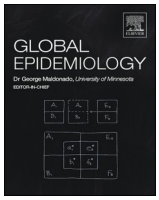
Global Epidemiology 8 (2024) 100155

Contents lists available at ScienceDirect

Global Epidemiology

journal homepage: www.sciencedirect.com/journal/global-epidemiology



Hospital outcomes for young adults with COVID-19

Brian S. Williams [a,b,c,*], Thomas M. Piasecki [a,d], Michael C. Fiore [a,d], Karen L. Conner [a,d], Wendy S. Slutske [a,e]

[a] Center for Tobacco Research and Intervention, University of Wisconsin School of Medicine and Public Health
[b] Division of Hospital Medicine and Complex Care, Department of Pediatrics, University of Wisconsin School of Medicine and Public Health
[c] Division of Hospital Medicine, Department of Medicine, University of Wisconsin School of Medicine and Public Health
[d] Division of General Internal Medicine, Department of Medicine, University of Wisconsin School of Medicine and Public Health
[e] Department of Family Medicine and Community Health, University of Wisconsin School of Medicine and Public Health

ARTICLE INFO

Keywords:
COVID-19
Young adults
Hospitalization
Outcomes

ABSTRACT

Background: Older adults are at higher risk of severe outcomes from COVID-19 with comorbidities increasing such risk. Much less is known about the outcomes of young adults with COVID-19 despite their having had high infection rates.

Objectives: Our objective was to determine outcomes of hospitalized young adults with COVID-19 infection including rates of oxygen use, mortality, ICU admission, intubation, duration of hospitalization, and factors associated with adverse outcomes.

Study design: This retrospective cohort study included EHR data from 21 health systems in the United States on 18–29-year-olds hospitalized with COVID-19 from March 1, 2020 – January 31, 2022. Oxygen need was used to identify symptomatic COVID-19. Rates for mortality, ICU admission, and intubation were calculated for the symptomatic and asymptomatic groups. Effects of demographic and health characteristics on outcomes were assessed as were changes in hospital outcomes over time.

Results: Our sample included 9871 young adults hospitalized with COVID-19; 35% required oxygen. Of those who required oxygen, 53.5% were female, 23.7% had an anxiety disorder, 2.6% died ($n = 89$), 27.7% were admitted to the ICU ($n = 955$), and 15.8% were intubated ($n = 547$). A past-year history of any cancer was associated with a 2.1 times increased odds of death. Vaccination was associated with a >40% reduction in the odds of ICU admission. Mortality rates did not change significantly across the study period.

Conclusions: COVID-19 caused significant morbidity and mortality in hospitalized young adults who required oxygen. A cancer history was associated with increased risk of death. Vaccination appeared to have had a protective effect on illness severity.

Background

The COVID-19 pandemic has led to >6.1 million hospitalizations in the United States [1]. It is estimated that approximately 10–20% of adults hospitalized with COVID-19 died [1,2]. Older age has been a risk factor for severe disease including ICU admission and mortality [3–5]; other risk factors for mortality include male gender, COPD, cardiovascular disease, diabetes, hypertension, obesity, and cancer [2]. Death rates due to COVID-19 have improved over time [1] with vaccinations [6–8] and medical treatments [9–11] contributing to improved outcomes.

One population that has been less studied during the COVID-19 pandemic is young adults. Young adults have been noted to have higher incidences of COVID-19 than older adults [12] and less engagement in mitigation behavior [13]. As their rates of hospitalization are lower than older adults [14], few studies describe hospital outcomes for young adults. One study, from early in the pandemic (April – June 2020), revealed that of 18–34-year-olds who were admitted with COVID-19, 21% required ICU care, 10% were intubated, and 2.7% died [15]. Another study in New York City during March and April 2020 showed that 13% of young adults hospitalized with COVID-19 died [16]. In general, studies in this population have been limited to small sample sizes [16,17] or a short reporting time-frame [15,16]. Given the high rates of infection in young adults and the limited data on their hospital

* Corresponding author at: 600 Highland Ave H4/418, MC 4108, Madison, WI 53792, USA.
E-mail address: bswillia@medicine.wisc.edu (B.S. Williams).

https://doi.org/10.1016/j.gloepi.2024.100155
Received 3 May 2024; Received in revised form 2 July 2024; Accepted 3 July 2024
Available online 5 July 2024

outcomes, this group warrants additional study to better understand the outcomes of hospitalization across the COVID-19 pandemic.

Objectives

Our primary objective was to determine the mortality rate of young adults hospitalized with *symptomatic* COVID-19, defined as requiring oxygenation during hospitalization. Our secondary objectives were to a) describe rates of ICU admission, intubation, and duration of hospitalization for young adults with symptomatic and asymptomatic COVID-19, b) assess the association of demographic and health characteristics with ICU admission and death for individuals who required oxygen, and c) describe changes in hospital outcomes over time.

Study design

This study used data from the COVID EHR Cohort at the University of Wisconsin (CEC-UW). This retrospective cohort study included EHR data from 21 health systems. Health systems affiliated with the National Cancer Institute (NCI) Cancer Center Cessation Initiative [18] and other health systems were invited to contribute data. See Fig. S1 in supplemental materials for health system's locations across the United States. Participating health systems periodically extracted selected EHR data for all patients encountered during the study period (February 1, 2020 – January 31, 2022) with evidence of COVID-19 via ICD-10 diagnosis or lab test (PCR or antigen). Participating health systems transmitted EHR data to the University of Wisconsin Center for Tobacco Research and Intervention (UW-CTRI) for harmonization and merging. The CEC-UW study was approved by the University of Wisconsin-Madison Health Sciences Minimal Risk Institutional Review Board (MR-IRB) for the collection of de-identified EHR data from the 21 health systems and the MR-IRB determined that the study met criteria for a human subject's research exemption and qualified for a waiver of informed consent under the Federal Common Rule. All participating health systems provided written notice of either their own institution's IRB approval or exemption status.

Study Sample

The current analyses used data from hospitalized young adults in CEC-UW, aged 18–29. To capture background health information, individuals were required to have at least one pre-hospitalization contact with the healthcare system in which their hospitalization occurred. Inclusion in the analytic sample required hospitalization for at least 24 h with evidence of a COVID-19 infection. The exception was if an individual was hospitalized with evidence of a COVID-19 infection but died within 24 h of admission, they were still included in the sample. COVID-19 infection was determined by a positive PCR test within a 14-day window, spanning seven days pre-admission to seven days post-admission and/or by an ICD-10-CM diagnosis of COVID-19 (U07.1 or J12.82) at any point during the hospitalization.

Measures

Patient Characteristics

Variables used as covariates and in descriptive analyses were sex, race, ethnicity, insurance status, body mass index (BMI), smoking status, current or past year comorbid diagnoses (cancer, asthma, hypertension, chronic kidney disease, diabetes, depression, anxiety disorder, alcohol use disorder), pregnancy [see Supplemental Table S1 for the ICD-10 codes used]), and COVID-19 vaccination prior to hospitalization (none vs any).

Oxygen Supplementation as a Surrogate for Symptomatic COVID-19

Inclusion in the broad analytic sample required the conjunction of (a) hospital admission and (b) evidence of current COVID-19 infection. To better characterize outcomes of symptomatic COVID-19 hospitalizations, we identified and examined patients with documentation of receiving oxygen during the hospitalization. In addition, positive pressure ventilation (PPV) and intubation were also queried in the EHR to meet oxygen use criteria.

Outcomes

Mortality was the primary outcome, reflecting if the patient died during the hospitalization. Mortality rates were computed for the full sample and separately for patients who did, and did not, require oxygen.

ICU admission, intubation, and duration of hospitalization were secondary outcomes. To characterize trends over time, admission dates were divided into 4 discrete periods based on national trends in hospitalizations [1]: Wave 1 included March 1, 2020 – September 30, 2020 (there were no young adults in the cohort hospitalized in February 2020), Wave 2 included October 1, 2020 – June 30, 2021, Wave 3 included July 1, 2021 – November 30, 2021, and Wave 4 included December 1, 2021 – January 31, 2022. The CEC-UW Cohort study completed data collection January 31, 2022, limiting Wave 4 to 2 months. Descriptive statistics were used to characterize rates of oxygen use, ICU admission, and mortality during each wave.

Data Analyses

Chi-square tests were used to assess whether patients who required oxygen differed from those who did not on hospital outcomes, demographics, and health characteristics. Group differences in length of hospital stay were tested using a non-parametric Mann-Whitney *U* test.

In patients who required oxygen, bivariate and multivariate tests for associations of patient characteristics (sex, race, ethnicity, insurance status, BMI, smoking status, comorbid diagnoses, and vaccination receipt) with death and ICU admission in adjusted models were examined. Multilevel generalized linear models with a binomial distribution and a logit link were fit; multilevel analysis was used to account for the clustering of patients within the 21 health systems.

Results

Study Sample

The analytic sample included 9871 young adults, aged 18–29, who were hospitalized with COVID-19 between March 1, 2020, and January 31, 2022 (Table 1). The sample was stratified by whether the young adult required oxygen (35%) or not. Of the 3453 individuals who required oxygen, 53.5% were female, 43.1% White, 75.3% overweight or obese, and 7.7% had received at least one vaccination against COVID-19.

Hospital Outcomes

The most common chronic diseases in the oxygen requiring group were anxiety disorder (23.7%) and asthma (20.4%). The oxygen requiring group had significantly higher rates than the non-oxygen-requiring group of cancer, asthma, hypertension, chronic kidney disease, type 2 diabetes, and anxiety disorder. Rates of vaccination were significantly lower in those who required oxygen.

Among the 3453 individuals requiring oxygen, 2.6% died, 27.7% were admitted to the ICU, and 15.8% were intubated (Table 2). The median duration of hospitalization for the oxygen-requiring group was 4.64 days compared to 2.43 days for those who did not require oxygen.

Table 3 shows unadjusted and adjusted associations for the outcomes of death and ICU admission among individuals who required oxygen. A diagnosis of cancer was the only clinically significant predictor of death during hospitalization with these individuals having a 2.1 times greater odds of death (95% CI: 1.11, 3.99). ICU admission was independently associated with several characteristics: Medicaid insurance (1.3 times

Table 1
Demographic and health characteristics of young adult inpatients ages 18–29 from the CEC-UW COVID-19 cohort.

	Full sample	Required Oxygen?		
		Yes	No	*p* value
	N = 9871	*N* = 3453 (35%)	*N* = 6418 (65%)	
Characteristic	N (%)	N (%)	N (%)	
Sex				< 0.001
Female	6877 (69.7)	1846 (53.5)	5031 (78.4)	
Male	2993 (30.3)	1607 (46.5)	1386 (21.6)	
Race				< 0.001
White	4342 (44)	1489 (43.1)	2853 (44.5)	
American Indian or Alaska Native	44 (0.4)	25 (0.7)	19 (0.2)	
Asian	229 (2.3)	84 (2.4)	145 (2.3)	
Black or African American	2844 (28.8)	1041 (30.2)	1803 (28.1)	
Native Hawaiian or Pacific Islander	55 (0.6)	30 (0.9)	25 (0.3)	
Other or Not Specified	2020 (20.5)	674 (19.5)	1346 (21.0)	
More than one	89 (0.9)	40 (1.2)	49 (0.8)	
Missing	248 (2.5)	70 (2)	178 (2.8)	
Ethnicity				0.009
Not Hispanic or Latino	7002 (70.9)	2497 (72.3)	4505 (70.2)	
Hispanic or Latino	2689 (27.2)	883 (25.6)	1806 (28.1)	
Missing	180 (1.8)	73 (2.1)	107 (1.7)	
Insurance Status				< 0.001
Commercial	4421 (44.8)	1567 (45.4)	2854 (44.5)	
Medicare	323 (3.3)	165 (4.8)	158 (2.5)	
Medicaid	3418 (34.6)	1124 (32.6)	2294 (35.7)	
Uninsured	463 (4.7)	150 (4.3)	313 (4.9)	
Other	1246 (12.6)	447 (12.9)	799 (12.4)	
Body Mass Index (BMI)				< 0.001
Underweight	280 (2.9)	107 (3.1)	173 (2.7)	
Healthy Weight	2515 (25.8)	731 (21.2)	1784 (28.2)	
Overweight	2422 (24.9)	643 (18.6)	1779 (28.1)	
Obese	4527 (46.5)	1936 (56.7)	2591 (41.0)	
Smoking status				< 0.001
Never smoker	7161 (72.5)	2455 (71.1)	4706 (73.3)	
Former smoker	1038 (10.5)	352 (10.2)	686 (10.7)	
Current smoker	924 (9.4)	326 (9.4)	598 (9.3)	
Missing	748 (7.6)	320 (9.3)	428 (6.7)	
Past Year (Including Current) Comorbidities				
Cancer (any)	275 (2.8)	124 (3.6)	151 (2.4)	< 0.001
Asthma	1484 (15.0)	705 (20.4)	779 (12.1)	< 0.001
Hypertension	814 (8.2)	427 (12.4)	387 (6.0)	< 0.001
Chronic Renal Failure	374 (3.8)	192 (5.6)	182 (2.8)	< 0.001
Diabetes (Type 1)	337 (3.4)	102 (3.0)	235 (3.7)	0.07
Diabetes (Type 2)	575 (5.8)	321 (9.3)	254 (4.0)	< 0.001
Depression (any)	1359 (13.8)	496 (14.4)	863 (13.4)	0.2
Anxiety Disorder (any)	2048 (20.7)	819 (23.7)	1229 (19.1)	< 0.001
Alcohol Use Disorder (any)	335 (3.4)	134 (3.9)	201 (3.3)	0.05
Pregnancy (among women)	1256 (12.7)	83 (2.4)	1173 (18.3)	< 0.001
Any Vaccination*	978 (9.9)	266 (7.7)	712 (11.1)	< 0.001

* Any vaccination = at least one dose of any vaccine for SARS-CoV-2 prior to hospitalization.

Table 2
Outcomes of young adult inpatients ages 18–29 from the CEC-UW COVID-19 cohort by oxygen requirement.

Outcome	Full Sample (*n* = 9871)	Required Oxygen?		Statistical comparison of oxygen groups	*p*
		Yes (n = 3453)	No (n = 6418)		
Death (N, %)	92 (0.9)	89 (2.6)	3 (0.0)	$\chi^2 = 155.73$ (df = 1)	< 0.001
Admission to Intensive Care Unit (N, %)	1282 (13.0)	955 (27.7)	327 (5.1)	$\chi^2 = 101.31$ (df = 1)	< 0.001
Intubation (N, %)	547 (5.5)	547 (15.8)	–	–	–
Duration of Hospitalization[a] (Median, interquartile range)	2.89 (2.93)	4.64 (4.88)	2.43 (1.68)	Mann-Whitney U = 15,804,951.5	< 0.001

[a] Among non-deceased patients.

greater odds, 95% CI: 1.07, 1.63)), underweight (1.6 times greater odds, 95% CI: 1.04, 2.52), missing EHR smoking status (2.3 times greater odds, 95% CI: 1.75, 3.12), hypertension (1.5 times greater odds, 95% CI: 1.20, 1.97), diabetes (Type 1: 1.8 times greater odds, 95% CI: 1.15, 2.83; Type 2: 1.5 times greater odds, 95% CI: 1.17, 2.03), anxiety disorder (1.3 times greater odds, 95% CI: 1.06, 1.62) and alcohol use disorder (2.7 times greater odds, 95% CI: 1.78, 3.96). Obesity (35% lower odds, 95% CI: 0.52, 0.80), current smoking (32% lower odds, 95% CI: 0.51, 0.91), former smoking (28% lower odds, 95% CI: 0.54, 0.97), and vaccination (42% lower odds, 95% CI: 0.41, 0.80) were all associated with lower odds of ICU admission.

Hospital Trends over Time

The highest number of young adults were admitted during December 2021 and January 2022 which coincided with the Omicron variant (Table 4). Those two months accounted for 2530 admissions (25.6% of total sample) though represented the lowest percentage of young adults

Table 3
Associations of demographic and health characteristics with mortality and ICU admission among the young adult inpatients ages 18–29 from the CEC-UW COVID-19 cohort who required supplemental oxygen.

	Mortality				ICU admission			
	Unadjusted associations		Adjusted associations		Unadjusted Associations		Adjusted Associations	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Characteristic								
Sex								
Female (ref)	–	–	–	–	–	–	–	–
Male	1.21	0.87, 1.67	1.03	0.74, 1.45	1.40	1.20, 1.63	1.15	0.97, 1.36
Race								
White (ref)	–	–	–	–	–	–	–	–
Asian	0.80	0.24, 2.62	0.81	0.25, 2.64	1.09	0.66, 1.78	1.10	0.65, 1.87
Black or African American	1.01	0.69, 1.49	0.90	0.60, 1.36	1.08	0.89, 1.31	0.84	0.67, 1.04
Other, more than one or missing	0.98	0.65, 1.49	1.04	0.63, 1.73	0.88	0.72, 1.09	0.90	0.69, 1.17
Ethnicity								
Not Hispanic or Latino (ref)	–	–	–	–	–	–	–	–
Hispanic or Latino	0.88	0.60, 1.30	0.83	0.50, 1.38	0.78	0.64, 0.94	0.87	0.67, 1.13
Missing	1.22	0.43, 3.43	1.12	0.39, 3.24	1.28	0.77, 2.12	1.46	0.84, 2.54
Insurance Status								
Commercial (ref)	–	–	–	–	–	–	–	–
Medicare	0.85	0.36, 2.02	0.77	0.33, 1.83	1.37	0.96, 1.95	1.13	0.77, 1.67
Medicaid	1.10	0.75, 1.60	1.09	0.74, 1.61	1.30	1.08, 1.58	1.32	1.07, 1.63
Uninsured	1.30	0.61, 2.77	1.42	0.66, 3.06	0.93	0.63, 1.39	0.98	0.64, 1.50
Other	1.15	0.69, 1.90	1.11	0.67, 1.84	1.11	0.86, 1.44	1.20	0.91, 1.60
Body Mass Index (BMI)								
Underweight	0.85	0.28, 2.60	0.87	0.29, 2.56	1.67	1.10, 2.54	1.62	1.04, 2.52
Healthy Weight (ref)	–	–	–	–	–	–	–	–
Overweight	1.09	0.64, 1.87	1.19	0.71, 2.02	0.74	0.59, 0.94	0.79	0.61, 1.01
Obese	1.17	0.76, 1.80	1.35	0.87, 2.10	0.61	0.50, 0.73	0.65	0.52, 0.80
Smoking status								
Never smoker (ref)	–	–	–	–	–	–	–	–
Former smoker	0.87	0.48, 1.58	1.15	0.65, 2.03	0.85	0.65, 1.11	0.72	0.54, 0.97
Current smoker	1.18	0.69, 2.03	0.78	0.44, 1.41	1.00	0.77, 1.31	0.68	0.51, 0.91
Missing	1.54	0.94, 2.52	1.60	0.96, 2.65	2.30	1.76, 3.00	2.34	1.75, 3.12
Past Year (Including Current) Comorbidities								
Cancer (any)	2.53	1.37, 4.67	2.10	1.11, 3.99	1.79	1.23, 2.61	1.40	0.92, 2.13
Asthma	1.00	0.66, 1.50	1.04	0.69, 1.56	1.01	0.83, 1.22	1.15	0.94, 1.41
Hypertension	1.42	0.91, 2.21	1.12	0.70, 1.78	1.97	1.59, 2.44	1.54	1.20, 1.97
Chronic Renal Failure	1.60	0.88, 2.90	1.07	0.56, 2.03	2.03	1.50, 2.78	0.94	0.65, 1.35
Diabetes (Type 1)	0.91	0.33, 2.49	0.71	0.26, 1.94	3.00	1.99, 4.50	1.80	1.15, 2.83
Diabetes (Type 2)	1.09	0.63, 1.89	0.97	0.56, 1.69	1.69	1.32, 2.16	1.54	1.17, 2.03
Depression (any)	1.01	0.63, 1.61	0.94	0.56, 1.58	1.02	0.82, 1.27	0.83	0.64, 1.08
Anxiety Disorder (any)	1.15	0.79, 1.67	1.09	0.71, 1.65	1.31	1.09, 1.56	1.31	1.06, 1.62
Alcohol Use Disorder (any)	1.33	0.63, 2.83	1.27	0.58, 2.79	2.74	1.92, 3.91	2.65	1.78, 3.96
Any Vaccination	0.89	0.47, 1.69	0.88	0.46, 1.67	0.72	0.53, 0.97	0.58	0.41, 0.8

Note: adjusted analyses estimate the effect of each characteristic after adjusting for the influence of every other characteristic; ICU = intensive care unit, OR = odds ratio, CI = confidence interval, any vaccination = at least one dose of any vaccine for SARS-CoV-2 prior to hospitalization.

Table 4
Hospital Outcomes by Wave.

	Wave 1 3/1/2020-9/30/2020	**Wave 2** 10/1/2020-6/30/2021	**Wave 3** 7/1/2021-11/30/2021	**Wave 4** 12/1/2021–1/31/2022	Statistical comparison of wave groups	***p*-value**
Total admissions (N, %)	2000 (20.2)	3523 (35.7)	1818 (18.4)	2530 (25.6)	$\chi^2 = 712.55$, df = 3	<0.001[a]
Required oxygen (N, %)	705 (35.3)	1293 (36.7)	795 (43.7)	660 (26.1)	$\chi^2 = 153.82$, df = 3	<0.001
Required ICU admission (N, %)[b]	236 (33.5)	326 (25.2)	229 (28.8)	164 (24.8)	$\chi^2 = 18.92$, df = 3	<0.001
Deaths (N, %)[b]	16 (2.3)	30 (2.3)	28 (3.5)	15 (2.3)	$\chi^2 = 3.68$, df = 3	0.30

[a] Test of unequal proportions
[b] Individuals were only included if they were in the oxygen requiring group.

who required oxygen (26.1%) compared to 35.3% in Wave 1, 36.7% in Wave 2, and 43.7% in Wave 3. Among individuals requiring oxygen, ICU admission rates were highest in Wave 1 (33.5%) compared to Wave 2 (25.2%), Wave 3 (28.8%), and Wave 4 (24.8%). Mortality rates among the oxygen group ranged from 2.3% (Waves 1, 2, and 4) to 3.5% (Wave 3) but did not differ significantly.

Discussion

This study describes outcomes for young adults hospitalized with COVID-19 across the first 23 months of the pandemic. Oxygen was used as a surrogate for symptomatic disease which included 35% of our sample. This group had a mortality rate of 2.6% and an ICU admission rate of 27.7%. Odds of mortality were increased in individuals with a history of cancer whereas vaccination was associated with lower odds of ICU admission.

As age has been identified as a risk factor for severe COVID-19 [2–5], it is not surprising that most young adults did not require oxygen and were likely admitted for another condition. Interestingly, our sample was predominantly female in both the symptomatic and asymptomatic groups. This differed from prior studies showing that only 32.9% [16] and 42.4% [15] of hospitalized young adults with COVID-19 were female. It is unclear if the increased percentage of young adult females was a phenomenon related to the virus, social dynamics about how and where young adults sought care, or the result of underlying health systems' demographics.

Mortality, Intubation, ICU, and Length of Stay

Outcomes for young adults who were admitted with COVID-19 and required oxygen reveal that 2.6% died, 15.8% were intubated, and 27.7% were admitted to the ICU. These numbers are similar to Cunningham et al., from early in the pandemic when 2.7% died, 10% were intubated, and 21% were admitted to the ICU. Our higher rate of intubation is somewhat surprising as changes in standard practice for COVID-19 shifted over time from intubation towards less invasive respiratory support including high flow nasal cannula [19]. Adjusted odds ratios reveal that ICU admission was associated with Medicaid insurance, being underweight, and the presence of several comorbidities including hypertension, diabetes mellitus (Type 1 or Type 2), anxiety disorder, and alcohol use disorder. While it is possible some of these comorbidities may have led to an ICU admission not related to COVID-19 (for example, severe alcohol withdrawal), these findings correlate with adult studies showing a broad range of comorbidities increase risk of severe COVID-19 [2,3,5,20]. As socioeconomic status is related to health outcomes, it is not surprising that those eligible for Medicaid had worse outcomes in our sample (Medicaid is a program that provides health insurance to eligible low-income adults, children, pregnant women, and people with specific disabilities [21]).

Current or past-year diagnosis of cancer in young adults was associated with an increased risk of death. These results mirror findings by Nolan et al [22], also from the CEC-UW, showing that 18–59-year-olds hospitalized for COVID-19 with a current cancer diagnosis had an adjusted odds ratio of 2.62 for mortality. Vaccination for COVID-19 in our study was associated with a decrease in ICU admission but not mortality. It is possible that there was limited power to detect an effect of vaccination on mortality in this sample due to low rates of vaccination (7.7%) and mortality (2.6%). The low rate of vaccination is not surprising as vaccines were not available in Waves 1 and most of Wave 2, and even when vaccines were available, older adults and those with underlying health comorbidities were prioritized.

Trends over Time

Trends in hospital outcomes (Table 4) show that young adults who were admitted during Wave 3 (Delta variant) had the highest rate of oxygen use (43.8%) and mortality (3.5%). Although difference in mortality did not reach statistical significance, these findings differ from national data [1] which highlights both January of 2021 and January of 2022 as having peaks in numbers of deaths in the United States. Whereas death rates declined in the entire CEC-UW adult sample [23], rates in our population remained steady with Waves 1, 2, and 4 all having mortality rates of 2.3%. Results from the last 2 months of our study, which represent the transition from the Delta to Omicron variant, reveal the lowest proportion of young adults who required oxygen (26.1%) and transfer to the ICU (24.8%). Of note, those two months had the highest total number of COVID-19 admissions that required oxygen compared to any other time frame in our sample. This suggests that while the Omicron variant led to a higher percentage of young people having asymptomatic COVID, it still caused significant morbidity in many individuals based on the total number of symptomatic infections.

Implications

Older age has consistently been cited as a risk factor for severe COVID-19 disease. These findings may influence young people to feel less at-risk for complications from COVID-19 infection and limit their willingness to participate in disease mitigation strategies. The present study demonstrates the impact that COVID-19 had on young adults who required hospitalization. This study may inform preparedness for future pandemic responses and educational campaigns to young people.

Limitations

This study has limitations. First, the participants were selected because they were hospitalized with COVID-19 at one of 21 US health systems, many of which were Academic Medical Centers, so they are not perfectly representative of the US population. Nonetheless, the sample of young adults assembled for this study was geographically (from 39 different states), socioeconomically (39% uninsured or receiving Medicaid), racially (56% non-White), and ethnically (27% Hispanic or Latino) diverse. Second, this is an observational study, so inferences about causation cannot be drawn. Third, oxygen supplementation was used as a surrogate for symptomatic COVID-19 infection. Patients can require hospital admission for a variety of complications of COVID-19 that may not require oxygen (stroke, cardiomyopathy, deep venous thrombosis, suicide attempt, etc.) thus we likely did not capture all participants admitted with symptomatic disease. We used the need for oxygen supplementation to potentially distinguish individuals who were hospitalized *for* COVID-19 (symptomatic) versus *with* COVID-19 (asymptomatic). Fourth, the cause of death could not be definitively attributed to COVID-19 as some patients may have died from other causes. Fifth, patients who were discharged to hospice or died after their hospitalization would not have been captured in our sample, thus our data may underrepresent the death rate. Sixth, because the CEC-UW cohort included a diverse set of health systems, hospital policies and practices likely varied and may have affected rates of transfer to the ICU and intubation. Additionally, past medical history documentation in EHR records was likely variable. Seventh, at least one prior contact with the admission hospital system was required for inclusion into the cohort which may have differentially excluded certain types of patients. Finally, the start and stop times of specific waves of the pandemic have not been clearly delineated in the literature, and there were clearly regional variations in waves across the United States which likely affects interpretation of wave-specific findings.

Conclusion

Young adults who were hospitalized during the first 2 years of the pandemic with an oxygen requirement had significant morbidity and mortality with approximately 27% requiring ICU admission and 2.6% dying. Vaccination was associated with decreased rates of ICU transfer

in young adults hospitalized with COVID-19. Further research can focus on further delineating risk factors for severe outcomes in this population as well as protective factors beyond vaccination.

Financial disclosure

The CEC-UW data collection was funded by a contract from the National Cancer Institute (CRDF Award #66590) to B. Rolland. Funding for this project was provided by the UW School of Medicine and Public Health from the Wisconsin Partnership Program to M.C. Fiore.

CRediT authorship contribution statement

Brian S. Williams: Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization. **Thomas M. Piasecki:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Michael C. Fiore:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Karen L. Conner:** Writing – review & editing, Project administration, Conceptualization. **Wendy S. Slutske:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization.

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloepi.2024.100155.

References

[1] Centers for Disease Control and Prevention. COVID Data Tracker. Atlanta, GA: U.S. Department of Health and Human Services, CDC; 2023. Accessed June 1, 2023, https://covid.cdc.gov/covid-data-tracker.
[2] Dessie ZG, Zewotir T. Mortality-related risk factors of COVID-19: a systematic review and meta-analysis of 42 studies and 423,117 patients. BMC Infect Dis 2021;21(1):855. https://doi.org/10.1186/s12879-021-06536-3. Aug 21.
[3] Kim L, Garg S, O'Halloran A, et al. Risk factors for intensive care unit admission and in-hospital mortality among hospitalized adults identified through the US coronavirus disease 2019 (COVID-19)-associated hospitalization surveillance network (COVID-NET). Clin Infect Dis 2021;72(9):e206–14. https://doi.org/10.1093/cid/ciaa1012. May 4.
[4] Liu W, Yang C, Liao YG, et al. Risk factors for COVID-19 progression and mortality in hospitalized patients without pre-existing comorbidities. J Infect Public Health 2022;15(1):13–20. https://doi.org/10.1016/j.jiph.2021.11.012. Jan.
[5] Gao YD, Ding M, Dong X, et al. Risk factors for severe and critically ill COVID-19 patients: a review. Allergy 2021;76(2):428–55. https://doi.org/10.1111/all.14657. Feb.
[6] Tenforde MW, Self WH, Gaglani M, et al. Effectiveness of mRNA Vaccination in Preventing COVID-19-Associated Invasive Mechanical Ventilation and Death - United States, March 2021–January 2022. MMWR Morb Mortal Wkly Rep 2022;71(12):459–65. https://doi.org/10.15585/mmwr.mm7112e1. Mar 25.
[7] Lopez Bernal J, Andrews N, Gower C, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. Bmj 2021;373:n1088. https://doi.org/10.1136/bmj.n1088. May 13.
[8] Baker TB, Bolt DM, Smith SS, et al. The relationship of COVID-19 vaccination with mortality among 86,732 hospitalized patients: subpopulations, patient factors, and changes over time. J Gen Intern Med 2023;38(5):1248–55. https://doi.org/10.1007/s11606-022-08007-0. Apr.
[9] Najjar-Debbiny R, Gronich N, Weber G, et al. Effectiveness of Paxlovid in Reducing Severe Coronavirus Disease 2019 and Mortality in High-Risk Patients. Clin Infect Dis 2023;76(3):e342–9. https://doi.org/10.1093/cid/ciac443. Feb 8.
[10] Chokkalingam AP, Hayden J, Goldman JD, et al. Association of Remdesivir Treatment with Mortality among Hospitalized Adults with COVID-19 in the United States. JAMA Netw Open 2022;5(12):e2244505. https://doi.org/10.1001/jamanetworkopen.2022.44505. Dec 1.
[11] Horby P, Lim WS, Emberson JR, et al. Dexamethasone in Hospitalized Patients with Covid-19. N Engl J Med 2021;384(8):693–704. https://doi.org/10.1056/NEJMoa2021436. Feb 25.
[12] Boehmer TK, DeVies J, Caruso E, et al. Changing Age Distribution of the COVID-19 Pandemic - United States, May–August 2020. MMWR Morb Mortal Wkly Rep 2020;69(39):1404–9. https://doi.org/10.15585/mmwr.mm6939e1. Oct 2.
[13] Hutchins HJ, Wolff B, Leeb R, et al. COVID-19 Mitigation Behaviors by Age Group - United States, April–June 2020. MMWR Morb Mortal Wkly Rep 2020;69(43):1584–90. https://doi.org/10.15585/mmwr.mm6943e4. Oct 30.
[14] Couture A, Iuliano AD, Chang HH, et al. Estimating COVID-19 hospitalizations in the United States with surveillance data using a Bayesian hierarchical model: modeling study. JMIR Public Health Surveill 2022;8(6):e34296. https://doi.org/10.2196/34296. Jun 2.
[15] Cunningham JW, Vaduganathan M, Claggett BL, Jering KS, Bhatt AS, Rosenthal N, et al. Clinical outcomes in young US adults hospitalized with COVID-19. JAMA Intern Med 2020;181(3):379–81. https://doi.org/10.1001/jamainternmed.2020.5313. Sep 9.
[16] Altonen BL, Arreglado TM, Leroux O, Murray-Ramcharan M, Engdahl R. Characteristics, comorbidities and survival analysis of young adults hospitalized with COVID-19 in new York City. PloS One 2020;15(12):e0243343. https://doi.org/10.1371/journal.pone.0243343.
[17] Samuels S, Niu J, Sareli C, Sareli A, Eckardt P. Characteristics, vaccination status and outcomes among healthy younger adults in a large public healthcare system in the South Florida region. J Community Health 2022;47(2):371–7. https://doi.org/10.1007/s10900-022-01062-y. Apr.
[18] D'Angelo H, Rolland B, Adsit R, et al. Tobacco treatment program implementation at NCI Cancer centers: Progress of the NCI Cancer moonshot-funded Cancer center cessation initiative. Cancer Prev Res (Phila) 2019;12(11):735–40. https://doi.org/10.1158/1940-6207.Capr-19-0182. Nov.
[19] Attaway AH, Scheraga RG, Bhimraj A, Biehl M, Hatipoğlu U. Severe covid-19 pneumonia: pathogenesis and clinical management. Bmj 2021;372:n436. https://doi.org/10.1136/bmj.n436. Mar 10.
[20] Treskova-Schwarzbach M, Haas L, Reda S, et al. Pre-existing health conditions and severe COVID-19 outcomes: an umbrella review approach and meta-analysis of global evidence. BMC Med 2021;19(1):212. https://doi.org/10.1186/s12916-021-02058-6. Aug 27.
[21] Centers for Medicare and Medicaid services. Medicaid. Baltimore, MD: Centers for Medicare and Medicaid Services; 2024. Accessed June 23, 2024, https://www.medicaid.gov/medicaid/index.html.
[22] Nolan MB, Piasecki TM, Smith SS, et al. Relations of current and past Cancer with severe outcomes among 104,590 hospitalized COVID-19 patients: the COVID EHR cohort at the University of Wisconsin. Cancer Epidemiol Biomarkers Prev 2023;32(1):12–21. https://doi.org/10.1158/1055-9965.Epi-22-0500. Jan 9.
[23] Fiore MC, Smith SS, Adsit RT, et al. The first 20 months of the COVID-19 pandemic: mortality, intubation and ICU rates among 104,590 patients hospitalized at 21 United States health systems. PloS One 2022;17(9):e0274571. https://doi.org/10.1371/journal.pone.0274571.