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Clinical comorbidities, characteristics, and outcomes of mechanically ventilated patients in the State of Michigan with SARS-CoV-2 pneumonia

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In December 2019, a series of viral infections, eventually named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) appeared in China and quickly spread across the world [1]. The United States (USA) has been profoundly affected, reporting the most confirmed cases of SARS-CoV-2 of any country. As of June 10, 2020, SARS-CoV-2 infection has been confirmed in more than 7.3 million individuals in 188 countries and regions, with an overall mortality rate of more than 5.7% [2]. The State of Michigan has been particularly devastated by this disease; it ranks 9th in the USA with 65,182 total confirmed cases of SARS-CoV-2 and 6th in the USA with 5955 total deaths [2]. While the clinical course of patients with SARS-CoV-2 infection can vary from completely asymptomatic to critically ill, an understanding of differing patient characteristics and outcomes of infected patients is critical for health and government officials engaged in planning efforts to address outbreaks. We sought to describe the demographics, baseline comorbidities, and outcomes in patients with SARS-CoV-2 who required mechanical ventilation from a single hospital system in the state of Michigan, USA.

This retrospective observational study was conducted at St. Joseph Mercy Oakland Hospital, and data were obtained from medical records from the 7 hospitals in the health system (1996 beds). The institutional review board approved the study as minimal-risk research using data collected for routine clinical practice and waived the requirement for informed consent. All consecutive patients from March 10, 2020 to April 15, 2020 who required hospital admission with confirmed SARS-CoV-2 infection by positive result on polymerase chain reaction (PCR) testing of a nasopharyngeal sample were included in this study. The focus of this study was SARS-CoV-2 patients who required mechanical ventilation in the Intensive Care Unit (ICU), and only patients who completed their hospital course within the health system at study end (discharged alive or dead) were included in the study.

During the study period a total of 901 adult patients with confirmed SARS-CoV-2 infection were admitted to the 7 hospitals within the health system. After initial chart review 152 patients requiring mechanical ventilation were included. Of the 152 mechanically ventilated patients with confirmed SARS-CoV-2 infection, 39% (60) survived until discharge and 61% (92) died. The median age of patients was 68 years old (IQR 58–75), and 62.5% (95) were male. Forty-eight percent of patients had three or more comorbidities, the most common being hypertension (73%), hypercholesterolemia (61%),

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Table 1
Demographics, comorbidities, events, medications pre & after admission to hospital.

	Survivor (n = 60)	Non-survivor (n = 92)	Total (n = 152)	P value	Odds ratio
					95% C.I.
Pre-hospital demographics					
Age (years)					
Mean ± St. Dev.	59 ± 13	71 ± 10	66 ± 13	0.0000 *	1.081
Median [*IQR*]	61 [50–71]	72 [64–78]	68 [58–75]	0.0000 *	1.047–1.116
Sex					
Male	36 (60%)	59 (64%)	95 (62.5%)	0.6101	
Female	24 (40%)	33 (36%)	57 (37.5%)		
Race					
Black	33(55%)	41(%)	71(47%)	0.2478	
White	23(38%)	51(%)	70(46%)		
Other	4(7%)	8(%)	11(7%)		
Ethnicity					
Hispanic	2 (3%)	2 (2%)	4 (3%)	0.5168	
Non-Hispanic	58 (97%)	90 (98%)	148 (97%)		
BMI (kg/m ^{2})					
Mean ± StDv	32 ± 7	31 ± 7	32 ± 7	0.228	
Median [*IQR*]	32 [27–36]	29 [26–34]	31[26–35]	0.144	
Pre-admission comorbidities					
HTN	37(62%)	74(84%)	111(73%)	0.0108 *	2.556
					1.229–5.315
Coronary artery disease (CAD)	6(10%)	17(18%)	23(15%)	0.1542	
Diabetes	23(38%)	43(47%)	69(65%)	0.1583	
Hypercholesterolemia	31(52%)	61(66%)	92(61%)	0.0710	
Asthma	9(15%)	16(17%)	25(16%)	0.6985	
COPD	6(10%)	17(18%)	23(15%)	0.1463	
Renal disease	9(15%)	13(14%)	22(14%)	0.9203	
Cirrhosis	1(2%)	0(0%)	1(1%)	0.3947	
Smoker				0.8737	
Current (or quit < 6 months)	2(3%)	3(3%)	5(3%)		
Former (quit > 6 months)	16(27%)	27(29%)	43(28%)		
Never	27(45%)	37(40%)	64(42%)		
Unknown	15(25%)	25(27%)	40(26%)		
Pre-admission medications					
ACE inhibitors	12(20%)	23(25%)	35(23%)	0.4751	
ARBs	6(10%)	17(18%)	23(15%)	0.1542	
Statin	24(40%)	57(62%)	81(53%)	0.0080 *	2.443
					1.225–4.756
Oral steroids	6(10%)	10(11%)	16(11%)	0.8625	
Antithrombotic	19(32%)	38(41%)	57(38%)	0.2301	
Anticoagulant	7(12%)	15(16%)	22(14%)	0.4274	
ICU stay information					
Length of hospital stay (days)					
Mean ± SEM	13.1 ± 1.2	8.3 ± 0.7	10.2 ± 0.7	0.0003 *	0.852
Median [*IQR*]	11 [8–17]	7 [4–12]	8 [4–14]	0.0000 *	0.804–0.903
Length of ICU stay (days)					
Mean ± SEM	21 ± 1.4	10.1 ± 0.7	14.4 ± 0.8	0.0000 *	0.923
Median [*IQR*]	19 [14–23]	9 [5–14]	13 [7–20]	0.0002 *	0.882–0.968
Intub. fluid admin. (ml/kg/h)					
Mean ± SEM	0.56 ± 0.05	0.76 ± 0.05	0.68 ± 0.04	0.0057 *	3.616
Median [*IQR*]	0.47 [0.4–0.7]	0.64 [0.4–1.0]	0.57[0.4–0.9]	0.0043 *	1.394–9.379
Intub. urine output (ml/kg/h)					
Mean ± SEM	0.75 ± 0.05	0.4 ± 0.03	0.54 ± 0.03	0.0000 *	0.048
Median [*IQR*]	0.76 [0.5–1.0]	0.34 [0.2–0.6]	0.49[0.2–0.8]	0.0000 *	0.014–0.162
ICU stay events					
Continuous renal replacement therapy (CRRT)	5(8%)	20(23%)	26(17%)	0.0189 *	3.300
					1.170–9.311
Acute drop of hemoglobin	8(13%)	16(7%)	24(16%)	0.4839	
Cerebral thromboembolism	1(2%)	2(2%)	3(2%)	1.000	
Pulmonary embolism	4(7%)	5(5%)	9(6%)	1.000	

Table 1 (*Continued*)

	Survivor (n = 60)	Non-survivor (n = 92)	Total (n = 152)	P value	Odds ratio 95% C.I.
Deep vein thrombosis	6(10%)	4(4%)	10(7%)	0.1922	
Coronary artery thrombosis	0(0%)	3(3%)	3(2%)	0.2793	
Acute heart failure (EF < 30%)					
No	54(90%)	81(88%)	135(89%)	0.6483	
Yes	3(5%)	2(2%)	5(3%)		
N/A	3(5%)	9(10%)	12(8%)		
ICU stay medications					
Steroids	46(77%)	54(59%)	100(66%)	0.0225 *	0.432 0.209–0.896
Deep vein therapy (Prophylactic)	58(97%)	86(93%)	144(95%)	0.2473	
Therapeutic anti-coagulation	25(42%)	41(45%)	66(43%)	0.7290	
Hydroxychloroquine sulfate	58(97%)	86(93%)	144(95%)	0.4803	
Azithromycin	49(82%)	66(72%)	115(76%)	0.1637	
Tocilizumab	5(8%)	11(12%)	16(11%)	0.4624	
Zinc	27(45%)	31(34%)	58(38%)	0.1371	
Vitamin C	39(65%)	40(43%)	79(52%)	0.0066 *	0.394 0.200–0.778
Vitamin D	8(13%)	8(9%)	16(11%)	0.3428	
Vasopressor/inotrope admin.	33(55%)	79(86%)	112(74%)	< 0.0001 *	5.386 2.439–11.90
ICU stay lab results					
Ferritin at discharge (ng/mL)					
Mean ± SEM	663 ± 97	1952 ± 455	1812 ± 211	0.0251 *	1.001
Median [*IQR*]	476 [359–881]	1166[594–1500]	849[462–1431]	0.0001	1.00–1.002
LDH at discharge (U/L)					
Mean ± SEM	301 ± 22	947 ± 276	705 ± 177	0.07622	1.008
Median [*IQR*]	287 [230–347]	461 [351–644]	393[286–538]	0.0001 *	1.003–1.014

Data are *Mean ± St. Dev.*, *Median* [*IQR*] or n (%). p values were calculated by t-test, Mann-Whitney U test, χ^2 test, or Fisher's exact test, as appropriate. Univariate logistic regression odds ratio and 95% Confidence of intervals (C.I.) are given for the variables with significant difference ($P < 0.05$). *: indicates significant difference. ACE: angiotensin-converting enzyme. ARB: angiotensin receptor blockers, BMI: body mass index, care unit, COPD: chronic obstructive pulmonary disease, EF: ejection fraction, HTN: hypertension, ICU = intensive care unit, IQR = Inter quartile range, LDH: lactate dehydrogenase.

and diabetes mellitus (45%). Increased age, pre-existing hypertension, pre-admission statin use, increased fluid administration, need for continuous renal replacement therapy (CRRT), and use of vasopressor/inotrope were associated with increased mortality. There was a decreased risk of mortality in patients treated with steroids and vitamin C, and in patients with greater urine output (Table 1).

As this is a previously unknown virus, the mainstay of treatment for hospitalized patients has been isolation and supportive care including supplemental oxygen therapy, fluid resuscitation, administration of antimicrobials for treatment of secondary bacterial infections, and prevention of end-organ dysfunction [3]. Due to the constantly changing hypotheses on best management practices for SARS-CoV-2, treatment protocols vary widely between hospitals and mortality in patients with critical disease characteristics requiring ICU care have been reported to be as high as 78% [1,4,5].

SARS-CoV-2 has placed a tremendous strain on hospitals and hospital resources all over the world; this study can potentially help health officials identify patients who are at higher risk of death, guide planning efforts for management of this disease, as well as direct further prospective study looking at specific therapies in an effort to improve patient outcomes.

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CRediT authorship contribution statement

Sandeep Krishnan: Investigation, Methodology, Data curation, Writing - original draft, Writing - review & editing. **Kinjal Patel:** Investigation, Writing - original draft, Writing - review & editing. **Ronak Desai:** Investigation, Writing - original draft, Writing - review & editing. **Anupam Sule:** Investigation, Writing - original draft, Writing - review & editing. **Peter Paik:** Investigation, Writing - review & editing. **Ashley Miller:** Investigation, Writing - review & editing. **Alicia Barclay:** Investigation, Writing - review & editing. **Adam Cassella:** Investigation, Writing - review & editing. **Jon Lucaj:** Investigation, Writing - review & editing. **Yvonne Royster:** Investigation, Writing - review & editing. **Joffer Hakim:** Writing - review & editing. **Zulfiqar Ahmed:** Writing - review & editing. **Farhad Ghoddoussi:** Investigation, Formal analysis, Data curation, Methodology, Writing - original draft, Writing - review & editing.

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