Modeling Patient Risk for Hospital-Acquired Pressure Injuries During COVID-19

A Retrospective Study

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ABSTRACT

Background: COVID-19 negatively impacts many organ systems including the skin. One of the most significant skin-associated adverse events related to hospitalization are pressure injuries.

Purpose: The aim of this study was to determine 8 risk factors that would place hospitalized patients at a higher risk for hospital-acquired pressure injuries (HAPIs) during the COVID-19 pandemic.

Methods: A retrospective, descriptive analysis was conducted in an urban academic health science center located in the southeastern United States.

Results: There were 247 of 23 093 patients who had pressure injuries and 1053 patients who had a positive COVID-19 diagnosis. Based on the generalized estimating equation model, diagnosis of COVID-19, age, male gender, risk of mortality, severity of illness, and length of stay are statistically significant factors associated with the development of HAPIs.

Conclusions: Further study should explore pathology of COVID-19 skin changes and what interventions are effective against HAPIs in the COVID-19 population taking into consideration current treatments.

Keywords: coronavirus, COVID-19, hospital-acquired pressure injuries, pressure injury, skin changes

The novel coronavirus, COVID-19, pandemic has been an unprecedented health care challenge. The virus has resulted in higher mortality among hospitalized patients. Researchers and health care providers quickly began studying the evolving patient outcomes associated with COVID-19 to mitigate the risk of the disease on organs and systems of the body.[1] Health care providers have learned much about the negative impact of COVID-19, although an organ system, the skin, was unexpectedly impacted. Dermatologists and health care providers around the globe have encountered cutaneous lesions such as (1) urticarial rash, (2) confluent erythematous maculopapular-morbilliform rash, (3) papulovesicular exanthem, (4) chilblain-like acral pattern, (5) livedo reticularis–livedo racemosa-like pattern, and (6) purpuric "vasculitic" pattern.[2] Given these inflammatory and vasculopathic manifestations, it is clear that this novel coronavirus disease has broad-reaching impacts on the skin, although much is still unknown.[3] There is also little known about risk factors or social determinants of health that place patients at greater risks for developing negative outcomes of organs or systems impacted by COVID-19.

One of the most significant skin-associated adverse events related to hospitalization is pressure injury. The more common pathophysiological causes of pressure injuries include local tissue ischemia, reperfusion injury, increased capillary permeability and soft-tissue edema,

compromised lymphatics, direct mechanical insult to cells, upregulated autophagy, accelerated cell senescence, and alterations in skin microclimate including temperature and moisture.[4] Pressure injuries are also linked to prolonged hospital stays, pressure over bony prominences, and lack of blood flow to an area of the body, often as a result of lack of positional change or pressure associated with medical devices.[5-7] Researchers have shown that there are specific risk factors such as advanced age and severity of illness (SOI) that place hospitalized patients at a higher risk for the development of pressure injuries.[8,9] The risk factors can be grouped into 6 categories including demographic/patient characteristics, comorbidities, intrinsic factors (eg, hypotension), iatrogenic/care factors (eg, prolonged mechanical ventilation use), pressure injury risk assessment scales, and SOI/mortality risk.[10] However, there is limited evidence on multiple risk factors in a single study. Hospitalized patients being treated for COVID-19 may be at a significant risk for pressure injury, given their lack of mobility and use of devices associated with mechanical ventilation, positional pressure associated with proning for mitigation of consolidation of fluids in the lungs, and the vascular aspects and skin changes associated with the disease itself.[11-15] It is not known whether there are variations in the incidence of pressure injuries based on demographic and other characteristics. Yet, social determinants of health (eg, poor health literacy, lower income, insurance) and demographic characteristics have been shown to be associated with adverse health outcomes in general and the likelihood of pressure injuries specifically.

The purpose of this retrospective study was to examine 8 risk factors from demographic/patient characteristics and SOI/mortality risk[16] categories based on the Cox study, including age, race, gender, length of stay (LOS), risk of mortality (ROM), SOI, All Patients Refined Diagnosis Related Groups (APR-DRGs), and COVID-19 diagnosis, that would place hospitalized patients at a higher risk for the development of hospital-acquired pressure injuries (HAPIs). We sought to answer the following research questions: Are there differences in the development of HAPIs for patients with and without COVID-19? and Are there specific social determinants of health risk and demographic factors that place patients at a higher risk for the development of HAPIs

during COVID-19? The ability to identify patients at higher risk upon admission to a health care facility may allow providers to proactively prevent the patient harm associated with pressure injuries and specifically target certain social determinants of health predictive of pressure injury development in the patient population.

METHODS
Study design and setting
The study was designed as a retrospective, descriptive analysis. The setting for this project was an urban academic health science center located in the southeastern United States. The academic health center is the third largest public hospital in the United States. The medical center has 1157 beds and sees an average of 55 000 admissions per year and 6000 ambulatory visits per day, has 1400 physicians, 3600 nurses, 800 advanced practice providers, and since 2002 is a 5-time American Nurse Credentialing Center (ANCC) Magnet designated facility.

Study population
A total of 23 093 patient cases were used for the study, representing all patients discharged during the first 6 months of the COVID-19 pandemic, from March 2020 to August 2020. Administrative, demographic, and HAPI data were collated into an Excel spreadsheet from our hospital billing system and our internal HAPI analytic tool.[17,18] Patient demographic data were collected via a data steward using patient identifiers but were de-identified prior to analysis and provision to the study principal investigator.

Variables
We evaluated the impact of 8 demographic factors—age, race, gender, LOS, ROM, SOI, APR-DRGs, and COVID-19 diagnosis—specific to the hospitalized patient for the development of HAPIs during the pandemic. ROM and SOI are calculated on each hospitalized patient based on assigned diagnosis and procedure codes using an algorithm through medical record coding software.[19,20] ROM and SOI were scored 1 (minor), 2 (moderate), 3 (major), and 4 (extreme). Our outcome variable of pressure injury was obtained from wound, ostomy, continence nurse–staged pressure injury documentation, documented within our internal HAPI analytic tool.[18] The study was approved by the

organization's institutional review board (IRB) as exempt per protocol number IRB-300005834.

Statistical techniques

Descriptive statistics for the demographic variables were tabulated to characterize the sample. For continuous variables, average, SD, and range were reported, whereas frequency and percentages were reported for categorical variables. Listwise deletion was employed to address missing data. Independent-samples t tests and chi-square tests were performed to identify differences on variables between patients with and without HAPI.[21] Effect sizes for all comparisons also were obtained.[22] Finally, generalized estimating equation (GEE) models were used to predict HAPIs.[23] We used GEE to account for patients who were admitted more than once. To avoid multicollinearity, variance inflation factors (VIFs) were analyzed before using GEE models. All analyses were performed using SPSS version 27 (IBM Corp, Armonk, New York) and SAS version 9.4 (SAS Institute Inc, Cary, North Carolina).

RESULTS

Participant demographics

The average age of patients was 53 years (SD = 18.63). The average LOS was 7 days (SD = 9.39). The majority of participants were White (57%), female (52%), had ROM of class I (36%), had SOI of class II (38%), and had no COVID-19–positive diagnosis during the admission (95.4%). There were 247 of 23 093 (1%) patients who had HAPI. The top 3 APR-DRGs of all participants were septicemia (8.1%), vaginal delivery (5.2%), and heart failure (2.7%). Table 1 shows more details about patient demographics.

Comparisons between patients with and without HAPI

Patients with HAPI were significantly older (M = 63.5 years, SD = 17.0) than patients without HAPI (M = 53.1 years, SD = 18.6) ($t_{252.42}$ = −9.6, $P <$ .001, Glass's Δ = 17.0). Patients with HAPI stayed in the hospital longer (M = 29.8 days, SD = 27.2) than patients without HAPI (M = 6.44 days, SD = 8.7) ($t_{264.54}$ = −13.5, $P <$ .001, Glass's Δ = 27.2). Patients with HAPI were predominantly male (61%), while patients without HAPI were mostly female (52%) ($\chi^2_{1,23093}$ = 17.04, $P <$ .001, Cramer's V = 0.03). A higher percentage of patients with HAPI had ROM and SOI of class III and IV (95.1% and 95.6%, respectively) compared with patients without HAPI (38.5% and 45.9%, respectively) ($\chi^2_{4,23093}$ = 686.4 and 742.6, respectively, $P <$ .001, both Cramer's Vs = 0.18). More patients with HAPI were diagnosed with COVID-19 (20.2%) than patients without HAPI (4.4%) ($\chi^2_{1,23093}$ = 141.1, $P <$ .001, Cramer's Vs = 0.08). APR-DRGs were also significantly different between patients with and without HAPI ($\chi^2_{291,23093}$ = 1936.4, $P <$ .001, Cramer's V = 0.29). The top 5 APR-DRGs for each group are presented in Table 2. However, race was not significantly different between patients with and without HAPI ($\chi^2_{2,23093}$ = 0.75, P = .69, Cramer's V = 0.006).

Predictors of HAPIs during the COVID-19 pandemic

The results of VIF (<3) identified that there was no multicollinearity among the variables in the model. Based on the GEE model, we found the presence of COVID-19 (OR = 1.50), age (OR = 1.03), male gender (OR = 1.36), ROM (OR = 2.22), SOI (OR = 2.38), and LOS (OR = 1.05) to be statistically significant factors associated with the development of HAPIs. Race was not a significant predictor in this patient population (OR$_{Black}$ = 1.07 and OR$_{Other}$ = 1.23 compared with White). Because childbirth was the second most prevalent DRG in the original sample, we also repeated the analysis after removing all the labor and delivery patients (ie, cesarean delivery and vaginal delivery) (n = 1879). In the model without the labor and delivery patients, we found no differences in significant predictors (N = 21 214) and ORs were nearly identical to the original model (N = 23 093). Results of both models are presented in Supplemental Digital Content, Table (available at: http://links.lww.com/JNCQ/A910).

DISCUSSION

The study team sought to identify the characteristics associated with the likelihood of acquiring an HAPI among any patient hospitalized during the first 6 months of the COVID-19 pandemic. We found that certain demographic factors (being older and male), clinical characteristics (ROM and SOI of class III and IV, and APR-DRGs), and a longer LOS were associated with a greater likelihood of developing an HAPI. In

Table 1. Patient Characteristics by HAPI Status

Characteristics	Overall (N =23 093)	Patients Without HAPI (N = 22 846)	Patients With HAPI (N = 247)
Age, mean (SD), y	53.23 (18.6)	53.12 (18.6)	63.52 (16.9)
Race, n (%)			
White	13 106 (56.8)	12 972 (56.8)	134 (54.3)
Black	8 647 (37.4)	8 548 (37.4)	99 (40.1)
Hispanic	587 (2.5)	582 (2.5)	5 (2.0)
Others	753 (3.3)	744 (3.3)	9 (3.6)
Female, n (%)	11 990 (51.9)	11 894 (52.1)	96 (38.9)
LOS, mean (SD), d	6.69 (9.4)	6.44 (8.7)	29.77 (27.2)
SARS-CoV-2, n (%)			
No infection	22 040 (95.4)	21 843 (95.6)	197 (79.8)
Infection	1 053 (4.6)	1 003 (4.4)	50 (20.2)
Number of PIs, mean (SD)	0.02 (0.2)	...	1.57 (1.2)
ROM, n (%)			
0	1 (0)	1 (0)	0 (0)
1	8 331 (36.1)	8 330 (36.5)	1 (0.4)
2	5 725 (24.8)	5 714 (25.0)	11 (4.5)
3	5 370 (23.3)	5 321 (23.3)	49 (19.8)
4	3 666 (15.9)	3 480 (15.2)	186 (75.3)
SOI, n (%)			
0	1 (0)	1 (0)	0 (0)
1	3 528 (15.3)	3 527 (15.4)	1 (0.4)
2	8 826 (38.2)	8 816 (38.6)	10 (4.0)
3	6 924 (30.0)	6 886 (30.1)	38 (15.4)
4	3 814 (16.5)	3 616 (15.8)	198 (80.2)

Abbreviations: HAPI, hospital-acquired pressure injury; LOS, length of stay; PI, pressure injury; ROM, risk of mortality; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SOI, severity of illness.

Table 2. Top 5 APR-DRG Codes by HAPI Status

APR-DRG Codes	Overall, N (% of 23 093)	Patients Without HAPI, N (% of 22 846)	APR-DRG Codes	Patients With HAPI, N (% of 247)
720 Septicemia	1863 (8.1)	1801 (7.9)	720 Septicemia	62 (25.1)
560 Vaginal delivery	1190 (5.2)	1190 (5.2)	004 Tracheostomy with extensive procedure	58 (15.0)
194 Heart failure	623 (2.7)	623 (2.7)	005 Tracheostomy without extensive procedure	21 (8.5)
540 Cesarean delivery	479 (2.1)	479 (2.1)	710 Infectious and parasitic diseases	15 (6.1)
137 Respiratory infections	346 (1.5)	343 (1.5)	045 CVA and precerebral occlusion with infarction	6 (2.4)

Abbreviations: APR-DRG, All Patients Refined Diagnosis Related Groups; CVA, cerebrovascular accident; HAPI, hospital-acquired pressure injury.

addition, our analysis demonstrated that patients with a diagnosis of COVID-19 were 1.5 times more likely to develop an HAPI than patients without a COVID-19 diagnosis, controlling for age, ROM, SOI, APR-DRGs, gender, and LOS. We found that race was not a predictor of HAPIs in our patient population. As seen in Table 1, the breakdown by race was similar between patients with and without HAPI.

COVID-19 has been reported to impact all body systems including the skin,[1-3] and our results suggest that COVID-19 is a factor for a greater risk of developing HAPIs. There could be several reasons for the increased risk of developing HAPIs in the COVID-19 patient population. Researchers have shown that there are vascular-associated skin changes with the virus infection that may impact the development of pressure injuries in patients who are physiologically compromised.[24] COVID-19 may impact the respiratory system, requiring mechanical ventilation.[25] With mechanical ventilation, patients are exposed to tubes and drains known to increase the risk for device-related pressure injuries, the necessity for proning or placing the patient in a position that increases the risk for upper-body pressure injuries (specifically face and neck).[12,15]

Health care provider workflow and other process changes may also be a factor in the development of HAPIs. The pandemic required changes to workflow that limited nurse-patient interaction to what was absolutely necessary, given supply concerns with personal protective equipment.[26] Family and other patient caregivers were often restricted from the bedside, decreasing the number of individuals seeing the patient.[27]

Our study sought to evaluate predictors such as race that are associated with demographic characteristics found in other published research. We did not find a statistically significant association for the development of pressure injuries in any particular race for patients with COVID-19. It is well established that patients who are older, who are sicker, and who stay in the hospital longer are at an increased risk of developing HAPIs.[8,9] These premises remained true for our study, as older patients with higher ROM and SOI were found to be at a greater risk of developing HAPIs. However, future research should examine whether the occurrence and pro-gression of HAPIs in COVID-19 patients are different from those in non–COVID-19 patients. Furthermore, research should examine whether the various mitigation, prevention, or treatment strategies have differential impact on COVID-19 versus non-COVID-19 patients.

Implication of our findings

With more than 6 million people having tested positive for the COVID-19 in the United States as of August 2020,[28] patients with a diagnosis of COVID-19 were 1.5 times more likely to develop an HAPI than patients without a COVID-19 diagnosis after we controlled for patients' age, race, gender, ROM, SOI, and LOS in this study. The presence of an HAPI is painful for the patient and can progress to more serious stages, even septicemia, rather quickly if not properly treated. An HAPI has implications for home care after discharge, as wound care must continue until complete healing takes place. Prevention of pressure injuries is an essential aspect of nursing practice. Further studies should explore what intervention(s) may be most effective in COVID-19 patients (eg, proning and silicone adhesive dressings). Further studies should explore (1) the pathology of COVID-19 skin changes that result in additional risk of developing HAPIs, and (2) what interventions are effective against HAPIs in the COVID-19 population taking into consideration current treatments.

Strengths and limitations

The strengths of our study include its size and completeness, with patients admitted to the hospital during the early COVID-19 pandemic. However, some limitations should be noted. Residual confounding is possible. Since administrative (billing) data were obtained from our hospital billing system, we did not have availability of all possible factors related to the risk of developing an HAPI, such as the patients' nutritional status.

CONCLUSIONS

COVID-19 is reported to impact all body systems including the skin, and our results suggest that COVID-19 is a factor for a greater risk of developing HAPIs. Our study shows that patients with a diagnosis of COVID-19 were more likely to develop an HAPI. Research is needed to explore and test interventions specific to the

mitigation of HAPIs in COVID-19 patients in comparison with mitigation strategies for all hospitalized patients.

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