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MAJOR ARTICLE

In-Hospital 30-Day Survival Among Young Adults With Coronavirus Disease 2019: A Cohort Study

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Background. Our objective was to characterize young adult patients hospitalized with coronavirus disease 2019 (COVID-19) and identify predictors of survival at 30 days.

Methods. This retrospective cohort study took place at 12 acute care hospitals in the New York City area. Patients aged 18–39 hospitalized with confirmed COVID-19 between March 1 and April 27, 2020 were included in the study. Demographic, clinical, and outcome data were extracted from electronic health record reports.

Results. A total of 1013 patients were included in the study (median age, 33 years; interquartile range [IQR], 28–36; 52% female). At the study end point, 940 (92.8%) patients were discharged alive, 18 (1.8%) remained hospitalized, 5 (0.5%) were transferred to another acute care facility, and 50 (4.9%) died. The most common comorbidities in hospitalized young adult patients were obesity (51.2%), diabetes mellitus (14.8%), and hypertension (13%). Multivariable analysis revealed that obesity (adjusted hazard ratio [aHR], 2.71; 95% confidence interval [CI], 1.28–5.73; $P = .002$) and Charlson comorbidity index score (aHR, 1.20; 95% CI, 1.07–1.35; $P = .002$) were independent predictors of in-hospital 30-day mortality.

Conclusions. Obesity was identified as the strongest negative predictor of 30-day in-hospital survival in young adults with COVID-19.

Keywords. coronavirus disease 2019 (COVID-19); mortality; severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2); young adults.

On December 31, 2019, the World Health Organization was notified about the condition that would later be named coronavirus disease (COVID-19) [1, 2]. Estimates of severe disease range from 20% to 30% with case fatality rates ranging from 2% to 7% [3–5]. The majority of deaths due to COVID-19 have been in patients over 65 years old, who are also more likely to be hospitalized and require treatment in intensive care units [5]. However, this disease has not only afflicted the elderly; young adults are 41% of total COVID-19 cases in both the United States and in New York City in particular [6, 7].

Predictors of mortality for patients of all age groups with COVID-19 have been identified in several studies. Consistent predictors include older age, male sex, and comorbidities, such as hypertension, cardiovascular disease, and diabetes [8–13]. Studies have also noted obesity as a significant predictor of severe illness, particularly hospitalization [14–16]. Although these factors may increase mortality risk in young adults, our understanding of COVID-19 in this age group is limited. One research letter describing the clinical outcomes of hospitalized young adults with COVID-19 indicated a mortality rate of 2.7%, with obesity being the strongest risk factor for adverse events [17]. Well founded concerns about a second wave of COVID-19 and evidence of shifts in differential mortality by demographics in previous pandemics are among many reasons why we must understand predictors of risk and survival in this age group [18–21].

Our objective was to characterize hospitalized patients aged 18 to 39 and define predictors of 30-day survival in these young adults. In addition, we characterize hospitalized, college-aged (18 to 24 years) patients. This group is of particular interest considering the inherent infectious disease risk associated with the close social contact that is typical in most college and university settings; more than 12 million individuals worldwide attend college or university every year. Such settings carry significant risk of rapid spread and potential severe disease and mortality [22].

METHODS

This retrospective cohort study was conducted at 12 hospitals within Northwell Health, the largest academic health

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system in New York. These acute care facilities are located throughout New York City and the surrounding suburbs of Long Island and Westchester County. The Northwell Health Institutional Review Board approved this study as minimal-risk research using data collected for routine clinical practice and therefore waived the requirement for informed consent. Previous studies have used portions of this cohort of patients; however, none examined predictors of mortality in young adults [23–25]. The study included patients aged 18 to 39 who were sufficiently medically ill to require hospital admission with confirmed severe acute respiratory syndrome coronavirus 2 infection by nasopharyngeal polymerase chain reaction testing. The study includes consecutively admitted patients between March 1, 2020 and April 27, 2020. The last day of follow-up was May 12, 2020. Pregnant patients with a length of stay of 2 days or less were excluded from the study. These patients were admitted for labor and delivery after asymptomatic screening for COVID-19.

Data Collection

Data were collected from the enterprise electronic health record ([EHR] Sunrise Clinical Manager, Allscripts, Chicago, IL) reporting database. Transfers from one in-system hospital to another were merged and considered as 1 visit. Transfers out of the system to another acute care facility were considered censored at transfer date. These transfers were conducted to offload high-census hospitals during the peak of the epidemic. Data collected included patient demographic information (age, sex, race, ethnicity, insurance type), body mass index (BMI), smoking status, comorbidities (as captured in the database by International Classification of Disease designation), and outcomes including discharge, length of stay, and death. Body mass index was categorized into 2 groups: obese (including all those with a BMI greater than or equal to 30) and nonobese (all those with a BMI less than 30). Body mass index was recorded for 954 (94.2%) of the patients in the study. Race and ethnicity are recorded by patient self-report in specified categories.

Charlson comorbidity index (CCI) was calculated for all patients in the cohort. The CCI predicts 10-year survival probability for patients with multiple comorbidities and was used as a measure of total comorbid burden [26]. Comorbidities in the 16-item CCI include, for example, diabetes, cancer, and congestive heart disease. As the accumulated CCI score increases, the estimated 10-year survival rate decreases. The lowest score of zero on this index typically translates to an estimated 98% 10-year survival rate in general, whereas a score of 7 points and above corresponds to a 0% 10-year survival rate.

Data Analysis

Summary statistics were calculated for the comparison of baseline characteristics and reported as median, along with interquartile range (IQR) or counts with percentages for each category as appropriate. For in-hospital survival, we used the Kaplan-Meier survival curve and extended Cox model, which is an extension of Cox proportional hazards regression model for time-dependent covariates [27]. Age, sex, race, ethnicity, insurance type, obesity, asthma, hypertension, smoking status, and CCI score were included as covariates in the original model. Obesity, asthma, and hypertension were included in the model in addition to CCI score because these medical conditions are not included in the CCI and have been of particular interest in COVID-19. A backward elimination procedure removed sex, hypertension, asthma, smoking status, and insurance type from the final model. Interaction term for Other race with time was included in the model to incorporate violation of proportionality assumption of these 2 covariates. Data analysis was performed using the statistical software SAS v9.4 (SAS institute, Inc., Cary, NC). Results were considered significant if the corresponding *P* value was less than .05.

RESULTS

A total of 1052 patients between the ages of 18 and 39 were admitted during the study period. Of these, 1013 patients were included in the study (median age, 33 years; IQR, 28–36; 52% female) and 39 patients were excluded as those admitted for less than 2 days for labor and delivery after asymptomatic screening for COVID-19. Of the 1013 patients included in the study, 940 (92.8%) were discharged alive, 18 (1.8%) remained hospitalized, 5 (0.5%) were transferred to another acute care facility, and 50 (4.9%) died by the study end point. Participant demographics and comorbidities are presented in Table 1.

Median length of stay was 3.85 days (IQR, 2.17–7.18) for all patients: 3.67 days (IQR, 2.13–6.88) for patients discharged alive and 11.84 days (IQR, 4.31–18.93) for those who died. The most prevalent age group was 32 to 39. The most common comorbidities for hospitalized patients were obesity (51.2%), diabetes mellitus (14.8%), and hypertension (13%). The median score on the CCI, which does not include obesity, asthma, or hypertension, was zero.

Patients Who Received Invasive Mechanical Ventilation

There were 105 (10.3%) patients who received treatment with invasive mechanical ventilation (median age, 34.5; IQR, 30–37; 31% female). For these patients, the median length of stay was 4.8 days (IQR, 3–9.7) compared to 3.3 days (IQR, 2–6.8) for those who did not receive invasive mechanical ventilation. The most common comorbidities in this group were obesity (56.2%), diabetes mellitus (31.4%), and hypertension (25.7%). Median score on the CCI was 1. Obese patients were not more likely to receive invasive mechanical ventilation, with 11.28% (59 of 523) of these patients requiring ventilation compared to 8.82% (38 of 431) of non-obese patients ($P < .210$). Eight of the patients who received treatment with invasive mechanical ventilation did not have a recorded body mass index and were left out of this analysis.

Table 1. Participant Demographics and Comorbidities

Variables	Total n = 1013	Died n = 50	Alive n = 963
Demographic Information			
Age, median, IQR (range)	33 (28–36)	35 (30–38)	32 (28–36)
Age, n (%)			
18–24	119 (11.7)	4 (3.4)	115 (96.6)
25–31	329 (32.5)	12 (3.7)	317 (96.4)
32–39	565 (55.8)	34 (6.0)	531 (94.0)
Female, n (%)	527 (52)	15 (2.9)	512 (97.2)
Male, n (%)	486 (48)	35 (7.2)	451 (92.8)
Race, n (%)			
African American	215 (21.2)	14 (6.5)	201 (93.5)
Asian	82 (8.1)	2 (2.4)	80 (97.6)
White	263 (26)	9 (3.4)	254 (96.6)
Other/Multiracial	416 (41.1)	24 (5.8)	392 (94.2)
Unknown/Declined	37 (3.7)	1 (2.7)	36 (97.3)
Ethnicity, n (%)			
Hispanic	334 (33)	19 (5.7)	315 (94.3)
Non-Hispanic	623 (61.5)	28 (4.5)	595 (95.5)
Unknown/Declined	56 (5.5)	3 (5.4)	53 (94.6)
Insurance, n (%)			
Commercial	405 (40)	16 (4.0)	389 (96.1)
Medicaid	516 (50.9)	27 (5.2)	489 (94.8)
Medicare	41 (4)	4 (9.8)	37 (90.2)
Self-pay	33 (3.6)	3 (9.1)	30 (90.9)
Other	18 (1.8)	0 (0.0)	18 (100.0)
Comorbidities			
Cancer, n (%)	5 (.5)	3 (60.0)	2 (40.0)
Cardiovascular Disease, n (%)			
Hypertension	132 (13)	13 (9.9)	119 (90.2)
Coronary artery disease	2 (.2)	0 (0.0)	2 (100.0)
Congestive heart failure	9 (.9)	4 (44.4)	5 (55.6)
Chronic liver disease	21 (2.1)	1 (4.8)	20 (95.2)
Chronic Respiratory Disease, n (%)			
Asthma	122 (12)	6 (4.9)	116 (95.1)
Chronic Obstructive Pulmonary Disease	3 (.3)	1 (33.3)	2 (66.7)
Diabetes mellitus	150 (15)	8 (12.0)	132 (88.0)
End-stage kidney disease, n (%)	23 (2.3)	2 (8.7)	21 (91.3)
BMI, median, IQR, n = 954	30.9 (26.6–36.7)	33.7 (28.3–40.6)	30.7 (26.6–36.6)
Obesity, n (%), n = 954			
Normal (BMI <25.0)	163 (16.1)	5 (3.1)	158 (96.9)
Overweight (BMI 25.0–29.9)	272 (26.9)	9 (3.3)	263 (96.7)
Obese (BMI 30.0–39.9)	368 (36.3)	20 (5.4)	348 (94.6)
Severe obese (BMI ≥40.0)	151 (15)	12 (8.0)	139 (92.1)
Charlson comorbidity index, median (IQR)	0 (1.0)	1 (2.0)	0 (1.0)
Smoking Status, n (%)			
Never	881 (87)	34 (3.86)	847 (96.1)
Former	47 (4.6)	3 (6.4)	44 (93.6)
Active	39 (3.8)	2 (5.1)	37 (94.9)
Unknown	46 (4.5)	11 (23.9)	35 (76.1)

Abbreviations: BMI, body mass index; IQR, interquartile range.

College-Aged Patients (18–24 Years Old)

There were 119 patients in our study within this age group (median age, 22 years [IQR, 21–23]; 69% female). Median length of stay for these patients was 3 days (IQR, 1.9–4.9). Only 7 required invasive mechanical ventilation and, of those, 4 died. Two of the 7 who required invasive mechanical ventilation had no prior medical history except for obesity, whereas the remaining 5 patients all had comorbidities, including Down's syndrome, congestive heart failure, end-stage kidney disease, and obstructive sleep apnea. The median BMI was 39.8 (IQR, 24.7–34.8) for all

patients in this age group, 33.0 (IQR, 23.4–49.0) for those requiring invasive mechanical ventilation, and 24.0 (IQR, 21.1–40.5) for those who died.

Predictors of Survival

Obesity and CCI were both negatively associated with in-hospital 30-day survival (Table 2). The strongest predictor of mortality in this age group was obesity (Figures 1 and 2). Patients who were obese, compared to those who were not, were 2.7 times more likely to expire within 30 days. Mortality risk increased by 20% for each additional point on the CCI. Among covariates examined sex, insurance type, asthma, hypertension, and smoking status were eliminated from the final model as these were not associated with increased mortality risk. The hazard ratio for other race varied over time and was significant only in patients with a hospital stay over 20 days.

DISCUSSION

This is the first study to report on predictors of survival in young adults, and its findings are significantly strengthened by our large number of participants. As expected, the overwhelming majority (95%) of hospitalized patients in this age group were alive at the study end point. Obesity, diabetes mellitus, and hypertension were the most common comorbidities in hospitalized patients; these findings echo reports for hospitalized patients of all age groups and support the findings from study in young adults [17, 23]. Body mass index and comorbidity burden (as measured by the CCI) were identified as predictors of in-hospital survival in young adults with COVID-19.

Obesity emerged as the most significant predictor of mortality in this age group. Obesity does not show a decreased prevalence by age in America, where approximately 40% of adults in all age groups are obese [28]. With the exception of 1 patient, with cachexia secondary to metastatic choriocarcinoma, all of the college-aged (18–24) patients in our cohort who died or required invasive mechanical ventilation were obese or morbidly obese. Our findings are supported by a recent study detailing the differential effect of obesity on risk of mortality based on age [29]. That study found that obesity was independently associated with mortality in those younger than 50 with an adjusted odds ratio of 5.1. For those with age above 50, however, the strength of association was weaker, with an adjusted odds ratio of 1.6.

We analyzed data only for patients admitted with COVID-19 and were unable to assess for predictors of infection or severe disease in young adults outside of the hospital. However, of the 954 people in our study with a recorded BMI, 519 (54.4%) were obese. This is higher than the national average and average in the NYC metropolitan area and suggests either a higher susceptibility to infections or a higher likelihood of severe disease requiring hospitalization. Further study will assess obesity as a predictor of severe disease and out-of-hospital survival in those with COVID-19.

The reason that obesity is associated with mortality in young adults is likely multifactorial. Obesity is associated with several additional chronic medical problems, such as diabetes and chronic kidney disease. However, we adjusted for these and other medical conditions in our analysis using the CCI. Obese persons are known to have reduced lung volumes and hypoventilation, which makes them at greater risk for complications from respiratory illnesses [30]. In addition, there is emerging evidence that patients with COVID-19 suffer from a hypercoagulable state that may act synergistically with the hypercoagulable state seen in obesity, which can lead to an increased risk of potentially fatal conditions such as pulmonary embolism, stroke, and arterial thrombosis [31].

Table 2. In-Hospital 30-Day Mortality Risk Assessment Using an Extended Cox Model

Factor	aHR (95% CI)[a]	*P* Value
Age	1.05 (0.98–1.13)	.148
Charlson comorbidity index	1.20 (1.07–1.35)	.002
Obesity	2.71 (1.28–5.73)	.009
Asian, compared with white	0.36 (0.043–2.98)	.342
Black, compared with white	2.0 (0.81–4.90)	.136
Other/multiracial, compared with white	1.05 (0.32–3.48)	.934
Hispanic, compared with non-Hispanic	1.14 (0.42–3.10)	.801

Abbreviations: aHR, adjusted hazard ratio; CI, confidence interval.

[a]All variables were used in multivariate analysis.

Limitations

Several limitations should be noted. First, this cohort comprised only patients within the New York metropolitan area. Data were extracted from the EHR database and do not include the level of granularity that would be possible with a manual chart review. Of note, smoking status was limited given the inability to capture e-cigarette and vaping usage among this younger cohort. Evidence-based treatment regimens were developing and changing rapidly, and thus data collection of these regimens was not possible. Despite these limitations, the results are based on a large and diverse number of patients and thus significantly contribute to the existing literature.

CONCLUSIONS

Obesity may represent the most significant barrier to survival in young adults hospitalized with COVID-19. Given these findings and our understanding of obesity as an almost entirely preventable disease, public health recommendations to improve population-level health should include food policy changes in addition to existing diet and lifestyle recommendations. In this

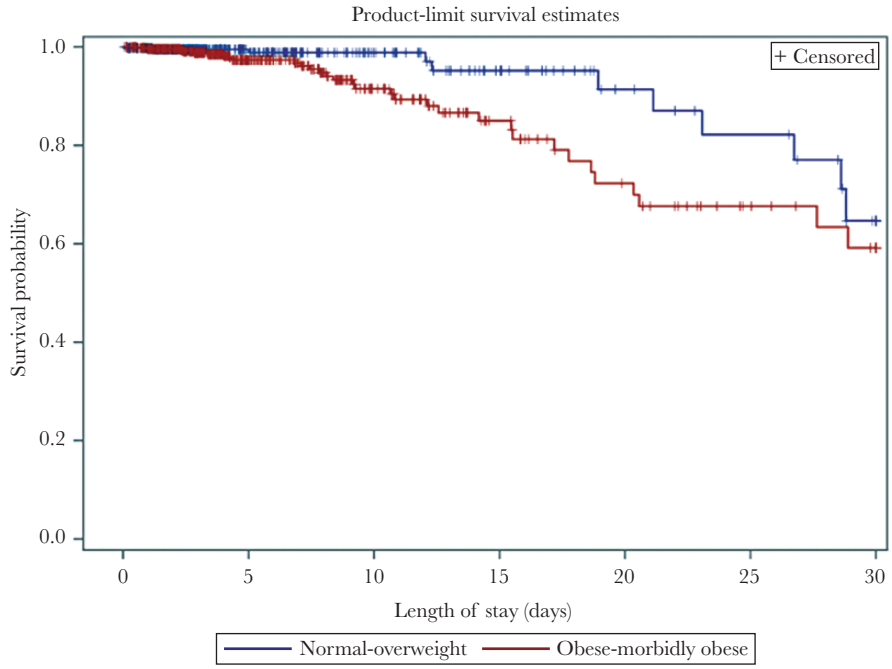

Figure 1. Unadjusted Kaplan-Meier curve for survival by obesity status.

study, the impact of obesity on in-hospital survival in young adults was similar in magnitude to the previously reported impact on survival of age over 65 in patients of all ages [10].

We acknowledge and honor all of our Northwell team members who consistently put themselves in harm's way during the coronavirus disease 2019 (COVID-19) pandemic. This article is dedicated to them, to honor their vital contribution to knowledge about COVID-19 and their sacrifices on

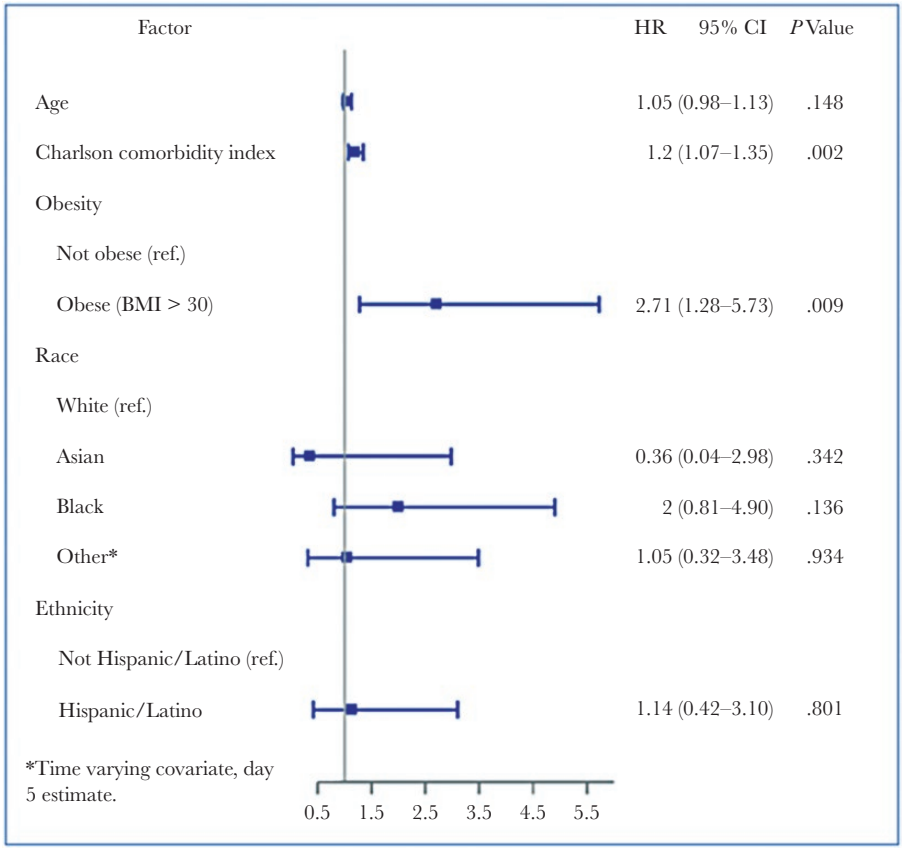

Figure 2. Forest plot: in-hospital 30-day mortality. BMI, body mass index; HR, hazard ratio.

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