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Major Article

The epidemiology of nonventilator hospital-acquired pneumonia in the United States

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Background: Nonventilator hospital-acquired pneumonia (NV-HAP) is among the most common hospital-acquired infections. The purpose of our study was to quantify the incidence and influence of NV-HAP in the United States using a national dataset.

Methods: The 2012 US National Inpatient Sample dataset was used to compare an NV-HAP group to 4 additional group cohorts: pneumonia on admission, general hospital admissions, matched on mortality and disease severity, and ventilator-associated pneumonia (VAP). The main outcome was NV-HAP incidence. The secondary outcome was to compare hospital length of stay, total hospital charges, and mortality between the NV-HAP group and the 4 additional group cohorts.

Results: The overall incidence of NV-HAP was 1.6%, which represents a rate of 3.63 per 1,000 patient-days. NV-HAP was associated with increased total hospital charges, a longer hospital length of stay, and greater likelihood of death in comparison to all groups except patients with VAP.

Conclusion: NV-HAP is an underappreciated and serious patient safety issue, resulting in significant increases in cost, length of stay, and mortality. Efforts toward prevention of NV-HAP should be raised to the same level of concern as VAP prevention.

Hospital-acquired pneumonia (HAP) is a common health care-acquired infection (HAI) worldwide,[1] occurring at a rate of up to 21 cases per 1,000 hospital admissions.[2] HAP includes 2 distinct subgroups: nonventilator HAP (NV-HAP) and ventilator-associated pneumonia (VAP).[3] Results from a multistate point-prevalence survey using the National Healthcare Safety Network criteria for HAIs suggest that NV-HAP and VAP combined accounted for 21.8% (95% confidence interval, 18.4-25.6) of all HAIs in the United States during 2011. This is equivalent to 157,500 infections (95% confidence interval, 50,800-281,400), with 60.9% of these classified as NV-HAP.[4] Both NV-HAP and VAP are associated with substantial clinical and economic burdens, including prolonged hospital length of stay (LOS), higher overall health care costs, and increased morbidity and mortality.[5-7]

The majority of research during the past 2 decades has focused primarily on VAP. VAP is an identifiable, trackable event for which evidence-based preventive care bundles have been developed and widely implemented.[8-10] These efforts have produced significant declines in VAP rates, resulting in improved patient outcomes and decreased health care costs related to VAP.[11-13]

However, a recent statewide study in Pennsylvania found that NV-HAP is more common than VAP, NV-HAP is associated with similar risk factors and complications to VAP, and was associated with a greater overall economic burden.[14] Data from 2009-2011 revealed 5,597 NV-HAP cases compared with 2,299 VAP diagnoses, with equivalent mortality (18.7% and 18.9%, respectively). The total cost for NV-HAP cases was $156 million compared with $86 million for VAP.[14] These findings are consistent with data from other studies that found an incidence of 1.22-8.9 per 1,000 patient-days and mortality of 13.9%-19%.[4,15-17]

The purpose of this study was to determine the incidence, total hospital charges, and mortality associated with NV-HAP in US hospitals, and compare these findings to 4 group cohorts

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without NV-HAP. The following research questions were addressed:

1. What is the overall incidence of NV-HAP in US acute care hospitals?
2. Do significant differences exist in total hospital charges, LOS, and mortality between acute care patients with NV-HAP and patients with a primary diagnosis of pneumonia?
3. Do significant differences exist in total hospital charges, LOS, and mortality between acute care patients with NV-HAP and the general population of acute care patients?
4. Do significant differences exist in total hospital charges, LOS, and mortality between acute care patients with NV-HAP and patients matched for illness acuity and mortality risk?
5. Do significant differences exist in total hospital charges, LOS, and mortality between acute care patients with NV-HAP and patients with VAP?

MATERIALS AND METHODS

Before receiving the Healthcare Cost and Utilization Project (HCUP) US National Inpatient Sample (NIS) dataset from the Agency for Healthcare Research and Quality (AHRQ), Data Use Agreement (DUA) training is required. On April 27, 2015, the principal investigator (PI) completed the DUA training and a DUA was executed between the PI and the AHRQ (HCUP-318K72CUW), with records kept by both AHRQ and the PI. The NIS is a public-use dataset commonly used for secondary analyses on US hospital trends. Although no institutional review board approval is required for use of the dataset, an institutional review board determination of exemption was obtained from the PI's hospital system.

Data source

The NIS was developed as part of the HCUP, a partnership between federal and state agencies and the health care industry, with sponsorship provided by AHRQ. The NIS is the largest all-payer, inpatient care database in the United States, consisting of a 20% stratified sample of all inpatient discharges from community hospitals, excluding rehabilitation units, long-term acute care hospitals, psychiatric hospitals, and alcoholism or chemical dependency units.[18,19]

Discharges are stratified by hospital, census division, ownership status, urban or rural location, teaching status, bed size, patient diagnosis-related group, and month of admission. Patients covered by Medicare, Medicaid, private payers, and those who are uninsured are included in the NIS. The data are sampled from state inpatient databases, which include all inpatient data reported to the HCUP.

A total of 46 states participate in HCUP, which represents more than 95% of the US population. The NIS contains anonymized information about each hospital admission, including patient demographic characteristics, admission status, primary and secondary diagnosis and procedure codes, hospital characteristics, expected source of payment, total charges, LOS, disease severity, comorbidity measure, locations from which patients were admitted, and transfer information at the time of discharge. The 2012 HCUP NIS contains a total of 7,296,968 unweighted patient records and was the most recent year data were available from NIS when the secondary data analyses were conducted. The self-weighted NIS data estimates patterns and trends for more than 36 million inpatient hospital stays nationally.

Sample

The diagnosis codes in the 2012 HCUP NIS database distinguish between a primary diagnosis and up to 24 secondary diagnoses. The dataset was mined for patient records of adults aged 18 years or older) with a secondary diagnosis of pneumonia. Because we sought to calculate the incidence of NV-HAP, we used ICD-9-CM codes 480.8, 481, 482.1, 482.0, 482.2, 482.39, 482.41, 482.42, 482.82, 482.83, 483.8, 484.6, 484.7, and 486.0 to identify the NV-HAP cases. ICD-9 codes have been used in previous research to determine NV-HAP incidence.[15,20] This effort resulted in a sample (N = 133,595) of patients with NV-HAP. Because NV-HAP is defined as an episode of pneumonia unassociated with mechanical ventilation that is not incubating at the time of hospital admission and occurs ≥48 hours following admission,[3,21] we excluded all patients without a hospital LOS of at least 48 hours. This resulted in a final sample for analysis of 119,075.

To create clinically relevant comparisons, four comparison groups were generated from the remaining records (Fig 1). For groups 2-4, random sampling was performed without replacement to ensure that duplicate records did not appear in >1 group. The sequential process used to create all 4 groups is shown in Figure 1. Group 2 (n = 119,075) was a randomly generated sample of patients admitted with pneumonia as a primary diagnosis (research question 2). Group 3 (n = 119,075) was a randomly generated sample of any patient in the NIS dataset (research question 3). Group 4 (n = 119,075), was a randomly generated sample of cases for which each patient was matched to the NV-HAP group on both disease severity and mortality score. In the NIS dataset, the disease severity and mortality risk data elements are both recorded using an ordinal scale, with scores ranging from 0-4 (0 = not specified, 1 = minor, 2 = moderate, 3 = major, and 4 = extreme). Thus, the combined total score had a possible range of 0-8. Patients in group 4 were matched to patients in the NV-HAP group on the combined score for disease severity and mortality risk (research question 4). Group 5 (N = 3,260) was created using the ICD-9 code 997.31 to capture all cases of VAP (research question 5).

Study variables

Three main outcome variables were compared between the NV-HAP group and each of the 4 comparison groups. These variables included total inpatient charges, LOS (up to a maximum of 365 days), and mortality.

Demographic variables provided by the dataset included age, sex, payer source, and race/ethnicity.

Additional clinical variables of interest that were available in the dataset included admission status (elective/nonelective), admission history (transferred in or not, and if so from what type of facility), discharge disposition (where patients went immediately after hospital discharge), the total number of comorbid conditions, and whether patients underwent a surgical procedure.

Statistical analysis

Data were analyzed using SPSS version 23 (IBM-SPSS Inc, Armonk, NY). Mean differences for the continuous outcome and descriptive variables between the NV-HAP group (group 1) and each of the comparison groups were analyzed with *t* tests with Bonferroni corrections. The χ^2 test was used for significance testing for the noncontinuous variables.

Second, multivariate regressions were run using patient group as the key independent variable and total charges, LOS, and mortality as the dependent variables. Analyses were run adjusting for demographic and other clinical variables. Ordinary least squares regression was used to analyze total cost and length of stay. Logistic regression was used to analyze patient death.

Listwise deletion was used for missing data. Nominal-scale variables were dummy-coded to be included for analyses. Residuals for total hospital charges, and length of stay violated assumptions of