypertension                                          | 61.2                                                             |
| Diabetes mellitus with chronic complications           | 6.6                                                              |
| Diabetes mellitus without chronic complications        | 22.7                                                             |
| Congestive heart failure                              | 22.9                                                             |
| Valvular heart disease                                | 7.0                                                              |
| History of chronic pulmonary disease                  | 45.9                                                             |
| Pulmonary circulatory disease                         | 4.6                                                              |
| Peripheral vascular disease                           | 6.5                                                              |
| Paralysis                                             | 2.8                                                              |
| Coagulopathy                                          | 4.8                                                              |
| Solid tumor without metastasis                        | 3.8                                                              |
| Lymphoma                                              | 1.8                                                              |
| Metastatic cancer                                     | 3.5                                                              |
| Weight loss                                           | 6.9                                                              |
| Liver disease                                         | 2.8                                                              |
| Alcoholism                                            | 2.8                                                              |
| Neurology disorders                                   | 11.9                                                             |
| Renal failure                                         | 17.6                                                             |
| Hypothyroidism                                        | 15.2                                                             |
| Arthritis                                             | 4.3                                                              |
| Anemia deficiency                                     | 25.2                                                             |
| Blood loss                                            | 0.6                                                              |
| Fluid and electrolyte disorders                       | 34.7                                                             |
| Depression                                            | 13.1                                                             |
| Psychoses                                             | 5.0                                                              |
| Drug abuse                                            | 2.7                                                              |
| Peptic ulcer disease                                  | 0.1                                                              |
| AIDS                                                  | 0.0                                                              |
| Median household income (%)†                          | <0.001                                                           |
| 1st quartile                                          | 32.0                                                             |
| 2nd quartile                                          | 27.2                                                             |
| 3rd quartile                                          | 21.8                                                             |
| 4th quartile                                          | 16.8                                                             |
| Primary insurance (%)                                 | <0.001                                                           |
### Table 1: Baseline characteristics of the study cohort

| Predictor                          | Small   | Medium  | Large   | Hospital bed size (%)<br><br>Small 21.6 16.1 13.2 21.16<br>Medium 27.3 29.2 27.1 27.31<br>Large 50.7 54.5 59.0 51.12 | Hospital type (%)<br><br>Rural 22.0 15.2 12.1 21.4<br>Urban non-teaching 38.6 39.0 38.5 38.59<br>Teaching 39.1 45.6 48.8 39.6 | Hospital region (%)<br><br>Northeast 17.5 22.4 19.8 17.72<br>Midwest 25.1 20.2 21.9 24.86<br>South 41.0 40.8 40.0 40.96<br>West 16.4 16.7 18.3 16.46 | Day of admission (%)<br><br>Weekday 75.0 73.7 74.2 74.96<br>Weekend 25.0 26.3 25.8 25.04 | Source of admission (%)<br><br>Transfer from other hospital or other health facility 20.6 12.7 19.0 20.26<br>Emergency department 79.4 87.3 81.0 79.74 | Type of admission (%)<br><br>Emergent or urgent 92.8 96.3 95.0 92.96 | Elective 7.2 3.7 5.0 7.04 |

**Predictors of ventilation utilization during CAP hospitalizations**

From our analysis, several predictors associated with increased ventilation utilization (a composite of either NIV or IMV) were the age group 50-64 (OR 1.1; 95% CI 1.06-1.15; p<0.0001), obesity (OR 1.86; 95% CI 1.82-1.90; p=0.0001), septicemia (OR 6.14; 95% CI 5.98-6.30; p=0.0001), congestive heart failure (OR 2.15; 95% CI 2.12-2.19; p=0.0001), history of chronic pulmonary disease (OR 1.61; 95% CI 1.58-1.64; p=0.0001), pulmonary circulatory disease (OR 1.83; 95% CI 1.79-1.88; p=0.0001), paralysis (OR 1.94; 95% CI 1.86-2.01; p=0.0001), and electrolyte and fluid disorders (OR 1.88; 95% CI 1.85-1.92; p=0.0001).

Meanwhile, we also found several predictors associated with reduced ventilation utilization: age >80 (OR 0.66; 95% CI 0.65-0.69; p=0.0001), female sex (OR 0.89; 95% CI 0.88-0.90; p=0.0001), uninsured/self-pay (OR 0.86; 95% CI 0.83-0.89; p=0.0001), small hospital bed size (OR 0.66; 95% CI 0.64-0.69; p=0.0001), and rural hospital (OR 0.60; 95% CI 0.57-0.63; p=0.0001). Detailed predictors of ventilation utilization are shown in Table 2.
| Independent variable/characteristic | Odd ratio | 95% CI (LL) | 95% CI (UL) | p value |
|------------------------------------|-----------|-------------|-------------|---------|
| Year                               | 1.02      | 1.01        | 1.02        | 0.0001  |
| **Age in years**                   |           |             |             |         |
| 18-34                              | ref       | ref         | ref         |         |
| 35-49                              | 0.97      | 0.93        | 1.01        | 0.1085  |
| 50-64                              | 1.10      | 1.06        | 1.15        | 0.0001  |
| 65-79                              | 0.98      | 0.94        | 1.02        | 0.2907  |
| ≥80                                | 0.661     | 0.632       | 0.691       | 0.0001  |
| **Gender**                         |           |             |             |         |
| Male                               | ref       | ref         | ref         |         |
| Female                             | 0.89      | 0.88        | 0.90        | 0.0001  |
| **Race**                           |           |             |             |         |
| White                              | ref       | ref         | ref         | 0.0001  |
| Black                              | 0.956     | 0.928       | 0.985       | 0.0028  |
| Hispanic                           | 1.025     | 0.986       | 1.065       | 0.2107  |
| Others                             | 1.082     | 1.041       | 1.125       | 0.0001  |
| **Comorbidities/concurrent diagnosis** |         |             |             |         |
| Obesity                            | 1.86      | 1.82        | 1.90        | 0.0001  |
| Hypertension                       | 0.93      | 0.91        | 0.95        | 0.0001  |
| Septicemia                         | 6.14      | 5.98        | 6.30        | 0.0001  |
| Diabetes mellitus                  | 1.03      | 1.01        | 1.06        | 0.0181  |
| Congestive heart failure           | 2.15      | 2.12        | 2.19        | 0.0001  |
| Valvular heart disease             | 1.02      | 1.00        | 1.05        | 0.0967  |
| History of chronic pulmonary disease | 1.61      | 1.58        | 1.64        | 0.0001  |
| Pulmonary circulatory disease      | 1.83      | 1.79        | 1.88        | 0.0001  |
| Peripheral vascular disease        | 1.02      | 0.99        | 1.04        | 0.2353  |
| Paralysis                          | 1.94      | 1.87        | 2.01        | 0.0001  |
| Metastatic cancer                  | 1.19      | 1.15        | 1.24        | 0.0001  |
| Weight loss                        | 1.82      | 1.77        | 1.87        | 0.0001  |
| Liver disease                      | 0.99      | 0.96        | 1.03        | 0.7755  |
| Alcoholism                         | 1.23      | 1.18        | 1.28        | 0.0001  |
| Anemia deficiency                  | 1.12      | 1.10        | 1.14        | 0.0001  |
| Drug abuse                         | 1.01      | 0.97        | 1.05        | 0.6015  |
| Neurological disorders             | 1.24      | 1.22        | 1.27        | 0.0001  |
| Renal failure                      | 1.03      | 1.01        | 1.05        | 0.0053  |
| Arthritis                          | 0.95      | 0.91        | 0.98        | 0.0011  |
| Electrolyte and fluid disorders    | 1.88      | 1.85        | 1.92        | 0.0001  |
| Lymphoma                           | 1.03      | 0.97        | 1.08        | 0.3853  |
| Median household income            |           |             |             |         |
### TABLE 2: Predictors of ventilation utilization during CAP hospitalizations

CAP, community-acquired pneumonia; HMO, Health Maintenance Organization

Outcomes of ventilation utilization during CAP hospitalizations
We divided all the CAP hospitalizations into those who received no ventilation, those who received NIV and those who received IMV. There was a comparable difference between the patterns of discharge disposition in patients who received no ventilation, NIV or IMV. Among those patients who did not receive any ventilation, we found that 74.6% were discharged home, 23.2% discharged to a facility and 2.2% died during the hospital stay. This mortality was significantly different from those patients who received either NIV or IMV, with 10.7% mortality for the NIV group and 29.8% for the IMV group. In the NIV group, 56.7% went home and 32.5% were discharged to a facility. In the IMV group, 28.6% were discharged home, while 41.6% were discharged to a facility. Even after adjusting with confounders, we found that any ventilation utilization was

| Predictor                                | 1st quartile | 2nd quartile | 3rd quartile | 4th quartile |
|------------------------------------------|--------------|--------------|--------------|--------------|
| Primary Insurance                        |              |              |              |              |
| Medicare/Medicaid                        | ref          | ref          | ref          |              |
| Private including HMO                    | 0.60         | 0.57         | 0.63         | 0.0001       |
| Uninsured/self-pay                       | 0.86         | 0.83         | 0.89         | 0.0001       |
| Hospital bed size                        |              |              |              |              |
| Small                                    | 0.66         | 0.64         | 0.69         | 0.0001       |
| Medium                                   | 0.90         | 0.86         | 0.93         | 0.0001       |
| Large                                    | ref          | ref          | ref          |              |
| Hospital type                            |              |              |              |              |
| Rural                                    | 0.60         | 0.57         | 0.63         | 0.0001       |
| Urban non-teaching                       | 0.86         | 0.83         | 0.89         | 0.0001       |
| Teaching                                 | ref          | ref          | ref          |              |
| Hospital region                          |              |              |              |              |
| Northeast                                | 1.24         | 1.18         | 1.30         | 0.0001       |
| Midwest                                  | 0.82         | 0.77         | 0.87         | 0.0001       |
| South                                    | 0.98         | 0.94         | 1.02         | 0.3569       |
| West                                     | ref          | ref          | ref          |              |
| Day of admission                         |              |              |              |              |
| Weekday                                  | ref          |              |              |              |
| Weekend                                  | 1.05         | 1.03         | 1.06         | 0.0001       |
| Source of admission                      |              |              |              |              |
| Transfer from other hospital or other health facility | ref        | ref          | ref          |              |
| Emergency department                     | 0.92         | 0.89         | 0.95         | 0.0001       |
| Type of admission                        |              |              |              |              |
| Emergent or urgent                       | ref          | ref          | ref          |              |
| Elective                                 | 0.84         | 0.80         | 0.90         | 0.0001       |
associated with higher adjusted in-hospital mortality (OR 10.4; 95% CI 10.09-10.67, p<0.001) and discharge to facility (OR 2.05; 95% CI 2.0-2.09, p<0.001). Length of stay (LOS) was the lowest among the ‘no ventilation’ group with 5 days. The mean LOS for those who required NIV was 8 days, while that for the IMV group was the highest, at 15 days (p<0.001).

In trend analysis, in-hospital mortality declined from 2.8% in 2008 to 1.7% in 2017 (p<0.001) among those who did not require any sort of ventilation. A similar trend was observed in NIV (14% in 2008 to 8.5% in 2017; p<0.001) and IMV (34.8% in 2008 to 26.7% in 2017; p<0.001) groups. Detailed visualization of discharge disposition trends from 2008 to 2017 of CAP hospitalization among all three groups has been presented in Figures 2-4.
Discussion

In our study, the total hospitalizations due to CAP are declining from 2008 to 2017. However, a study done on CAP in Spain reported a significant increase in hospitalizations due to CAP between 2003 and 2014 [16]. Another study done in Denmark stated that total pneumonia hospitalizations increased by 63%, between 1997 and 2011. In our study period of 2008 to 2018, an increase of NIV use in CAP was seen while the trend of IMV use in CAP declined. A study analysing CAP hospitalizations in Spain between 2001 and 2015 also showed that the use of NIV and NIV+IMV increased significantly over the time period specified while the IMV utilization decreased [17,18].

The results of our study suggest that the age range 50-64 is associated with the highest NIV/IMV utilization rate whereas age >80 years had reduced NIV/IMV utilization. A decreased NIV/IMV usage rate in people older than 80 is notable on account of an increase in DNR (do not resuscitate) orders among patients aged >75 compared with those aged <65, according to a previous meta-analysis [19]. Furthermore, women received more trials of NIV compared to men that was also supported by the Taiwanese study by Shen et al. [20]. Additionally, we found obese patients were at higher odds of receiving ventilation that was even validated by Anzueto et al., and due to an increasing incidence of increased body weight in the general population, it is likely that more overweight patients will require mechanical ventilation in the future [21]. A number of studies have documented a marked increase in respiratory issues, especially respiratory failure in paralysis patients following either spinal cord injury or neuromuscular diseases due to several mechanisms, and the impact of NIV use on those cases [22]. Therefore, it could be an obvious explanation for the increase in ventilation usage in paralysis patients.

Furthermore, uninsured/self-pay patients had lower odds of receiving any sort of ventilation as these patients are more likely to receive the lowest intensity of care such as radiographic and surgical procedures, consultations, and ICU care, which might be the leading contributing factor for lower utilization of invasive or non-invasive ventilation [23-25]. Additionally, our study showed that small and rural hospitals were associated with a lower rate of ventilation utilization that can be attributed to restricted facilities and fewer resources in small and rural hospitals serving as a reason to transfer patients to a greater extent to larger or academic hospitals capable of providing the required definitive care [26]. It is hypothesized that patients treated by a health care provider or admitted to a medical facility on a weekend or holiday might experience worse outcomes than patients treated on weekdays [27]. Proposed reasons for this include a decreased availability of staff or other resources on the weekend, limited access to laboratory or diagnostic tools, or selection bias stemming from a general reluctance by patients to solicit care during the weekend, which we found in our study as well as patients admitted during the weekend who received mechanical ventilation compared to the weekday admissions [27].

This study was able to track the trends of in-hospital mortality and discharge to facility among the three groups in a 10-year period. This can serve as a gateway to conduct different studies into identifying useful tools to decrease mortality and also improve quality of care. The overall in-hospital mortality has decreased in all ventilation groups from 2007 to 2017. This finding was also consistent with 15-year trends in CAP patients that reported a decrease in in-hospital mortality in patients who received non-invasive or invasive

![FIGURE 4: Temporal trends of discharge disposition among the IMV group](image)

IMV, invasive mechanical ventilation
ventilation or both [28]. This may be attributed to a better understanding of CAP treatment, adoption of better practice guidelines and care bundles, improved quality of care, and early and/or aggressive treatment. A study conducted by Dean et al. showed that the implementation of a pneumonia practice guideline was associated with a reduction in 30-day mortality among elderly pneumonia patients [29].

The proportion of mortality still remains the highest among those who required IMV. This may be explained by the increased severity of disease in patients where they require invasive ventilation, as evidenced by higher CURB-65 scores, Acute Physiology and Chronic Health Evaluation II (APACHE-II) scores and other predictors, including acute respiratory failure [30]. Overall discharge to facility has been relatively consistent throughout 2008 to 2017 in the respective ventilation groups, while discharge to home has mildly increased in each group, with the highest in the NIV group. This is supported by the studies by Nicolini et al. that concluded that NIV treatment had a high rate of success [31-33]. However, the same studies also concluded the use of NIV in severe CAP as controversial due to greater variability in success compared to other pulmonary conditions. This was echoed by other studies that associated NIV with high failure rates without improvement in mortality [34,35]. Further studies into the role of NIV and variables impacting its efficacy in CAP are required. The length of stay at hospital was predictably lowest in those who did not require any ventilation and highest among those who required IMV. This may be attributed to early recovery in those who did not need ventilation. The IMV group typically has more severe disease and likely to have further complications thus extending the length of stay at the hospital.

Our study has several limitations. First, our study is a retrospective study that makes it subjectable to selection bias. Secondly, the selection of samples relies on accurate coding practices that could have confounded our results. Despite its limitations, our study has several strengths. Our study is the first comprehensive nationwide study looking at the noninvasive and invasive ventilation utilization during hospitalization due to CAP and our sample size most closely represents the 95% standardized U.S. population, which reduces the chance of selection bias [5].

Conclusions
Our study showed that the total hospitalizations due to CAP have trended downwards from 2008 to 2017. Also, there was an increase of NIV use in CAP while the trend of IMV use in CAP has decreased. Furthermore, several predictors associated with an increased NIV/IMV usage rate are age 50-64, septicemia, congestive heart failure, history of chronic pulmonary disease and pulmonary circulatory disease; LOS was also higher among the ventilation groups. As per our study, there are various modifiable factors that can improve the outcomes of the patients admitted with CAP requiring ventilation support and future studies should focus on assuaging the outcomes of patients.

Additional Information
Disclosures
Human subjects: Consent was obtained or waived by all participants in this study. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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