Hospital-acquired pneumonia—no apparent seasonal variation: A single institution study

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Abstract

Unlike the clear seasonal differences that have been recorded for certain respiratory infectious illnesses, variation in hospital-acquired pneumonia (HAP) rates by time of year has not been thoroughly investigated. The primary aim of this study was to determine whether HAP rates fluctuate during the year at the University Medical Center (UMC) in Lubbock, Texas. An internal data source maintained by UMC's Infection Prevention & Control Office called MedMined that builds an algorithm using nosocomial infection markers (NIMs) was used to track HAP rates. The NIMs are microbiology results from various sample sources, including urine, stool, wound, respiratory secretions, and other, that provide a better understanding of a patient's infection risk and status. MedMined respiratory NIMs data on quarterly scorecards from January 2015 to March 2020 were evaluated using one-way analysis of variance (ANOVA) and subsequently stratified to the departmental level (e.g., MICU, SICU, etc.) followed by a repeat one-way ANOVA for each of the selected departments. Analysis of hospital-wide and selected UMC hospital department respiratory NIMs data revealed no statistically significant difference in respiratory NIM rate by time of year (P = 0.25). Therefore, there is no apparent variation in HAP rates at UMC with respect to time of year either on a hospital-wide or a selected departmental level. Analysis of a national dataset might help determine whether this finding occurs at other institutions.

Keywords: hospital-acquired pneumonia, intensive care units, seasons

Introduction

The relationship between the time of year and fluctuations in incidence of infectious illnesses affecting the respiratory system has long been understood. The word influenza dates to the 14^{th} century and stems from the word influence. It is believed that the term was devised following the observation of varying rates of people with the constellation of symptoms commonly associated with this respiratory disease and certain celestial patterns in the night sky that Italians believed were interrelated.[1] Influenza infections vary by the time of year with peak prevalence in winter months.[2] Other pathogens, such as *Mycoplasma pneumonia*, have a peak infectious prevalence in the winter and spring months, and some viruses, such as the respiratory syncytial virus, cause more infections in the winter months.[3,4] As a result, several studies have established a clear connection between the time of year and community-acquired pneumonia (CAP) rates.[5]

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Pneumonia occurs when microbes of the nasopharynx become aerosolized and travel through the respiratory tract until they are deposited in the alveoli of the lung. Microbes then multiply in the alveoli and move from one alveolus to the next through structures that allow communication between alveoli called pores of Kohn. Eventually, these replicating microbes cause inflammation and consolidation that can ultimately spread to include an entire lung lobe. Hospital-acquired pneumonia (HAP) is defined as a case of pneumonia that starts after 48 hours of admission. In patients who are mechanically ventilated, pneumonia in this time frame is called ventilator-associated pneumonia and accounts for up to 90% of all HAPs.[6,7] Outside of the ICU, HAPs more commonly occur in elderly, surgical, and immunocompromised patients, especially in those who require nasogastric tube enteral feeding.[7] Hospital-acquired pneumonia is typically caused by aspiration of infected oropharyngeal secretions.[8] Several predisposing factors increase the risk of developing aspiration pneumonia in hospitalized patients and include intubation, immunological senescence, reduced levels of consciousness, decreased mobility, and poor oral hygiene. Several strategies have been used in hospitalized patients to reduce their risk of HAP.[9] These include the use of incentive spirometry, frequent ambulation, routine oral hygiene, and positioning. Regardless of whether the pneumonia is community-acquired or hospital-acquired, treatment involves the use of broad-spectrum antibiotics due to the resistance patterns of the infecting pathogens.

Unlike seasonal differences in CAP rates, variation in HAP rates by time of year has not been thoroughly investigated. The goal of this study was to determine whether HAP rates fluctuate throughout the year at the University Medical Center (UMC) in Lubbock, Texas. Presence or absence of variations in HAP will help define the frequency of such events and guide efforts towards preventing HAP.

Methods

Hospital-acquired pneumonia was defined by the clinical diagnosis and subsequent ICD-10 code generated and coded upon patient discharge. To address whether HAP rates fluctuate by time of year, an internal data source maintained by the UMC Infection Prevention & Control Office called MedMined (MedMined, Inc, Birmingham, AL) was used. The MedMined database accrues data of all nosocomial infection markers or microbiology results from various sources (urine, stool, wound, respiratory, blood, and "other"). It then separates these results from sources of contamination, duplication, surveillance cultures, certain community-acquired infections, and non-infected clinical states. By grouping by source and location of patient, the MedMined database further parses out whether an infection was community-acquired or hospital-acquired using proprietary algorithms. Every 45 days, the database develops score cards that can further show infection trends over time. This database and algorithm create a powerful quality improvement tool that allows hospitals to analyze possible nosocomial infections. Using these scorecards, respiratory NIMs from January 1, 2015, through March 31, 2020, were collected and subdivided into four groups. Each group included data spanning three-month intervals, including winter (01/01–03/31) for the years 2015–2020; spring (04/01–06/30) for the years 2015–2019; summer (07/01–09/30) for the years 2015–2019; fall (10/01–12/31) for the years 2015–2019. The number of cases during these times intervals was averaged to provide an estimate of the case load during each three-month block.

Hospital-wide data, including both medical and surgical floor patients, were compiled for all years; 2 determine whether the differences observed in the data groupings were statistically significant, a one-way analysis of variance (ANOVA) was used. Hospital-wide data from each grouping spanning all years were then stratified by the following units: MICU, SICU, CICU, and BICU. One-way ANOVA for the data from each of the ICUs listed prior was then performed.

Results

One-way analysis of variance of hospital-wide and selected UMC hospital department respiratory NIM data revealed no statistically significant change in respiratory NIM rate by time of year. While some departments had increased respiratory infection rates in the early spring and late winter periods, these findings were not statistically significant.

Table 1. Descriptive and One-way ANOVA Comparing BICU Respiratory NIMs Across Quarters

	Quarters				
	1-Winter	**2-Spring**	**3-Summer**	**4-Fall**	**Total**
Mean	13.67	7.60	11.60	13.40	11.67
SD	6.83	3.13	3.21	4.28	5.04
Range	6–23	3–10	9–16	9–18	
Source	SS	df	MS	F	Significance
Between-groups	121.73	3	40.58	1.78	0.189
Within-groups	386.93	17	22.76		
Total	508.67	20			

BICU-burn intensive care unit, ANOVA-analysis of variance, NIMs-nosocomial infection markers, SD-standard deviation, SS-sum of squares, dF-degrees of freedom, MS-mean square.

BICU respiratory NIMs

There was minimal seasonal variation of respiratory NIMs in the burn unit with an average respiratory NIM count of 11.7 ranging between 7.6 NIMs during the spring and 13.7 NIMs in the winter that was not statistically significant ($p = 0.189$). Further T-test analysis of traditionally accepted high-risk months for CAP, i.e., the winter and fall months, when compared to the summer and spring months did not identify any variation in HAP trends ($p = 0.068$). Additional analysis is presented in Table 1.

SICU respiratory NIMs

There was no seasonal variation of respiratory NIMs in the SICU with an average respiratory NIM count of 20.3 ranging between 18.6 NIMs during the spring and 22.6 NIMs in the summer that was not statistically significant ($p = 0.760$). Further T-test analysis of traditionally accepted high-risk months for community pneumonia, i.e., the winter and fall months, when compared to the summer and spring months did not identify any variation in HAP trends ($p = 0.856$). Additional analysis is presented in Table 2.

MICU respiratory NIMs

There was no seasonal variation of respiratory NIMs in the MICU with an average respiratory NIM count of 16.3 ranging between 14.2 NIMs during the spring and 18.2 NIMs in the summer that was not statistically significant ($p = 0.776$). Further T-test analysis

Table 2. Descriptive and One-way ANOVA Comparing SICU Respiratory NIMs Across Quarters

	Quarters				
	1-Winter	**2-Spring**	**3-Summer**	**4-Fall**	**Total**
Mean	20.83	18.60	22.60	19.20	20.33
SD	6.59	8.79	4.28	5.07	6.13
Range	13–31	7–31	20–28	16–26	
Source	SS	df	MS	F	Significance
Between-groups	48.63	3	16.21	0.39	0.76
Within-groups	702.03	17	41.3		
Total	750.67	20			

SICU-surgical intensive care unit, ANOVA-analysis of variance, NIMs-nosocomial infection markers, SD-standard deviation, SS-sum of squares, dF-degrees of freedom, MS-mean square.

Table 3. Descriptive and One-way ANOVA Comparing MICU Respiratory NIMs Across Quarters

	Quarters				
	1-Winter	**2-Spring**	**3-Summer**	**4-Fall**	**Total**
Mean	16.67	14.20	18.20	16.20	16.33
St	6.15	4.97	3.63	8.47	5.78
Range	11–27	6–19	12–21	9–28	
Source	SS	df	MS	F	Significance
Between-groups	40.93	3.00	13.64	0.40	0.78
Within-groups	627.73	17.00	36.93		
Total	668.67	20.00			

MICU-medical intensive care unit, ANOVA-analysis of variance, NIMs-nosocomial infection markers, SD-standard deviation, SS-sum of squares, dF-degrees of freedom, MS-mean square.

of traditionally accepted high-risk months for CAP, i.e., the winter and fall months, when compared to the summer and spring months did not identify any variation in HAP trends ($p = 0.921$). Additional analysis is presented in Table 3.

CICU respiratory NIMs

There was minimal seasonal variation of respiratory NIMs in the CICU with an average respiratory NIM count of 6.6 ranging between 5.6 NIMs during the summer and 7.5 NIMs in the winter that was not statistically significant ($p = 0.872$). Further T-test analysis of traditionally accepted high-risk months for CAP, i.e., the winter and fall months, when compared to the summer and spring months did not identify any variation in HAP trends ($p = 0.639$). Additional analysis is presented in Table 4.

Hospital-wide respiratory NIMs

There was minimal seasonal variation of respiratory NIMs in the hospital with an average respiratory NIM count of 87.81 ranging between 75.0 NIMs during the spring and 100.7 NIMs in the winter that was not statistically significant ($p = 0.257$). Further T-test analysis of traditionally accepted high-risk months for CAP, such as the winter and fall months, when compared to the summer and spring months did not identify any variation in HAP trends ($p = 0.103$). Additional analysis is presented in Table 5.

Table 4. Descriptive and One-way ANOVA Comparing CICU Respiratory NIMs Across Quarters

	Quarters				
	1-Winter	**2-Spring**	**3-Summer**	**4-Fall**	**Total**
Mean	7.50	6.80	5.60	6.40	6.62
SD	1.52	3.42	6.39	2.61	3.60
Range	5–9	5–12	2–17	2–8	
Source	SS	df	MS	F	Significance
Between-groups	10.25	3.00	3.42	0.23	0.87
Within-groups	248.70	17.00	14.63		
Total	258.95	20.00			

CICU-coronary intensive care unit, ANOVA-analysis of variance, NIMs-nosocomial infection markers, SD-standard deviation, SS-sum of squares, dF-degrees of freedom, MS-mean square.

Table 5. Descriptive and One-way ANOVA Comparing Hospital-wide Respiratory NIMs Across Quarters

	Quarters				
	1-Winter	2-Spring	3-Summer	4-Fall	Total
Mean	100.67	75.00	85.00	88.00	87.81
SD	30.10	14.97	11.02	17.33	21.17
Range	62–142	57–98	74–97	64–109	
Source	SS	df	MS	F	Significance
Between-quarters	1851.91	3.00	617.30	1.47	0.26
Within-quarters	7115.33	17.00	418.55		
Total	8967.24	20.00			

ANOVA-analysis of variance, NIMs-nosocomial infection markers, SD-standard deviation, SS-sum of squares, dF-degrees of freedom, MS-mean square.

Discussion

The lack of seasonal variation in HAP rates suggests that hospitalization, itself, is the predominant factor in these infections. In the ICU, the majority of pneumonias arise secondary to prolonged intubation.[10] However, each ICU has different patient populations with differing respiratory injuries that can further increase their susceptibility to HAP. The BICU, for example, have patients at high risk for HAP because of the combination of both intubation and smoke inhalation injury. The CICU, on the other hand, mostly manages patients who have cardiac disorders and require less frequent intubation.

Hospital-acquired pneumonias contribute to both extended hospital stays and re-admissions. This places increased emphasis on preventative measures to reduce the incidence. To best accomplish this task, health care workers must use established preventive practices, such as consistent oral care and early mobilization of patients.[7] Other nonpharmacological approaches include preventing unnecessary intubation, increased use of non-invasive positive pressure ventilation, and appropriate hand washing and cleanliness.[6,7,10] Oral care in particular has been extensively studied using methods, such as mouth rinses with chlorhexidine, scrubbing of pharynx, topical application of absorbable antibiotic solutions, and antimicrobial prophylaxis. These methods can reduce the risk of pneumonia significantly.[7] Avoiding unnecessary empiric antibiotic administration and using shorter courses of parental antibiotics can reduce bacterial colonization.[10] Of note, assessment of patient's need for proton-pump inhibitors must be weighed against the increased risk of bacterial growth in the stomach that can be subsequently aspirated.[10] Especially in ICUs where patients may be intubated, positioning (head elevation), subglottic suctioning, and early extubation are all methods to prevent aspiration of contaminated secretions.[6] Even minimal methods to prevent HAP, including positioning, increased oral care, and early use of orogastric tubes, have been studied to reduce HAP rates.[10] In addition, timely vaccination of both patients and providers can reduce infection rates in the hospital.[10]

While prevention is key in reducing HAP rates, increased vigilance in identifying individuals at risk for nosocomial infections and effectively communicating their vulnerability to the entire healthcare team can improve patient care and reduce HAP rates. To do so, there must be good health care staff compliance with routine care protocols, especially with oral care. This increased vigilance may require increased staffing. Studies have noted an inverse relationship between the staffing levels of hospitals and increased length of stay for patients that puts them at increased risk for HAP.[6]

Limitations

Low statistical power could contribute to the lack of statistical significance found in this study. The respiratory NIM data used for this study covered January 2015 through March 2020. Data collection over more time may be necessary to identify a statistically significant variation between time of year and respiratory NIM rates at UMC. Further study of this question of whether respiratory NIM rates fluctuate by time of year using national data could help to determine whether the observed lack of variance in respiratory NIM rates by time of year at UMC occurs in other institutions. In addition, the MedMined database does not record demographic data or additional risk factor information when recording the NIMs. As a result, more study of the risk factors associated with these respiratory NIMs might help understand the trends identified in this study.

Conclusion

Hospital-acquired pneumonia is a serious condition that can lead to increased intensive care requirements, hospital length of stay, and mortality. As HAP rates do not fluctuate by time of year, efforts to decrease the use of mechanical ventilation, morbidity, and mortality are essential throughout the calendar year. This requires comprehensive patient management and increased vigilance and communication about patients at increased risk for HAP.

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References

1. Etymologia: influenza. Emerging Infectious Diseases 2006; 12(1):179–179.
2. Lofgren E, Fefferman NH, Naumov YN, et al. Influenza seasonality: underlying causes and modeling theories. J Virology 2007;81(11):5429–5436.
3. Onozuka D, Hashizume M, Hagihara A. Impact of weather factors on *Mycoplasma pneumoniae* pneumonia. Thorax 2009;64(6):507–511.
4. Chan PWK, Chew FT, Tan TN, et al. Seasonal variation in respiratory syncytial virus chest infection in the tropics. Pediatric Pulmonology 2002;34(1):47–51.
5. Cilloniz C, Ewig S, Gabarrus A, et al. Seasonality of pathogens causing community-acquired pneumonia. Respirology 2017; 22(4):778–785.
6. Kollef MH. Prevention of hospital-associated pneumonia and ventilator-associated pneumonia. Critical Care Med 2004; 32(6):1396–1405.
7. Pássaro L, Harbarth S, Landelle C. Prevention of hospital-acquired pneumonia in non-ventilated adult patients: a narrative review. Antimicrobial Resistance Infection Control 2016;5(1). doi:10.1186/s13756-016-0150-3
8. Quinn B, Baker DL, Cohen S, et al. Basic nursing care to prevent nonventilator hospital-acquired pneumonia. J Nursing Scholarship 2014;46(1):11–19.
9. Cassidy MR, Rosenkranz P, McCabe K, et al. Cough. JAMA Surgery 2013;148(8). doi:10.1001/jamasurg.2013.358
10. Modi AR, Kovacs CS. Hospital-acquired and ventilator-associated pneumonia: Diagnosis, management, and prevention. Cleveland Clinic J Med 2020;87(10):633–639.