Clinical Mortality Review in a Large COVID-19 Cohort

Mark Jarrett, Susanne Schultz, Julie Lyall, Jason Wang, Lori Stier, Marcella De Geronimo, Karen Nelson

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Abstract

Background: Northwell Health (Northwell), an integrated health system in New York, treated more than 15000 inpatients with coronavirus disease (COVID-19) at the US epicenter of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic. We describe the demographic characteristics of COVID-19 mortalities, observation of frequent rapid response teams (RRT)/cardiac arrest (CA) calls for non-intensive care unit (ICU) patients, and factors that contributed to RRT/CA calls

Objective: To analyze the clinical characteristics of a large mortality cohort from the New York centered COVID-19 pandemic, with special attention to those not in an ICU setting..

Methods: A team of registered nurses reviewed medical records of inpatients who tested positive for SARS-CoV-2 via polymerase chain reaction (PCR) before or on admission and died between March 13 (first Northwell inpatient expiration) and April 30, 2020 at 15 Northwell hospitals. Findings for these patients were abstracted into a database and statistically analyzed.
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Results: Findings: Of 2634 COVID-19 mortalities, 56·1% had oxygen saturation levels greater than or equal to 90% on presentation and required no respiratory support. At least one RRT/CA was called on 42·2% of patients at a non-ICU level of care. Before the RRT/CA call, the most recent oxygen saturation levels for 76·6% of non-ICU patients were at least 90%. At the time RRT/CA was called, 43·1% had an oxygen saturation less than 80%.
Interpretation: This study represents one of the largest cohorts of reviewed mortalities that also captures data in non-structured fields. Approximately 50% of deaths occurred at a non-ICU level of care, despite admission to the appropriate care setting with normal staffing. The data imply a sudden, unexpected deterioration in respiratory status requiring RRT/CA in a large number of non-ICU patients.

Conclusions: Patients admitted to a non-ICU level of care suffer rapid clinical deterioration, often with a sudden decrease in oxygen saturation. These patients could benefit from additional monitoring (eg, continuous central oxygenation saturation), although this approach warrants further study Clinical Trial: Exempt by IRB.

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Clinical Mortality Review in a Large COVID-19 Cohort

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ABSTRACT

Background: Northwell Health (Northwell), an integrated health system in New York, treated more than 15,000 inpatients with coronavirus disease 2019 (COVID-19) at the US epicenter of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.

Objectives: We describe the demographic characteristics of COVID-19 mortalities, observation of frequent rapid response teams (RRT)/cardiac arrest (CA) calls for non-intensive care unit (ICU) patients, and factors that contributed to RRT/CA calls.

Methods: A team of registered nurses reviewed medical records of inpatients who tested positive for SARS-CoV-2 via polymerase chain reaction before or on admission and died between March 13 (first Northwell inpatient expiration) and April 30, 2020 at 15 Northwell hospitals. Findings for these patients were abstracted into a database and statistically analyzed.

Results: Of 2634 COVID-19 mortalities, 56.1% (1478/2634) had oxygen saturation levels greater than or equal to 90% on presentation and required no respiratory support. At least one RRT/CA was called on 42.2% (1112/2634) of patients at a non-ICU level of care. Before the RRT/CA call, the most recent oxygen saturation levels for 76.6% (852/1112) of non-ICU patients were at least 90%. At the time RRT/CA was called, 43.1% (479/1112) had an oxygen saturation less than 80%.

Conclusions: This study represents one of the largest cohorts of reviewed mortalities that also captures data in non-structured fields. Approximately 50% of deaths occurred at a non-ICU level of care, despite admission to the appropriate care setting with normal staffing. The data imply a sudden, unexpected deterioration in respiratory status requiring RRT/CA in a large number of non-ICU patients. Patients admitted to a non-ICU level of care suffer rapid clinical deterioration, often with a sudden decrease in oxygen saturation. These patients could benefit from additional monitoring (eg, continuous central oxygenation saturation), although this approach warrants further study.

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of Health.

INTRODUCTION

Downstate New York was the first epicenter of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic in the United States [1-2]. Northwell Health (Northwell), an integrated health system, treated more than 15,000 inpatients with coronavirus disease (COVID-19). Comprehensively analyzing the characteristics of those who died can help define the clinical nature of COVID-19 infection and potentially suggest new care protocols. For 7 years, Northwell has used a centralized mortality review process with data validated through rigorous internal review and inter-rater reliability (92% to 96%). This robust process used a customized database to review all 2634 COVID-19 mortalities in Northwell's adult acute care hospitals between March and April 2020. During this overwhelming surge, documentation was in various notes, as well as in structured fields in the electronic health record (EHR) systems. This study describes the demographic characteristics of COVID-19 mortalities and the observation of frequent calls for rapid response teams (RRT)/cardiac arrest (CA) in patients not in the intensive care unit (ICU). It also discusses factors that contributed to the RRT/CA calls, which may be a significant element in planning for a pandemic resurgence.

METHODS

Study Design

Northwell is New York State's largest health care provider and private employer. With 23 hospitals (including specialty hospitals) and nearly 800 outpatient practice sites, the organization cares for over 2 million people in greater metropolitan New York. A team of registered nurses in the corporate quality department retrospectively reviewed medical records from 15 acute care hospitals. This team routinely conducts clinical reviews of all adult acute inpatient mortalities—approximately 5000 per year. A physician advisor was available to the team to consult on clinical questions.

Database elements were based on Northwell's experience with treating COVID-19 patients, literature

review from countries that had early experience in treating patients, and clinical trials being conducted at the Feinstein Institutes for Medical Research. Also, the data were captured in the database established under the direction of critical care intensivists at the epicenter of the pandemic, other subject matter experts, and quality leadership. During data abstraction, modifications and enhancements were made to the database based on trends and emerging information. Demographics, comorbidities, clinical findings, and management of COVID-19 patients who died were analyzed.

Patient Characteristics

Analyzed cases included inpatients who tested positive for SARS-CoV-2 via polymerase chain reaction before or on admission and then died between March 13 (first Northwell inpatient death) and April 30, 2020. Emergency department (ED) mortalities were excluded. Demographic data and comorbidities were abstracted from the medical record on admitted patients. Initially data were collected on ten patient comorbidities that were deemed important and then narrowed down to six comorbidities for inclusion based on our initial analysis. Transfers from one in-system hospital to another were merged and considered as a single visit. Notable patient outcomes that were measured were the level of ICU care (validated and abstracted from the provider order) and a call for RRT/CA. The Institutional Review Board of Northwell Health deemed this study as exempt and waived the requirement for informed consent.

Statistical Analysis

Statistical analyses were performed using chi-square for categorical variables and *t*-test for continuous variables. A multivariable logistic regression model was created to determine independent risk factors for the outcome variable. Statistical significance was considered $P<.05$. All statistical analyses were done in SAS v9.4 (SAS Institute).

RESULTS

Patient Characteristics

Baseline characteristics of 2634 COVID-19 mortalities are described in Table 1. The age range was 21 to 107 years in the following categories: 21 to 39 (49/2634; 1.9%), 40 to 59 (351/2634; 13.3%), 60 to 79 (1241/2634; 47.1%), and 80 and older (993/2634; 37.7%). The patient cohort was 63.2% (1664/2634) male and 36.8% (970/2634) female. Of all patients, 47.7% (1256/2634) were white, 17.6% (463/2634) were black, 8.7% (230/2634) were Asian, and 26.0% (685/2634) were other/unknown. Insurance was Medicare for the majority of patients (1839/2634; 69.8%). The most common comorbidities among those collected were hypertension (1719/2634; 65.3%), diabetes mellitus (1043/2634; 39.6%), and dementia (431/2634; 16.4%). Fewer patients had chronic obstructive pulmonary disease (COPD) (385/2634; 14.6%), heart failure (291/2634; 11.1%), and end stage renal disease (166/2634; 6.3%). Of these six comorbidities, more than half (1350/2634; 51.3%) of patients had 2 or more comorbidities and 16.9% (445/2634) had 0 comorbidities. The majority of patients with a known body mass index (BMI) of 25 or more were categorized as follows: 25 to 29.99 (732/2634; 27.8%), 30 to 34.99 (401/2634; 15.2%), 35 to 39.99 (190/2634; 7.2%), and 40 or higher (147/2634; 5.6%).

Table 1. Baseline characteristics of Patients Hospitalized with COVID-19 Mortality (n=2634)

Baseline characteristics	No. (%)
Age	
21-39	49 (1.86)
40-59	351 (13.3)
60-79	1241 (47.1)
80≤	993 (37.7)
Sex	
Male	1664 (63.2)
Female	970 (36.8)
Race	
White	1256 (47.7)
Black	463 (17.6)
Asian	230 (8.7)
Other/Unknown	685 (26.0)
Payment method	
Commercial	413 (15.7)

Medicaid	341 (13.0)
Medicare	1839 (69.8)
Self-pay	41 (1.6)
Comorbidities	
Hypertension	1719 (65.3)
COPD	385 (14.6)
Diabetes Mellitus	1043 (39.6)
Heart Failure	291 (11.1)
Dementia	431 (16.4)
End Stage Renal Disease	166 (6.3)
0 Comorbidities	445 (16.9)
1 Comorbidity	839 (31.9)
2 Comorbidities	934 (35.5)
3 Comorbidities	343 (13.0)
4 Comorbidities	66 (2.5)
5 Comorbidities	7 (0.3)
6 Comorbidities	0 (0.0)
BMI	
Unknown	494 (18.8)
<18.5	82 (3.1)
18.5-24.99	588 (22.3)
25-29.99	732 (27.8)
30-34.99	401 (15.2)
35-39.99	190 (7.2)
40≤	147 (5.6)
Admit source	
Home	1895 (72.0)
Rehabilitation	127 (4.8)
Skilled Nursing Facility	411 (15.6)
Transfer from another acute care hospital	201 (7.6)
Emergency department visit	
Within 48 hours of this admission	51 (1.9)
Within 7 days of this admission	125 (4.8)
Readmission	
Within 24 Hours	20 (0.8)
Within 7 Days	75 (2.9)
Within 30 Days	194 (7.4)
Level of care at time of death	
ICU	1299 (49.3)
Non-ICU	1335 (50.7)
Level of care at time of admission	
ICU	541 (20.5)
Medical/Surgical	1230 (46.7)
Telemetry/Stepdown	863 (32.8)
Overall length of stay	
0-7	1420 (53.9)
8≤	1214 (46.1)
ICU length of stay, d	
0-7	872 (33.1)
8≤	574 (21.8)

Oxygen saturation on presentation		
<80	459 (17.4)	
80-89.9	667 (25.3)	
90≥	1478 (56.1)	
UTD	30 (1.2)	
Initial respiratory support on presentation		
None	1397 (53.0)	
Nasal cannula	363 (13.8)	
Non-rebreather	742 (28.2)	
Ventilator	24 (0.9)	
High-flow nasal cannula	8 (0.3)	
Ventimask	11 (0.4)	
BiPAP	13 (0.5)	
Other	27 (1.0)	
UTD	49 (1.9)	
RRT/CA while not at ICU level of care		
Yes	1112 (42.2)	
Mechanical Ventilation	n=2634	n=1403 subset
Yes	1403 (53.2)	1403 (100.0)
Subset (n=1403)		
Traditional ventilator	1259 (47.9)	1259 (89.7)
Converted BiPAP	142 (0.1)	142 (10.1)
Anesthesia machine	2 (0.08)	2 (0.1)
Increased oxygen requirement prior to MV	1332 (50.6)	1332 (94.9)
Mechanical ventilation length, d (n=1403)		
0-7	851 (32.3)	851 (60.7)
8≥	552 (20.9)	552 (39.3)
Terminal wean (n=1403)		
Yes	270 (10.3)	270 (10.3)
Proning		
Yes	756 (28.7)	
No	1878 (71.3)	
Proning without MV (n=756)	191 (25.3)	
Proning prior to MV (n=756)	213 (28.2)	
Proning during MV (n=756)	214 (28.3)	
Proning prior to and during MV (n=756)	138 (18.3)	
DNR complete		
Yes	1631 (61.9)	
Palliative care consult		
Yes	1014 (38.5)	
Clinical trial inclusion		
Yes	114 (4.3)	

Abbreviations: BiPAP, bilevel positive airway pressure; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DNR, do not resuscitate; ICU, intensive care unit; MV, mechanical ventilation; UTD, unable to determine

Patient Outcomes

Most patients were admitted from home (1895/2634; 71.9%). The remaining patients were admitted

from a skilled nursing facility (SNF) (411/2634; 15.6%), an acute care facility (201/2634; 7.6%), and rehabilitation (127/2634; 4.8%). The percentage of patients with a prior ED visit within 7 days of admission was 4.8% (125/2634), and within 48 hours of admission was 1.9% (51/2634). The percentage of patients readmitted within 30 days was 7.4% (194/2634), within 7 days was 2.9% (75/2634), and within 24 hours was 0.8% (20/2634). On presentation, most (1478/2634; 56.1%) patients had an oxygen saturation level greater than or equal to 90%, and more than half (1397/2634; 53.0%) required no respiratory support. Others required nasal cannula (363/2634; 13.8%), non-rebreather (742/2634; 28.2%), and mechanical ventilation (24/2634; 0.9%). More than half of the patients who died (1403/2634; 53.2%) required mechanical ventilation during their clinical course. Of those patients, 94.9% (1332/1403) had increasing oxygen requirements before intubation, 89.7% (1259/1403) were on traditional ventilators, 10.1% (142/1403) were on converted BiPAP machines, and 0.1% (2/1403) were on anesthesia machines. The length of time on mechanical ventilation was from 0 to 7 days for 60.7% (851/1403) of patients and was 8 days or more for 39.3% (552/1403) of patients.

Prone positioning was documented for 28.7% (756/2634) of patients, and 10.3% (270/2634) of patients were terminally weaned. Do Not Resuscitate (DNR) orders were complete for 61.9% (1631/2634) patients. A palliative care consult was provided to 38.5% (1014/2634) of patients. At the time of death, the level of care was the ICU for 49.3% (1299/2634) of patients and non-ICU for 50.7% (1335/2634) of patients.

Patient Outcomes Based on Rapid Response Teams/Cardiac Arrest Calls

Of all patients, 42.2% (1112/2634) had a RRT/CA call at a non-ICU level of care versus 57.8% (1522/2634) who did not. As shown in Table 2 and Table 3, the RRT/CA group was significantly different from the non-RRT/CA group in terms of age, race, and comorbidities. Among patients between 60 and 79 years old, 55.6% (618/1112) were in the RRT/CA group and 40.9% (623/1522)

were in the non-RRT/CA group. In terms of race, white was significantly lower in the RRT/CA group [36.3% (404/1112) versus 56.0% (852/1522); *P*<.001]. The RRT/CA cohort had a significantly higher rate of diabetes mellitus [44.2% (491/1112) versus 36.3% (552/1522), *P*<.001]. Patients in the RRT/CA cohort were more likely to be admitted from home (926/1112; 83.3%) versus the non-RRT/CA cohort (969/1522; 63.7%). The RRT/CA cohort versus the non-RRT/CA cohort was more likely to be admitted to a medical/surgical unit [(576/1112; 51.8%) versus (654/1522; 42.9%)] or telemetry/step-down unit [(455/1112; 40.9%) versus (408/1522; 26.8%)], and to die at an ICU level of care [(671/1112; 60.3%) versus (628/1522; 41.3%)]. An overall length of stay (LOS) of 8 days or more was higher for the RRT/CA cohort (645/1112; 58.0%) than the non-RRT/CA cohort (569/1522; 37.4%), as was an ICU LOS of 0 to 7 days [(472/1112; 42.0%) versus (400/1522; 26.3%)] and 8 days or more [(271/1112; 24.4%) versus (303/1522; 19.9%)]. After adjusting for demographic and clinical characteristics, oxygen saturation levels at presentation were significant for the RRT/CA cohort at oxygen saturation levels of 80% to 89% [odds ratio (OR)=1.988; 95% CI: 1.511, 2.616] and of 90% or higher (OR=2.517; 95% CI: 1.962, 3.230). See logistic regression results (Table 4).

Table 2. Baseline Characteristics of COVID-19 Mortalities that Experienced a RRT/CA at a Non-ICU Level of Care

	RRT/CA (n=2634)		
Baseline characteristics	**Yes, No. (%) (n=1112)**	**No, No. (%) (n=1522)**	***P* value**
Age			<.001
21-39	19 (1.7)	30 (2.0)	
40-59	194 (17.5)	157 (10.3)	
60-79	618 (55.6)	623 (40.9)	
80≤	281 (25.3)	712 (40.8)	
Sex			.35
Male	714 (64.2)	950 (62.4)	
Female	398 (35.8)	572 (37.6)	
Race			<.001
White	404 (36.3)	852 (56.0)	
Black	235 (21.1)	228 (15.0)	
Asian	125 (11.2)	105 (6.9)	
Other/Unknown	348 (31.3)	337 (22.1)	
Payment method			<.001
Commercial	226 (20.3)	187 (12.3)	
Medicaid	166 (14.9)	175 (11.5)	
Medicare	702 (63.1)	1137 (74.7)	
Self-pay	18 (1.6)	23 (1.5)	

Comorbidities			
Hypertension			.24
Yes	740 (66.5)	979 (64.3)	
No	372 (33.5)	543 (35.7)	
COPD			.08
Yes	147 (13.2)	238 (15.6)	
No	965 (86.8)	1284 (84.4)	
Diabetes mellitus			<.001
Yes	491 (44.2)	552 (36.3)	
No	621 (55.9)	970 (63.7)	
Heart failure			.03
Yes	106 (9.5)	185 (12.2)	
No	1006 (90.5)	1337 (87.8)	
Dementia			<.001
Yes	98 (8.8)	333 (21.9)	
No	1014 (91.2)	1189 (78.1)	
End stage renal disease			.02
Yes	85 (7.6)	81 (5.3)	
No	1027 (92.4)	1441 (94.7)	
0 Comorbidities	202 (18.2)	243 (15.9)	.47
1 Comorbidity	355 (31.9)	484 (31.8)	
2 Comorbidities	388 (34.9)	546 (35.9)	
3 Comorbidities	134 (12.1)	209 (13.7)	
4 Comorbidities	31 (2.8)	35 (2.3)	
5 Comorbidities	2 (0.2)	5 (0.3)	
BMI			<.001
Unknown	136 (12.2)	358 (23.5)	
<18.5	22 (1.9)	60 (3.9)	
18.5-24.99	236 (21.2)	352 (23.1)	
25-29.99	352 (31.7)	380 (24.9)	
30-34.99	206 (18.5)	195 (12.8)	
35-39.99	88 (7.9)	102 (6.7)	
40≤	72 (6.5)	75 (4.9)	
Admit source			<.001
Home	926 (83.3)	969 (63.7)	
Rehabilitation	34 (3.0)	93 (6.1)	
Skilled nursing facility	80 (7.2)	331 (21.7)	
Transfer from another acute care Hospital	72 (6.5)	129 (8.5)	
Emergency department visit			
Within 48 hours of this admission			.03
Yes	29 (2.6)	22 (1.5)	
No	1083 (97.4)	1500 (98.6)	
Within 7 days of this admission			.13
Yes	61 (5.5)	64 (4.2)	
No	1051 (94.5)	1458 (95.8)	
Readmission			
Within 24 hours			.51
Yes	7 (0.6)	13 (0.9)	
No	1105 (99.4)	1509 (99.2)	

Within 7 days			.88
Yes	31 (2.8)	44 (2.9)	
No	1081 (97.2)	1478 (97.1)	
Within 30 days			.10
Yes	71 (6.4)	123 (8.1)	
No	1041 (93.6)	1399 (91.9)	
Level of care at time of death			
ICU	671 (60.3)	628 (41.3)	
Non-ICU	441 (39.7)	894 (58.7)	
Level of care at time of admission			<.001
ICU	81 (7.3)	460 (30.2)	
Medical/Surgical	576 (51.8)	654 (42.9)	
Telemetry/Stepdown	455 (40.9)	408 (26.8)	
Overall length of stay, d			<.001
0-7	467 (42.0)	953 (62.6)	
8≤	645 (58.0)	569 (37.4)	
ICU length of stay, d			<.001
0-7	472 (42.5)	400 (26.3)	
8≤	271 (24.4)	303 (19.9)	
Oxygen saturation on presentation			<.001
<80	152 (13.7)	307 (20.2)	
80-89.9	289 (26.0)	378 (24.8)	
90≤	664 (59.7)	814 (53.5)	
UTD	7 (0.6)	23 (1.5)	
Initial respiratory support on presentation			<.001
None	687 (61.8)	710 (46.7)	
Nasal cannula	161 (14.5)	202 (13.3)	
High-flow nasal cannula	0 (0.0)	8 (0.5)	
Ventimask	2 (0.2)	9 (0.6)	
BiPAP	2 (0.2)	11 (0.7)	
Non-rebreather	239 (21.5)	503 (33.1)	
Ventilator	1 (0.1)	23 (1.5)	
Other	4 (0.4)	23 (1.5)	
UTD	16 (1.4)	33 (2.2)	
Mechanical ventilation			
Yes	723 (65.0)	680 (44.7)	<.001
Traditional ventilator	650 (58.5)	609 (40.0)	
Converted BiPAP	71 (6.4)	71 (4.7)	
Anesthesia machine	2 (0.2)	0 (0.0)	
Increased oxygen requirement before MV	699 (62.9)	633 (41.6)	<.001
Mechanical ventilation length, d			
0-7	461 (41.5)	390 (25.6)	
8≤	262 (23.6)	290 (19.1)	
Terminal wean			.52
Yes	109 (9.8)	161 (10.6)	
No	1003 (90.2)	1361 (89.4)	
Proning			<.001
Yes	500 (45.0)	256 (16.8)	

No	612 (54.9)	1266 (83.2)	
Proning without MV	116 (10.4)	75 (4.9)	
Proning before MV	171 (15.4)	42 (2.7)	
Proning during MV	99 (8.9)	115 (7.5)	
Proning before and during MV	114 (10.3)	24 (1.6)	
DNR complete			<.001
Yes	558 (50.2)	1073 (70.5)	
No	554 (49.8)	449 (29.5)	
Palliative care consult			<.001
Yes	385 (34.6)	629 (41.3)	
No	727 (65.4)	893 (58.7)	
Clinical trial inclusion			
Yes	91(8.2)	23(1.5)	
No	1021(91.8)	1499 (98.5)	

Abbreviations: BiPAP, bilevel positive airway pressure; BMI, body mass index; COPD, chronic obstructive pulmonary disease; DNR, do not resuscitate; ICU, intensive care unit; MV, mechanical ventilation; RRT/CA, Rapid Response Team/Cardiac Arrest; UTD, unable to determine.

Table 3. Additional characteristics associated with RRT/CA While on a Non-ICU Level of Care (n=1112)

	No. (%)
Required escalation in level of care following initial RRT/CA	
Yes	716 (64.4)
Oxygen saturation at time RRT/CA initiated	
<80	479 (43.1)
80-89	407 (36.6)
90≤	128 (11.5)
UTD	98 (8.8)
Oxygen supplement at time RRT/CA initiated	
Non-rebreather with or without nasal Cannula	868 (78.1)
Nasal cannula	147 (13.2)
Room air	40 (3.6)
Venti mask	18 (1.6)
Ventilator	11 (1.0)
High-flow nasal cannula	9 (0.8)
BiPAP	5 (0.4)
UTD	14 (1.3)
Most recent oxygen saturation before RRT/CA initiated	
<80	43 (3.9)
80-89	211 (18.9)
90≤	852 (76.6)
UTD	6 (0.5)
Documented timing of most recent oxygen saturation before RRT/CA initiated, h	
<1	263 (23.7)
1-2	191 (17.2)

2-3	140 (12.6)
3-4	109 (9.8)
4<	409 (36.8)

Abbreviations: BiPAP, bilevel positive airway pressure; RRT/CA, Rapid Response Team/Cardiac Arrest; UTD, unable to determine.

Table 4. Regression Analysis of COVID-19 Mortalities that Experienced a RRT/CA at a Non-ICU Level of Care (n=2634)

Baseline characteristics	**Estimate**	***P* value**	**Odds ratio**	**95% CI estimate**	
Age					
50-69	0.2653	.20	1.304	0.872	1.949
70-79	0.1721	.44	1.188	0.766	1.842
80≥	-0.3179	.17	0.728	0.460	1.151
Sex					
Male	-0.2299	.02	0.795	0.658	0.960
Race					
Black	0.6134	<.001	1.847	1.445	2.361
Asian	0.6548	<.001	1.925	1.395	2.655
Other/Unknown	0.5333	<.001	1.704	1.362	2.133
Payment method					
Medicaid	-0.0458	.78	0.955	0.691	1.321
Medicare	-0.0107	.94	0.989	0.750	1.305
Self-pay	-0.3020	.40	0.739	0.367	1.488
Comorbidities					
Heart failure	0.1429	.34	1.154	0.860	1.547
End stage renal Disease	0.6184	.002	1.856	1.262	2.729
COPD	-0.1216	.35	0.886	0.687	1.141
Hypertension	0.1239	.21	1.132	0.931	1.376
Diabetes mellitus	0.0833	.38	1.087	0.902	1.310
BMI					
Unknown	-0.4645	<.001	0.628	0.491	0.804
30≤	-0.0545	.62	0.947	0.765	1.173
Admit source					
Home	0.9060	<.001	2.474	1.850	3.310
Rehabilitation	0.2904	.25	1.337	0.813	2.199
Transfer from acute care hospital	0.0544	.80	1.056	0.691	1.614
Oxygen saturation on presentation					
80-89	0.6871	<.001	1.988	1.511	2.616
90≤	0.9232	<.001	2.517	1.962	3.230
Proning					
Yes	1.1840	<.001	3.267	2.667	4.003

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease

DISCUSSION

Summary of Findings

This study represents a review of one of the largest cohorts of COVID-19 mortality that includes data documented in non-structured fields within the EHR. The experienced team of registered nurses was

able to extract detailed information from the medical record that is typically not included in a structured dataset analysis. The demographics of the patients who died is similar to other published studies: age predominately over 69, male majority, payor mix [reflecting age and Medicare, along with a low number of self-pay (41/2634; 1.6%)], and multiple comorbidities [3-12].

Circumstances Preceding Patient Deterioration

This study provides a detailed clinical picture of the circumstances that precede the sudden deterioration in non-ICU patients reported by clinicians, but not fully examined in the literature. A striking feature of COVID-19 that has been reported is the rapid progression of respiratory failure soon after the the onset of dyspnea and hypoxemia [13]. The National Institutes for Health (NIH) has reported that hypoxemia is common in hospitalized patients with COVID-19 and that the criteria for hospital admission, ICU admission, and mechanical ventilation differ between countries [14]. In some hospitals in the United States, more than 25% of hospitalized patients require ICU care, mostly due to acute respiratory failure. Recommendations from the NIH are close monitoring for worsening respiratory status for adults with COVID-19 who are receiving supplemental oxygen. These recommendations align with our findings in the non-ICU patient population.

Approximately 50% (1335/2634; 50.7%) of deaths occurred at a non-ICU level of care, despite admission to the appropriate care setting with normal staffing. Our analysis of patients who experienced at least one RRT/CA at a non-ICU level of care revealed that 64.4% (716/1112) required an escalation in level of care. Of the RRT/CA patients, 59.7% (664/1112) presented to the hospital with oxygen saturation levels greater than or equal to 90%. In addition, 61.8% (687/1112) had no oxygen support. Of the RTT/CA patients, 92.7% (1031/1112) were admitted to a non-ICU level of care with normal staffing levels, which was appropriate based on their care needs. At presentation to the ED, the oxygen saturation levels for these patients were significantly higher than those for patients admitted to the ICU. Before the RRT/CA, the most recent oxygen saturation levels recorded

for the non-ICU patients remained high at greater than or equal to 90% for 76.6% (852/1112) of patients. Oxygen saturations were documented within two hours of the RRT/CA in 40.9% (454/1112) of patients in the RRT/CA cohort. When the RRT/CA was called, 43.1% (479/1112) of patients had an oxygen saturation less than 80%, and 78.1% (868/1112) were on a non-rebreather/non-rebreather with nasal cannula. These data imply a sudden, unexpected deterioration in respiratory status requiring an RRT/CA call in a large number of non-ICU patients.

Limitations

This study includes the following limitations. First, the study focuses on the demographic and clinical characteristics of in-hospital COVID-19 patients who died between March 13, 2020 and April 30, 2020; it does not provide a comparison group of similar patients who survived during the same time period. Second, data were obtained from the EHR and manually abstracted from medical records through retrospective review, but some routine documentation was less detailed due to the volume of patients being treated. Third, race was documented as other/unknown in 26% (685/2634) of patients; therefore, conclusions about race could not be drawn. Fourth, missing BMI data were included in the category of “Unknown” BMI. Finally, the study does not recognize a specific trigger that can distinguish which non-ICU patients in the cohort should be monitored.

Conclusions

Patients admitted to a non-ICU level of care appear to suffer a rapid clinical deterioration, often with the hallmark of a sudden decrease in oxygen saturation. This finding suggests non-ICU patients could benefit from additional monitoring, such as continuous central oxygenation saturation. The availability of wireless patch monitoring should be considered, along with other methods, such as carbon dioxide and/or cardiac monitoring. Although this approach does not ensure reduced mortality, the number of RRT/CA calls infers this area warrants further study.

CONTRIBUTORS

MPJ had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. MPJ, SES, JSL, and KLN were responsible for the conception and design of the study. MPJ, SES, JSL, JJW, LS, MDG, and KLN were responsible for data acquisition, analysis, and interpretation. MPJ, SES, JSL, JJW, LS, and KLN were responsible for drafting the manuscript. MPJ, SES, JSL, JJW, LS, MDG, and KLN were responsible for critical revision of the manuscript for important intellectual content. JJW was responsible for the statistical analysis. MPJ, SES, JSL, JJW, LS, MDG, and KLN were responsible for administrative, technical, and material support. MPJ supervised the study.

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DATA SHARING

The data that support the findings of this study are available on request from COVID19@northwell.edu. The data are not publicly available due to restrictions as it could compromise the privacy of research participants.

DECLARATION OF INTERESTS

We declare no competing interests.

REFERENCES

1. The Center for Systems Science and Engineering at Johns Hopkins University. COVID-19 dashboard. 2020. https:// gisanddata.maps.arcgis.com/apps/opsdashboard/ index.html#/ bda7594740fd40299423467b48e9ecf6. (accessed March 24, 2020).
2. New York State Department of Health. COVID-19 Tracker. 2020. https://covid19tracker.health.ny.gov/views/NYS-COVID19 Tracker/NYSDOHCOVID-19Tracker-Map?%. (accessed May 7, 2020).
3. CDC COVID-19 Response Team. Preliminary estimates of the prevalence of selected underlying health conditions among patients with coronavirus disease 2019 - United States, February 12-March 28, 2020. *MMWR Morb Mortal Wkly Rep* 2020; **69:** 382–386. doi:10.15585/mmwr.mm6913e2
4. Wortham JM, Lee JT, Althomsons S, et al. Characteristics of Persons Who Died with COVID-19 —United States, February 12–May 18, 2020. *MMWR Morb Mortal Wkly Rep* ePub: 10 July 2020. doi:10.15585/mmwr.mm6928e1
5. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. *Lancet* 2020; **395:** 470–473. doi:10.1016/ S0140-6736(20)30185-9
6. Richardson S, Hirsch JS, Narasimhan M, et al; and the Northwell COVID-19 Research Consortium. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA* Published online April 22, 2020. Corrected on April 24, 2020. doi:10.1001/jama.2020.6775
7. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020; **395:** 1054–1062. doi:10.1016/S0140-6736(20)30566-3
8. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical characteristics of Covid-19 in New York City. *N*

Engl J Med Published online April 17, 2020. doi:10.1056/ NEJMc2010419

9. Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospitalization and critical illness among 4,103 patients with COVID-19 disease in New York City. *medRxiv* Preprint posted April 11, 2020. doi:10.1101/2020.04.08.20057794
10. Garg S, Kim L, Whitaker M, et al. Hospitalization rates and characteristics of patients hospitalized with laboratory-confirmed coronavirus disease 2019 - COVID-NET, 14 States, March 1-30, 2020. *MMWR Morb Mortal Wkly Rep* 2020; **69:** 458–464. doi:10.15585/mmwr.mm6915e3
11. Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus Disease 2019 Case Surveillance — United States, January 22–May 30, 2020. *MMWR Morb Mortal Wkly Rep* ePub: 15 June 2020. doi:10.15585/mmwr.mm6924e2
12. Yancy, CW. COVID-19 and African Americans. *JAMA* Published online April 15, 2020. doi:10.1001/jama.2020.6548
13. Berlin, DA, Gulick, RM, Martinez, FJ.. Severe Covid-19. *N Engl J Med* Published online May 15, 2020. doi: 10.1056/NEJMcp2009575
14. NIH. COVID-19 treatment guidelines. https://covid19treatmentguidelines. nih.gov/introduction/. (accessed April 24, 2020).