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Major Article

Non-Ventilator Associated Hospital Acquired Pneumonia (NV-HAP) Risk Among Hospitalized Veterans Before and During the COVID-19 Pandemic

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Highlights

- NV-HAP among hospitalized Veterans decreased steadily between 2015-2020.
- NV-HAP rates increased by 25% among 2019-nCoV- and 108% among 2019-nCoV+ Veterans.

- Hospitalized Veterans experienced an increased NV-HAP risk during 2019-nCoV.
- Fundamental infection prevention and nursing care are essential to reduce NV-HAP.

ABSTRACT

Background. Among hospitalized U.S. Veterans, the rate of non-ventilator associated hospital acquired pneumonia (NV-HAP) decreased between 2015-2020 then increased following the onset of 2019-nCoV (COVID-19).

Methods. Veterans admitted to inpatient acute care for >= 48 hours at 135 Department of Veterans Affairs Medical Centers between 2015-2021 were identified (n=1,567,275). Non-linear trends in NV-HAP incidence were estimated using generalized additive modeling, adjusted for seasonality and patient risk factors.

Results. The incidence rate (IR) of NV-HAP decreased linearly by 32% (95% CI: 63-74) from 10/1/2015 to 2/1/2020, translating to 337 fewer NV-HAP cases. Following the U.S. onset of the COVID-19 pandemic in February 2020, the NV-HAP IR increased by 25% (95% CI: 14-36) among Veterans without COVID-19 and 108% (95% CI: 178-245) among Veterans with COVID-19, resulting in an additional 50 NV-HAP cases and $5,042,900 in direct patient care costs 12-months post admission.

Discussion. This increase in NV-HAP rates could be driven by elevated risk among Veterans with COVID-19, decreased prevention measures during extreme COVID-19 related system stress, and increased patient acuity among hospitalized Veterans during the first year of the pandemic.

Conclusions. Basic nursing preventive measures that are resilient to system stress are needed as well as population surveillance to rapidly identify changes in NV-HAP risk.

KEYWORDS*:* non-ventilator associated hospital acquired pneumonia; non-device related pneumonia; Covid-19; Veterans

Background

Among hospitalized U.S. Veterans, the rate of non-ventilator associated hospital acquired pneumonia (NV-HAP) decreased between 2015-2020 then increased following the onset of COVID-19.[1] This increase in NV-HAP rates could be driven by elevated risk among Veterans with COVID-19, decreased NV-HAP prevention measures during extreme COVID-19 related system stress, and increased patient acuity among hospitalized Veterans during the first year of the pandemic.

Methods

We identified a cohort of 1,567,275 U.S. Veterans admitted to 135 VA facilities in acute care settings between 10/1/2015 and 3/31/2021with a minimum 48-hour length of stay. Consistent with prior work,[2] transfer admissions were excluded as well as admissions with index diagnoses of acute respiratory distress, respiratory failure, respiratory arrest, asphyxia, or pneumonia indicated as present on admission (POA). The primary exposure was a positive SARS-CoV-2 test within the 28 days prior to admission date, referred to as COVID-19. The outcome of NV-HAP was identified based on International Classification of Diseases (ICD-10) codes for bacterial pneumonia indicated as not POA.[2] Patient demographics, comorbidities, exposure, and outcomes were identified using the VHA Corporate Data Warehouse (CDW).[3]

NV-HAP incidence rates (IR) were estimated using a log linked quasi-Poisson generalized additive model with an offset for hospitalized at risk days.[4] The following covariates were included a-priori for risk adjustment based on prior work: age, gender, recent diagnoses of peripheral vascular disease, chronic pulmonary disease, and cancer.[2] A cyclic cubic regression spline for admission month was included to adjust for seasonality. The trend in NV-HAP IR was estimated by a thin plate regression spline fit [5] separately for pre-COVID-19 era admissions (prior to 2/1/2020) and COVID-19 era admissions, with posterior simulations from model parameters used to identify era specific IR and the number of cases associated with that change in risk. The change in IR was summarized over two different eras: pre-COVID (10/1/2015 to 2/1/2020) and COVID-era (2/2/2020-3/31/2021). The reported change in IR and associated cases are compared to the conservative counterfactual assumption that the estimated IR at the start of each era remained constant. Additional 12-month direct medical system costs of the excess NV-HAP cases was calculated using a Monte-Carlo simulation with 10,000 replications.

Results

Hospitalized Veterans in this cohort have a high burden of clinical comorbidities documented in the year prior to admission across all eras reported (table 1). Most demographics and comorbidities are similar across eras except race and diagnosis of dementia. Veterans with COVID-19 are more likely to be Caucasian and have documented dementia in the previous year compared with COVID negative Veterans or those Veterans hospitalized prior to the onset of COVID-19.

The NV-HAP IR decreased linearly by 32% (95% CI: 63-74) between 10/1/2015 and 2/1/2020, representing 338 (95% CI: 263 - 412) fewer cases of NV-HAP in this cohort. Compared to the

conservative assumption that NV-HAP risk would remain constant following 2/2/2020, the observed NV-HAP IR increased by 24.8% (95% CI:14.6-35.8) among COVID-19 negative Veterans and by 108.4% (95% CI:78-144.8) among COVID-19 positive Veterans, representing an additional 50 (95% CI: 27-74) NV-HAP cases. Figure 2 summarizes these trends. Prior work estimated the additional 12-month direct medical costs of a single NV-HAP case is $100,858.61(SD=310),[2] thus we estimate these cases represent an additional $5,045,259 (95% CI: 2,707,708-7,363,787) in direct health system costs over one year post admission.

Discussion

Following several years of decreased incidence of NV-HAP among Veterans hospitalized in acute care settings, there was an increase in NV-HAP following the onset of the COVID-19 pandemic among all hospitalized Veterans. The highest risk was among the COVID-19 positive Veterans. The CDC reported that after years of decline from 2015-2020, U.S. hospitals experienced a rise in monitored hospital acquired infections (HAI) during COVID-19.[6] NV-HAP is not a required CMS metric but carries a higher morbidity and mortality than other HAI.[7] To our knowledge, this is the first published report of changes in NV-HAP risk associated with the onset of COVID-19 among all hospitalized Veterans in a national healthcare system.

The observed increase in NV-HAP risk among all patients during the COVID era is likely multifactorial. Prevention strategies are essential to mitigate NV-HAP risk, yet increased clinical workload seen during the COVID-19 pandemic may have limited completion of fundamental nursing care (e.g., early mobility programs, consistent oral care, aspiration precautions, see table 2) to prevent NV-HAP.[8] Other barriers include wearing personal protective equipment which impacts communication and the ability to get needed supplies to the bedside without cross-

contamination. Among patients with COVID-19 infections, increased NV-HAP risk could be due to changes in the lower respiratory tract microbiome, disruption of the immune response, and synergism seen during COVID-19 infection.[9] Increase in NV-HAP risk could also be associated with placing patients in the prone position (to improve oxygenation) as well as having the diagnosis of dementia, which increases the risk of microaspiration leading to development of secondary bacterial pneumonia.[10]

Beyond prevention efforts, implementation of NV-HAP monitoring via automated electronic surveillance may serve as a cornerstone of a strong infection prevention program. Previous studies on electronic surveillance of NV-HAP have demonstrated high sensitivity, negative predictive value, and accuracy along with a significantly reduced workload associated with manual chart audits.[7] If such a system were in place at the onset of the COVID-19 pandemic, the increase in NV-HAP risk would have been identified sooner.

Limitations of this analysis include the use of ICD-10 code-based definitions for NV-HAP which are prone to variability across settings and use of administrative data-based definitions for other variables. The exclusion of transfer patients to ensure the onset of NV-HAP diagnosis as well as the use of Veteran based demographics (higher proportion male and Caucasian) may limit generalizability to other health systems. The data reflects the VA demographic which is primarily made up of Caucasian Non-Hispanic males over age 50 which may limit external reliability.

Conclusions

Healthcare systems should strengthen plans to prioritize infection prevention efforts and basic nursing care that includes NV-HAP prevention measures (e.g., early mobility programs, oral care, aspiration precautions) for all hospitalized patients that are resilient to extreme system

stress. In addition to a focus on preventive measures, population surveillance is needed to rapidly identify changes in NV-HAP risk. Accurate and efficient NV-HAP surveillance informs and quantifies the impact of prevention initiatives and helps healthcare systems develop practical strategies to reduce HAIs including NV-HAP. Since prevention of NV-HAP improves patient safety and quality of life, saves lives, and reduces cost, strategies to reduce NV-HAP risk should be designed with resilience to significant system stress such as the COVID-19 pandemic.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

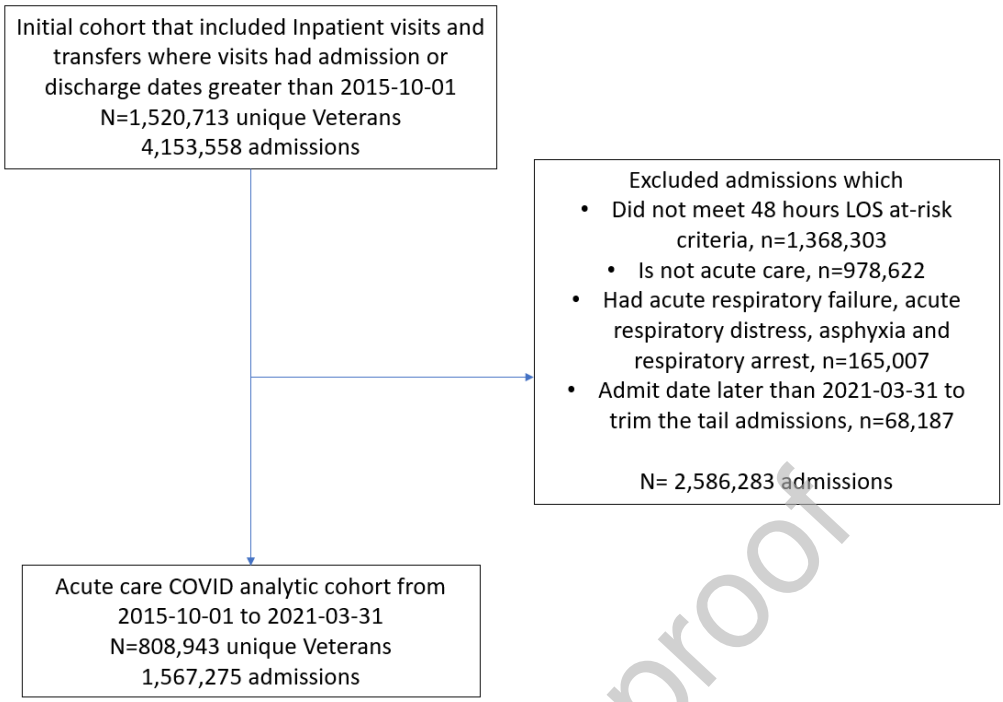

Figure 1: Population flow chart summarizing the inclusion/exclusion criteria

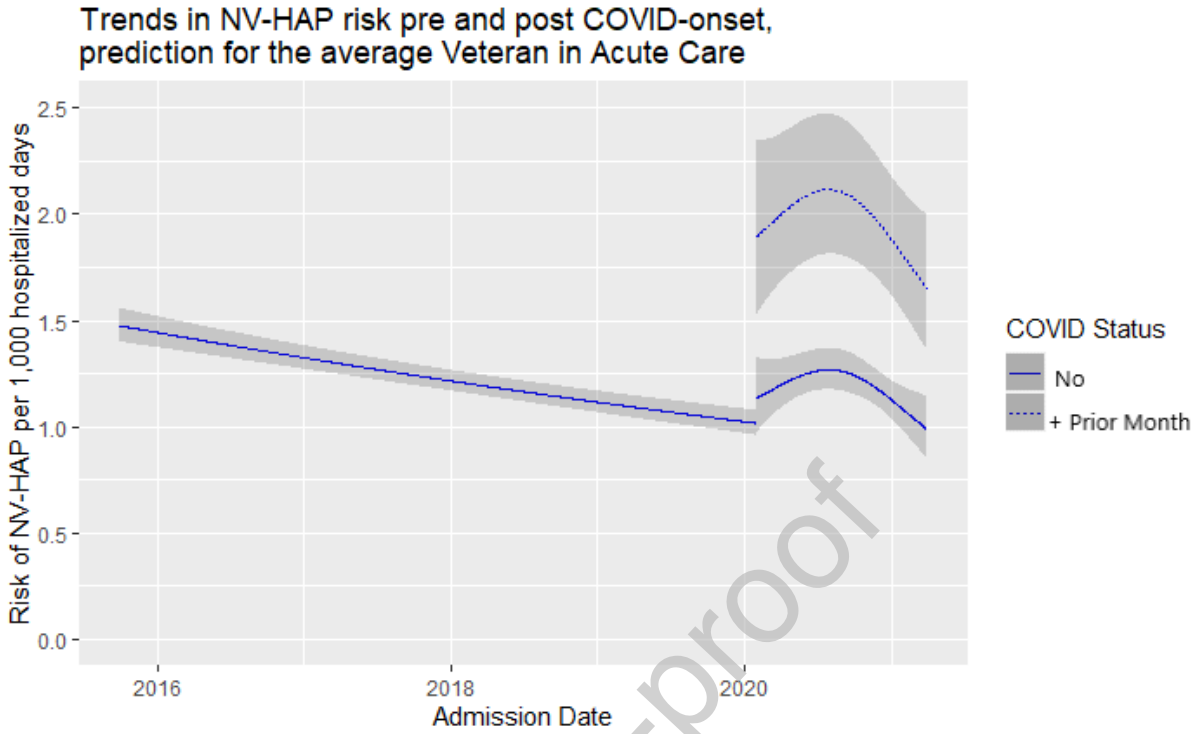

Figure 2: Time trends of NV-HAP incidence with pre/post COVID-19 onset, and separate curves for COVID-19+ patients post COVID-19 onset

Table 1: Select patient traits stratified by era: pre-COVID-19 era, post-COVID-19 era COVID+, and post-COVID-19 era COVID –. Continuous variables are summarized by mean (standard deviation) and categorical variables are summarized by count (percent). Standardized mean differences (SMD) are presented to identify imbalance across groups, with SMD >0.1 bolded.

Variable	Pre-COVID Era Admissions	COVID Era COVID- Admission	COVID Era COVID+ Admissio	SMD

			n	
Total unique index admissions	1,290,056	258,197	19,022	
Demographics				
Age, mean (SD)	70.34 (12.23)	69.35 (12.56)	69.84 (13.79)	0.052
Age<40	29,825 (2.3)	7,957 (3.1)	789 (4.1)	
40<=Age<50	40,649 (3.2)	9,750 (3.8)	698 (3.7)	
50<=Age<65	276,189 (21.4)	59,065 (22.9)	3,948 (20.8)	
65<=Age<75	513,448 (39.8)	99,891 (38.7)	6,758 (35.5)	
75<=Age	429,945 (33.3)	81,534 (31.6)	6,829 (35.9)	
Male Gender, N (%)	1,223,645 (94.9)	244,232 (94.6)	17,996 (94.6)	0.008
Race, N (%)				
Caucasian	910,275 (70.6)	176,715 (68.4)	11,736 (61.7)	**0.125**
African American	288,384 (22.4)	61,501 (23.8)	5,725 (30.1)	**0.118**

American Indian	12,729 (1.0)	2,643 (1.0)	216 (1.1)	0.01
Asian	5,927 (0.5)	1,452 (0.6)	106 (0.6)	0.01
Pacific Islander	11,798 (0.9)	2,553 (1.0)	198 (1.0)	0.009
Unknown	69,810 (5.4)	15,085 (5.8)	1,198 (6.3)	0.025
Ethnicity, N (%)				
Hispanic Latino	81,919 (6.4)	15,989 (6.2)	1,365 (7.2)	0.026
Not Hispanic Latino	1,121,149 (86.9)	216,121 (83.7)	15,762 (82.9)	0.075
Unknown	86,988 (6.7)	26,087 (10.1)	1,895 (10.0)	0.081
Clinical Comorbidities in 1 year prior to admission				
Myocardial infarction, N	121,686 (9.4)	28,037 (10.9)	1,925 (10.1)	0.032

(%)				
Congestive heart failure, N (%)	329,174 (25.5)	71,160 (27.6)	5,039 (26.5)	0.031
Peripheral vascular disease, N (%)	265,363 (20.6)	58,923 (22.8)	3,798 (20.0)	0.046
Cerebrovascular disease, N (%)	185,820 (14.4)	41,296 (16.0)	3,155 (16.6)	0.04
Dementia, N (%)	104,663 (8.1)	22,567 (8.7)	2,676 (14.1)	**0.127**
Chronic pulmonary disease, N (%)	387,765 (30.1)	77,572 (30.0)	5,569 (29.3)	0.011
Connective tissue disease, N (%)	27,392 (2.1)	5,643 (2.2)	414 (2.2)	0.003
Peptic Ulcer disease, N (%)	30,974 (2.4)	6,979 (2.7)	374 (2.0)	0.033
Mild Liver Disease, N	173,865 (13.5)	38,341 (14.8)	2,438 (12.8)	0.039

(%)				
Diabetes without comp, N (%)	525,240 (40.7)	106,913 (41.4)	8,516 (44.8)	0.055
Diabetes with comp, N (%)	309,360 (24.0)	70,686 (27.4)	5,536 (29.1)	0.077
Hemiplegia paraplegia, N (%)	59,071 (4.6)	9,867 (3.8)	685 (3.6)	0.033
Renal disease, N (%)	308,349 (23.9)	68,926 (26.7)	5,478 (28.8)	0.074
Cancer, N (%)	261,231 (20.2)	54,604 (21.1)	3,157 (16.6)	0.078
Severe liver disease, N (%)	36,936 (2.9)	8,362 (3.2)	502 (2.6)	0.024
Metastatic solid tumor	60,909 (4.7)	13,766 (5.3)	717 (3.8)	0.05
AIDS	12,924 (1.0)	2,694 (1.0)	197 (1.0)	0.003
Charlson index, mean (SD)	3.46 (3.04)	3.73 (3.20)	3.64 (3.21)	0.057

Table 2. Nursing interventions to reduce the risk of hospital acquired pneumonia in non-ventilated patients

Nursing intervention	Recommendations
Oral hygiene	Complete an oral care assessment and report any signs of active infection (e.g., abscess, candidiasis). Provide consistent oral care including toothbrushing a minimum of twice daily and dentures/ partials care nightly.[7] Use a suction toothbrush for patients at risk for aspiration.
Early mobility	Follow standardized mobility protocols including passive range of motion, turning in bed, and early and frequent ambulation depending on the physical capabilities of the patient initiated within 24 hours of admission.[7]
Nasogastric-tube care	Adhere to standardized process for placement and management of nasogastric tubes and provision of ongoing staff education and skills testing.[7]
Aspiration precautions	Facilitate dysphagia screening in high-risk patients and evaluation by speech and language pathologists, provide modified diets and feeding strategies for patients with abnormal swallowing, assist with head of bed elevation ("up to eat").[7] For the patient at high-risk for aspiration use a

	suction toothbrush for oral care.
Turn, cough, deep breathing exercises, incentive spirometry, and chest physiotherapy	Follow local healthcare facility policy.[7]
Routine handwashing	Decontaminate hands before and after contact with patients and when visibly soiled.
Influenza, covid-19, and pneumococcal vaccination for patients and healthcare personnel	Administer vaccinations following CDC guidelines and facility policy.
Patient, family and/or caregiver education	Discuss prevention strategies to reduce the risk of NV-HAP with patients and their family/caregivers.[7]

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