

The Third Wave: Comparing Seasonal Trends in COVID-19 Patient Data at a Large Hospital System in New York City

IMPORTANCE: The third wave of COVID-19 is unique in that vaccines have been widely available; however, the highly transmissible Delta variant has been the predominant strain. Temporal changes of hospitalized patient characteristics should continue to be analyzed as COVID-19 progresses.

OBJECTIVES: Compare the demographics and outcomes of hospitalized patients during New York City's third wave of COVID-19 to the first two waves.

DESIGN, SETTING, AND PARTICIPANTS: Retrospective cohort study across five hospitals within Mount Sinai Health System, a quaternary academic medical system in New York City. Participants were adult inpatients admitted with COVID-19 identified by positive severe acute respiratory syndrome coronavirus 2 polymerase chain reaction at admission or clinical documentation of infection during the three waves of COVID-19.

MAIN OUTCOMES AND MEASURES: Patient demographics, comorbidities, vaccination status, and outcomes of COVID-19 patients hospitalized at Mount Sinai Health System were examined. Patients admitted during the third wave were notably younger than the first two, were mostly unvaccinated against COVID-19, and there was a higher rate of patients who self-report as Black or African American as compared with the first two waves. The rate of patients requiring ICU level of care remained consistent throughout all three periods; however, the rate of patients requiring invasive mechanical ventilation decreased and in-hospital mortality has trended down. Unvaccinated patients in the third wave are significantly younger with lower comorbidity burden than fully vaccinated patients.

RESULTS: A total of 13,036 patients were included between the 3 waves. In the 3rd wave patients were notably younger, with a lower intubation rate and lower in-hospital death rate. In the 3rd wave, 400 (62.9%) were unvaccinated, 236 (37.1%) were fully vaccinated, and 34 (4.8%) were partially vaccinated. Unvaccinated patients had similar rates of intubation and invasive mechanical ventilation compared with vaccinated patients, though in-hospital mortality was lower in unvaccinated patients compared with vaccinated patients which may be expected given their lower age and burden of comorbidities.

CONCLUSIONS AND RELEVANCE: We continue to see improved outcomes in hospitalized COVID-19 patients. Patients that are unvaccinated against COVID-19 are younger and have less reported comorbidities.

KEY WORDS: COVID-19; intubation rate; mortality; renal failure; second wave

As of December 2021, New York City (NYC) has reported over 1 million cases of COVID-19 and almost 35,000 deaths. NYC Department of Health was one of the first COVID-19 epicenters in the United States in early 2020 and has subsequently experienced additional waves of surging COVID-19 cases—in the Winter 2020 into early Spring 2021, and in July to October 2021 (1).

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During NYC's initial surge, there was significantly high morbidity and mortality among hospitalized patients, especially in patients requiring intubation (2,3). During the second wave of COVID-19 hospitalizations in the Winter 2020, the mortality and morbidity rates of hospitalized patients were lower than the first wave and patients were less likely to be intubated (3).

The third wave of COVID-19 in NYC is unique in that vaccines were widely available for people over the age of 12 years old (4–6). By August 2021, about 55% of NYC's population had been fully vaccinated (7). However, the highly transmissible Delta variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus was the predominant strain at this time. The Delta variant is estimated to be about 50% more transmissible than the original SARS-CoV-2 strain (8, 9).

OBJECTIVES

Our objective is to compare the demographics and outcomes of patients admitted to Mount Sinai Health system during the third surge compared with the first two surges. As vaccine distribution continues and new variants potentially emerge, it is crucial that temporal changes of hospitalized patient characteristics continue to be analyzed.

DESIGN, SETTING, AND PARTICIPANTS

The study population consists of all adult inpatients admitted to five of Mount Sinai Health System's academic hospitals in NYC, with COVID-19 identified by positive SARS-CoV-2 polymerase chain reaction at admission or clinical documentation of infection. Patients were grouped into three periods based on visual analysis of the epidemic curve: wave 1, the primary surge from April 1, 2020, to June 30, 2020; wave 2, the second surge from September 1, 2020, to April 30, 2021; and wave 3, the third surge from July 1, 2021, to September 26, 2021, with follow-up through October 26, 2021. Time periods July 1, 2020, to August 31, 2020, and May 1, 2021, to June 30, 2021, were excluded due to very low patient volumes that were not representative of the three surge periods included in the analysis. Vaccination status was identified for patients in wave 3 by a manual chart review; patients were considered fully vaccinated 2 weeks after receiving the second dose of either the Pfizer-BioNTech COVID-19 vaccine or the Moderna COVID-19 vaccine, or 2 weeks after

receiving the Johnson & Johnson/Janssen COVID-19 vaccine. Patients were considered partially vaccinated if they had received any dose of COVID-19 vaccine but did not reach the definition of full vaccination. To provide the clearest understanding in differences in demographics and outcome between vaccinated and unvaccinated patients, patients who were partially vaccinated or whose vaccine status are unknown are not included in vaccine-specific analysis. Comorbidities were extracted from billing records using *International Classification of Diseases*, 10th Revision codes. Data processing was performed in Python Version 3.7.3 (Python Software Foundation, Wilmington, DE, <https://www.python.org/>), and analysis was completed in R Version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria, <https://www.R-project.org/>) with RStudio Version 1.2.5001 (RStudio PBC, Boston, MA, <http://www.rstudio.com/>). The study was approved by the Mount Sinai Hospital Institutional Review Board number 20-0054.

RESULTS

A total of 13,036 patients were included in the current analysis; 6,490 in wave 1, 5,842 in wave 2, and 704 in wave 3. An epidemic curve is shown in **SDC-Figure 1** (Supplemental Digital Content, <http://links.lww.com/CCX/A940>), and patient demographics are summarized in **Table 1**. Comparing wave 1 and wave 2; patient age, gender, body mass index, and rate of medical comorbidities including diabetes, hypertension, chronic lung disease, chronic liver disease, and chronic kidney disease were similar in both periods. High rates of unknown race were present in all periods (21% in wave 1 and wave 2, 17% in wave 3). The unadjusted in-hospital death rate was lower in wave 2 than in wave 1 (14% vs 24%), and the rate of mechanical ventilation was also lower in wave 2 compared with wave 1 (8.1% vs 13%). ICU level of care was given to similar proportions of patients in the first two waves (16% vs 19%).

Wave 3 patients were notably younger than in wave 1 and wave 2 (mean 60 in wave 3 vs 65 in wave 1 and wave 2; $p < 0.001$). There was a higher rate of reported Black race in wave 3 than in wave 1 and wave 2 (33% in wave 3 vs 26% in wave 1 and 21% in wave 2). ICU level of care was given to a similar proportion of patients in wave 3 (19%) as in wave 1 and wave 2; however, the intubation rate was lower (8.9% in wave 3 vs 13% in wave 1 and 8.1% in wave 2; $p < 0.001$). In-hospital death rate

TABLE 1.
COVID-19 Demographics and Outcomes in First, Second, and Third Surges of COVID-19 in Patients Admitted to MSHS

Characteristic	Wave 1, March 2020–June 2020, <i>n</i> = 6,490 ^a	Wave 2, September 2020–April 2021, <i>n</i> = 5,842 ^a	Wave 3, July 2021–September 2021, <i>n</i> = 704 ^a	<i>p</i> ^b
Age	65 (17)	65 (18)	60 (19)	< 0.001
Gender				< 0.001
Female	2,812 (43%)	2,782 (48%)	340 (48%)	
Male	3,678 (57%)	3,060 (52%)	364 (52%)	
Unknown	0 (0%)	0 (0%)	0 (0%)	
BMI	29 (9)	29 (11)	30 (18)	0.015
Race				
White	1,612 (25%)	1,868 (32%)	211 (30%)	
Black	1,664 (26%)	1,243 (21%)	231 (33%)	
Hispanic	1,513 (23%)	1,077 (18%)	114 (16%)	
Asian	330 (5.1%)	408 (7.0%)	20 (2.8%)	
Native American or Pacific Islander	23 (0.4%)	14 (0.2%)	5 (0.7%)	
Other	1,348 (21%)	1,232 (21%)	123 (17%)	
History of diabetes	899 (40%)	664 (39%)	55 (28%)	0.003
History of hypertension	1,376 (62%)	1,037 (61%)	93 (47%)	< 0.001
History of chronic lung disease	442 (20%)	314 (18%)	29 (15%)	0.2
History of chronic liver disease	196 (8.8%)	147 (8.6%)	25 (13%)	0.2
History of renal failure	452 (20%)	352 (21%)	38 (19%)	0.9
History of heart failure	332 (15%)	330 (19%)	35 (18%)	0.001
HIV/AIDS	64 (2.9%)	22 (1.3%)	5 (2.5%)	0.002
History of alcohol or substance use disorder	110 (4.9%)	62 (3.6%)	5 (2.5%)	0.063
BMI ≥ 30.0	1,778 (37%)	1,932 (36%)	233 (36%)	0.3
Ever received ICU level of care	1,242 (19%)	923 (16%)	135 (19%)	< 0.001
Ever intubated	831 (13%)	473 (8.1%)	63 (8.9%)	< 0.001
Hospital length of stay, d	7 (3–12)	7 (4–14)	6 (3–12)	< 0.001
Died	1,550 (24%)	840 (14%)	81 (12%)	< 0.001
Discharged out of hospital	4,932 (76%)	4,998 (86%)	606 (86%)	< 0.001
Routine discharge to home	2,913 (45%)	3,010 (52%)	427 (61%)	< 0.001
Not routine discharge to home	2,019 (31%)	1,988 (34%)	179 (25%)	< 0.001

BMI = body mass index, MSHS = Mount Sinai Health System.

^aMean (sd); *n* (%); median (interquartile range).

^bKruskal-Wallis rank-sum test; Fisher exact test; Pearson χ^2 test.

in wave 3 was 12%, compared with 14% in wave 2 and 24% in wave 1 ($p < 0.001$).

Of the 704 admitted patients in wave 3, 400 (62.9%) were unvaccinated, 236 (37.1%) were fully vaccinated, 34 (4.8%) were partially vaccinated, and 34 (4.8%) had unknown vaccine status. Comparison between fully

vaccinated and unvaccinated patients is presented in **Table 2**. Fifty-three percent of vaccinated patients received the Pfizer-BioNTech vaccine, 25% the Moderna, and 18% the Johnson & Johnson vaccine. Ten patients had unknown type of vaccine but were reported to be fully vaccinated. Unvaccinated patients were significantly

TABLE 2.

COVID-19 Demographics and Outcomes by Vaccine Status in Patients Admitted to MSHS From July 1, 2021, to August 17, 2021

COVID-19 Demographics and Outcomes by Vaccine Status in MSHS			
Fully Vaccinated and Unvaccinated Patients Admitted From July 1, 2021, to September 26, 2021			
Characteristic	Unvaccinated, <i>n</i> = 400 ^a	Fully Vaccinated, <i>n</i> = 236 ^a	<i>p</i> ^b
Age	54 (19)	69 (17)	< 0.001
Gender			0.007
Female	208 (52%)	96 (41%)	
Male	192 (48%)	140 (59%)	
U	0 (0%)	0 (0%)	
BMI	32 (23)	27 (7)	< 0.001
Race			< 0.001
White	93 (23%)	98 (42%)	
Black	148 (37%)	60 (25%)	
Hispanic	74 (18%)	32 (14%)	
Asian	11 (2.8%)	9 (3.8%)	
Native American or Pacific Islander	3 (0.8%)	2 (0.8%)	
Other	71 (18%)	35 (15%)	
BMI ≥ 30.0	153 (41%)	62 (29%)	0.004
History of diabetes	25 (23%)	25 (33%)	0.2
History of hypertension	38 (36%)	47 (62%)	< 0.001
History of chronic lung disease	19 (18%)	9 (12%)	0.4
History of chronic liver disease	8 (7.5%)	15 (20%)	0.025
History of renal failure	9 (8.4%)	24 (32%)	< 0.001
History of heart failure	13 (12%)	19 (25%)	0.04
HIV/AIDS	2 (1.9%)	3 (3.9%)	0.7
History of alcohol or substance use disorder	3 (2.8%)	2 (2.6%)	> 0.9
Ever received ICU level of care	74 (18%)	51 (22%)	0.4
Ever intubated	37 (9.2%)	22 (9.3%)	> 0.9
Hospital length of stay, d	6 (3–11)	7 (4–14)	0.1
Died	36 (9.0%)	35 (15%)	0.034
Discharged out of hospital	350 (88%)	198 (84%)	0.2
Routine discharge to home	261 (65%)	129 (55%)	0.01
Not routine discharge to home	89 (22%)	69 (29%)	0.061
Vaccination type			< 0.001
Johnson and Johnson	0 (0%)	42 (18%)	
Moderna	0 (0%)	58 (25%)	
Pfizer-BioNTech	0 (0%)	126 (53%)	
Unknown/other	0 (0%)	10 (4.2%)	
Unvaccinated	400 (100%)	0 (0%)	

BMI = body mass index.

^aMean (sd); *n* (%); median (interquartile range).

^bWilcoxon rank-sum test; Pearson χ^2 test.

younger than vaccinated patients (mean 54 vs 69; $p < 0.001$). Unvaccinated patients were less likely to identify as White (23% unvaccinated vs 42% fully vaccinated) and more likely to identify as Black (37% unvaccinated vs 25% vaccinated) or Hispanic (18% vs 14%) (χ^2 test; $p < 0.001$). Unvaccinated patients had a significant trend toward higher rates of obesity (41% vs 29%; $p = 0.004$). Unvaccinated patients had significantly lower rates of hypertension (36% vs 62%; $p < 0.001$), chronic kidney disease (8.4% vs 32%; $p < 0.001$), chronic liver disease (7.5% vs 20%; $p = 0.025$), and heart failure (12% vs 25%; $p = 0.04$). Unvaccinated patients had similar rates of intubation and invasive mechanical ventilation compared with vaccinated patients (9.2% vs 9.3%), although in-hospital mortality was lower in unvaccinated patients compared with vaccinated patients (9.0% vs 15%; $p = 0.034$). Hospital length of stay and ICU level of care were similar in both groups. Given differences in comorbidity burden between groups, a multivariable logistic regression predicting in-hospital mortality including age, vaccine status, and history of hypertension, chronic kidney disease, chronic liver disease was fit (**SDC-Table 1**, Supplemental Digital Content, <http://links.lww.com/CCX/A940>). After adjustment for comorbidities, being fully vaccinated had odds ratio (OR) for in-hospital death of 0.82 ($p = 0.7$). In univariate regression predicting in-hospital mortality, increasing age (in years) (OR 1.04, $p < 0.001$); fully vaccinated status (OR 1.76, $p = 0.025$); and histories of hypertension (OR 3.01, $p < 0.01$), chronic liver disease (OR 3.94, $p < 0.01$), renal failure (OR 3.64, $p < 0.01$), and heart failure (OR 4.83, $p = 0.001$) were associated with in-hospital mortality (**SDC-Table 2**, Supplemental Digital Content, <http://links.lww.com/CCX/A940>).

CONCLUSIONS AND RELEVANCE

Throughout the COVID-19 pandemic, inpatient demographics and outcomes have been dynamic. We have previously reported a greater than 50% reduction in death rate over time for patients admitted for COVID-19 between the first and second surge periods (3). In the current study, we examine the third surge of COVID-19 hospitalizations in NYC. In general, the patient population admitted with COVID-19 during the third wave has been younger (10–12). This aligns with previous research reporting that since the first wave, the age distribution of COVID-19 positive patients has shifted

with an increase of cases in ages 39 and below (13). There appears to be a lower comorbidity burden in the third wave compared with earlier in the pandemic. The percentage of patients admitted to ICUs remains unchanged at 16–19%; however, there is a continued decrease in mortality rates. While mortality is lower as the pandemic extends, it is difficult to investigate the cause due to the retrospective nature of this review. Possible contributions include population factors (potentially the highest risk patients for mortality already died in the first two waves of COVID-19, fewer patients are now at-risk given widespread vaccination), patient factors (many more patients are vaccinated and may have a more benign course with breakthrough infection), hospital factors (during the initial wave in early 2020 patient volume was significantly higher with commensurately higher stress on the healthcare system), or improved therapies (new treatments and better understanding of what treatments have been showed to be efficacious for COVID-19).

With the increased prevalence of the three COVID-19 vaccines approved in the United States, an additional analysis of vaccination status and vaccine type was included for the third COVID-19 wave patients. The majority of hospitalized patients in wave 3 were unvaccinated. Vaccinated, hospitalized patients were older, more likely to be male, White, and non-obese, as well as having significantly higher rates of hypertension, chronic kidney disease, chronic liver disease, and heart failure. While the percentage of patients requiring ICU admission was not affected, vaccinated patients had a higher rate of in-hospital death in wave 3; however, after adjustment for comorbidities, there was a nonsignificant trend to lower in-hospital mortality in vaccinated patients. Of the vaccinated patients who tested positive and were admitted to the hospital, 53% received the Pfizer vaccine, 25% received the Moderna, and 18% received the J&J. This imbalance may be at least partially related to the Pfizer vaccine being more heavily used in this health system and the surrounding areas.

In conclusion, we continue to see the trend of improved outcomes in patients admitted to a large healthcare system in NYC with COVID-19. During the most recent surge period of July 2021 to September 2021, just under two-thirds of the admitted patients (400 vs 236) were unvaccinated; however, there was no difference in the vaccination status of intubated patients (9.2%

vs 9.3%). Of concern, there has been a relative increase in younger, unvaccinated COVID patients without significant comorbidities in the most recent wave. The data herein serve to further perpetuate the evidence supporting vaccination against COVID-19 for all individuals.

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