# Clinical Characteristics and Outcomes of Non-ICU Hospitalization for COVID-19 in a Nonepicenter, Centrally Monitored Healthcare System

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**BACKGROUND:** The clinical characteristics and outcomes associated with non–intensive care unit (non-ICU) hospitalizations for coronavirus disease 2019 (COVID-19) outside disease epicenters remain poorly characterized.

**METHODS:** Systematic analysis of all non-ICU patient hospitalizations for COVID-19 completing discharge between March 13 and May 1, 2020, in a large US health care system utilizing off-site central monitoring. Variables of interest were examined in relation to a composite event rate of death, ICU transfer, or increased oxygen requirement to high-flow nasal cannula, noninvasive ventilation, or mechanical ventilation.

**RESULTS:** Among 350 patients (age, 64 ± 16 years; 55% male), most (73%) required 3 L/min or less of supplemental oxygen during admission. Telemetry was widely utilized (79%) yet arrhythmias were uncommon (14%) and were predominantly (90%) among patients with abnormal troponin levels or known cardiovascular disease. Ventricular tachycardia was rare (5%), nonsustained, and

not associated with hydroxychloroquine/azithromycin treatment. Adverse events occurred in 62 patients (18%), including 22 deaths (6%), 48 ICU transfers (14%), and 49 patients with increased oxygen requirement (14%) and were independently associated with elevated C-reactive protein (odds ratio, 1.09 per 1 mg/dL; 95% CI, 1.01-1.18; $P = .04$) and lactate dehydrogenase (OR, 1.006 per 1U/L; 95% CI, 1.001-1.012; $P = .03$) in multivariable analysis.

**CONCLUSION:** Among non–critically ill patients hospitalized within a nonepicenter health care system, overall survival was 94% with the development of more severe illness or death independently associated with higher levels of C-reactive protein and lactate dehydrogenase on admission. Clinical decompensation was largely respiratory-related, while serious cardiac arrhythmias were rare, which suggests that telemetry can be prioritized for high-risk patients. *Journal of Hospital Medicine* 2020;15:XXX-XXX. © Society of Hospital Medicine

S evere acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of coronavirus disease 2019 (COVID-19), is associated with a wide range of illness severity and community prevalence, with an estimated 20% to 30% of patients requiring hospitalization.[1,2] Outcome studies of hospitalized patients to date have focused on epicenter healthcare systems operating at surge-level bed capacity in resource-limited settings with mortality exceeding 20% among patients with a discharge disposition[3,4] and have had a publication bias toward those suffering critical illness.[5-7] Generalizability of these results to nonepicenter hospital systems is unclear given potential differences in triage practices and resource availability according to disease prevalence, with nonepicenter

systems that are operating below capacity potentially able to accommodate the needs of most, if not all patients, requiring inpatient level care. Clinical outcomes associated with non–critically ill patients in nonepicenter regions remain poorly characterized yet highly relevant because these will ultimately apply to most US and global healthcare environments.

Nonepicenter healthcare systems must anticipate disease requirements for noncritically ill patients hospitalized with COVID-19 in order to appropriately allocate resources, including monitoring services like continuous pulse oximetry and cardiac telemetry. Data regarding the incidence of in-hospital respiratory and cardiovascular complications, including arrhythmias, among non–intensive care unit (non-ICU) hospitalized patients with COVID-19 are limited, with little granularity in terms of associated variables.[7-11] Further data are needed to guide prioritization of valuable non-ICU continuous monitoring resources to the highest-risk patients in order to minimize consumption of personal protective equipment, reduce healthcare worker exposure, and ensure adequate availability for the expansion of prepandemic services.

Projections indicate that COVID-19 incidence may persist in the coming months.[11-13] As nonessential hospital operations simultaneously resume, planning for resource allocation for patients with COVID-19 must be incorporated into broader systems of care. Further data are needed to help hospitals anticipate resource needs during this transition, especially by most systems that are caring for COVID-19 patients in nonepicenter environments. Therefore, we conducted a retrospective study of a large, multihospital, nonepicenter health system equipped with centralized continuous monitoring services in order to describe the detailed clinical course, resource utilization, and risk factors for adverse events in patients with COVID-19 initially admitted to the non-ICU setting.

## METHODS
### Central Monitoring Unit
The central monitoring unit (CMU) provides standardized and continuous off-site secondary monitoring of cardiac telemetry and pulse oximetry for non-ICU patients within Cleveland Clinic hospitals (Ohio, Florida), with direct communication to bedside nursing and inpatient emergency response teams for clinically significant cardiac arrhythmias, respiratory events, and vital sign changes according to standardized indications, as previously reported.[14] Clinical variables of interest, including electrocardiographic and vital sign data, are collected and periodically analyzed within a central registry for quality assurance, risk stratification, and resource allocation. The data registry carries Institutional Review Board approval for retrospective analysis and deidentified outcomes reporting with consent form waiver.

### Study Design and Data Collection
All patients positive for SARS-CoV-2 infection by nasopharyngeal polymerase chain reaction assay (Applied Biosystems) admitted from the emergency department to a non-ICU bed at a CMU hospital on or after March 13, 2020, and subsequently discharged on or before May 1, 2020, were identified. Retrospective review of the electronic medical record was performed, with follow-up continued through hospital discharge. Data were collected on patient demographics, clinical characteristics including admission laboratories and chest x-ray findings (abnormal defined as presence of an infiltrate/opacity consistent with airspace disease), continuous monitoring utilization, respiratory support, medication treatment, ICU transfer, and final hospital disposition. In addition, prospective recordings of cardiac arrhythmias that prompted CMU notification of bedside nursing were reviewed.

The primary outcome was a composite of death, ICU transfer, or increased oxygen requirement defined as escalation from simple nasal cannula to either high-flow nasal cannula (HFNC), noninvasive ventilation (NIV) consisting of continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP), or mechanical ventilation. In accordance with published guidelines, patients were treated with supplemental oxygen to maintain peripheral oxygen saturation between 92% and 96%.[15]

Of note, based on the validated performance of high sensitivity troponin primarily for the diagnosis of acute myocardial infarction in patients presenting to the emergency department with chest pain, our system reserves its use for this context and prefers conventional (fourth generation) troponin T testing for inpatients. Therefore, conventional troponin T values are reported in this study.

### Statistical Analyses
Continuous variables are expressed as mean ± standard deviation or median (interquartile range), and categorical variables are expressed as absolute numbers with percentages. Independent samples $t$ and Mann-Whitney $U$ tests were used to compare continuous variables, as appropriate, and chi-square testing was used to compare categorical variables. Clinical variables satisfying an a priori two-tailed threshold of $P < .05$ were retained for multivariable logistic regression analysis. Variables retaining $P < .05$ in multivariable modeling were considered statistically significant. Analyses were performed using SPSS software, Version 23 (SPSS Inc).

## RESULTS
### Baseline Characteristics
Between March 13, 2020, and May 1, 2020, a total of 350 patients admitted from the emergency department to a non-ICU inpatient bed had a final hospital disposition. Baseline characteristics, medication treatments, and continuous monitoring utilization are shown in Table 1 and Table 2. The average age was 64 ± 16 years, more than half of patients were male (n = 194; 55%), and most patients had at least one underlying comorbidity (n = 297; 85%), the most common being hypertension (n = 230; 66%), diabetes mellitus (n = 113; 32%), and current or prior tobacco use (n = 99; 28%). The presenting syndrome most frequently included subjective fever (n = 191; 55%), cough (n = 191; 55%), or dyspnea (n = 180; 51%).

### Continuous Monitoring Use
Continuous monitoring was used in most patients (n = 289; 83%), including telemetry with intermittent pulse oximetry (n = 197; 56%), telemetry with continuous pulse oximetry (n = 81; 23%), or continuous pulse oximetry alone (n = 11; 3%). Among telemetry-monitored patients (n = 278; 79%), the most frequent indication was for a noncardiac disease state (n = 187; 67%), while indications for known cardiac arrhythmia (n = 74; 27%), heart failure (n = 10; 4%), or coronary artery disease (n = 7; 2%) were less common.

### Oxygen Requirements and Cardiac Arrhythmias
The maximum level of respiratory support required by each patient is shown in Appendix Figure 1A. A total of 256 patients (73%) required 3 L/min or less of supplemental oxygen by nasal cannula, 45 (13%) required more than 3 L/min of supplemental oxygen by nasal cannula, 19 (5%) required HFNC, 8 (2%) required NIV, and 22 patients (6%) required mechanical ventilation. Among patients requiring HFNC or NIV, there were 13

## TABLE 1. Baseline Characteristics and Presentation Symptoms Stratified by the Primary Composite Outcome[a]

| | All patients (N = 350) | Event free (n = 288) | Event (n = 62) | *P* value |
|---|---|---|---|---|
| **Clinical characteristics, No. (%)** | | | | |
| Age, mean ± SD, y | 64 ± 16 | 63 ± 16 | 72 ± 13 | <.001 |
| Male sex | 194 (55) | 161 (56) | 33 (53) | .70 |
| Body mass index, mean ± SD, kg/m² | 31 ± 7 | 31 ± 7 | 29 ± 5 | .006 |
| Asthma | 40 (11) | 36 (13) | 4 (6) | .18 |
| Cardiac arrhythmia | 47 (13) | 39 (14) | 8 (13) | .89 |
| Chronic kidney disease | 61 (17) | 46 (16) | 15 (24) | .12 |
| Congestive heart failure | 42 (12) | 28 (10) | 14 (23) | .005 |
| Chronic obstructive pulmonary disease | 28 (8) | 19 (7) | 9 (15) | .04 |
| Coronary artery disease | 55 (16) | 41 (14) | 14 (23) | .10 |
| Diabetes | 113 (32) | 89 (31) | 24 (39) | .23 |
| Hypertension | 230 (66) | 185 (64) | 45 (73) | .21 |
| Tobacco use, current or prior | 99 (28) | 76 (26) | 23 (37) | .09 |
| **Medication history, No. (%)** | | | | |
| Angiotensin-converting enzyme inhibitor | 65 (19) | 57 (20) | 8 (13) | .21 |
| Angiotensin II receptor blocker | 59 (17) | 45 (16) | 14 (23) | .18 |
| Beta blocker | 109 (31) | 87 (30) | 22 (35) | .42 |
| Immunosuppressive therapy | 28 (8) | 21 (7) | 7 (11) | .48 |
| **Presenting Symptoms, No. (%)** | | | | |
| Altered mental status | 21 (6) | 19 (7) | 2 (3) | .31 |
| Anosmia | 5 (1) | 5 (2) | 0 (0) | .30 |
| Cough | 191 (55) | 157 (55) | 34 (55) | .96 |
| Dyspnea | 180 (51) | 142 (49) | 38 (61) | .09 |
| Diarrhea | 64 (18) | 52 (18) | 12 (19) | .81 |
| Fever | 191 (55) | 154 (53) | 37 (60) | .37 |
| Fatigue | 83 (24) | 63 (22) | 20 (32) | .08 |
| Headache | 22 (6) | 17 (6) | 5 (8) | .53 |
| Myalgia | 65 (19) | 55 (19) | 10 (16) | .59 |
| Nausea/vomiting | 39 (11) | 28 (10) | 11 (18) | .09 |

[a]Primary composite outcome was defined as death, ICU transfer, or increased oxygen requirement.
Abbreviations: ICU, intensive care unit; SD, standard deviation.

(48%) who remained in a non-ICU bed, while the remaining 14 patients (52%) were transferred to the ICU.

Cardiac arrhythmias were detected in 39 (14%) of the 278 telemetry-monitored patients (Appendix Figure 1B). Clinical arrhythmias consisted of supraventricular tachycardia (SVT) in 17 patients (6%), nonsustained monomorphic ventricular tachycardia (VT) in 15 patients (5%), and a prolonged pause or severe bradyarrhythmia in 12 patients (4%). There were no cases of sustained monomorphic VT, polymorphic VT (including torsades de pointes), or ventricular fibrillation. All supraventricular tachycardias, nonsustained monomorphic VTs, and bradyarrhythmias/pauses were managed medically in the non-ICU

**TABLE 2.** Presentation Vital Signs, Clinical Testing, and Continuous Monitoring Use Stratified by the Primary Composite Outcome[a]

| | Reference range | All patients (N = 350) | Event free (n = 288) | Event (n = 62) | P value |
|---|---|---|---|---|---|
| **Vital signs, mean ± SD** | | | | | |
| Temperature, °C | | 37.4 ± 0.8 | 37.4 ± 0.8 | 37.4 ± 0.7 | .91 |
| Heart rate, beats per minute | | 88 ± 18 | 88 ± 17 | 91 ± 20 | .27 |
| Systolic blood pressure, mm Hg | | 133 ± 22 | 133 ± 22 | 134 ± 23 | .62 |
| Diastolic blood pressure, mm Hg | | 74 ± 14 | 75 ± 15 | 72 ± 12 | .15 |
| Respiratory rate, breaths per minute | | 20 ± 9 | 21 ± 10 | 21 ± 5 | .64 |
| Peripheral oxygen saturation on room air, %[b] | | 95 ± 3 | 95 ± 3 | 93 ± 5 | .01 |
| **Laboratory, mean ± SD** | | | | | |
| Creatinine, mg/dL | 0.73-1.22 | 1.27 ± 1.14 | 1.23 ± 0.98 | 1.43 ± 1.70 | .21 |
| Lactic acid, mmol/L[c] | 0.5-2.2 | 1.5 ± 0.6 | 1.5 ± 0.6 | 1.5 ± 0.6 | .98 |
| White blood cell count, k/µL[d] | 3.7-11.0 | 6.2 ± 2.7 | 6.3 ± 2.8 | 6.1 ± 2.4 | .66 |
| Hemoglobin, g/dL[d] | 13.0-17.0 | 13.1 ± 2.1 | 13.2 ± 2.1 | 12.7 ± 2.1 | .13 |
| Platelets, k/µL[d] | 15-400 | 213 ± 89 | 215 ± 90 | 199 ± 84 | .19 |
| C-reactive protein, mg/dL[e] | 0.0-0.9 | 7.9 ± 6.8 | 6.9 ± 6.1 | 12.0 ± 7.8 | <.001 |
| Lactate dehydrogenase, U/L[f] | 135-225 | 314 ±137 | 302 ± 133 | 358 ± 140 | .009 |
| Troponin T, ng/mL[h] | <0.01 | 0.02 ± 0.08 | 0.02 ± 0.06 | 0.05 ± 0.13 | .01 |
| Abnormal troponin T level, No. (%)[h] | | 49 (21) | 33 (19) | 16 (29) | .14 |
| NT-proBNP, median (IQR), pg/mL[i] | <125 | 212 (79-902) | 356 (74-712) | 337 (137-2,113) | .18 |
| D-dimer, median (IQR), ng/mL FEU[j] | <500 | 780 (495-1,460) | 720 (460-1,290) | 975 (753-3,140) | <.001 |
| Abnormal D-dimer level, No. (%)j | | 141 (75) | 102 (70) | 39 (93) | .003 |
| **Abnormal CXR findings, No. (%)[k]** | | **214 (62)** | **166 (58)** | **48 (77)** | **.005** |
| Unilateral infiltrate | | 59 (28) | 46 (28) | 13 (27) | .93 |
| Bilateral infiltrate | | 155 (72) | 120 (72) | 35 (73) | |
| **Monitoring, No. (%)** | | | | | |
| Telemetry with intermittent pulse oximetry | | 197 (56) | 171 (59) | 26 (42) | .06 |
| Telemetry with continuous pulse oximetry | | 81(23) | 60 (21) | 21 (34) | |
| Continuous pulse oximetry only | | 11 (3) | 8 (3) | 3 (5) | |
| Intermittent pulse oximetry only | | 61 (17) | 49 (17) | 12 (19) | |

[a]Primary composite outcome was defined as death, ICU transfer, or increased oxygen requirement
[a]Available for 299 patients, 249 event free and 50 with event.
[b]Available for 194 patients, 142 event free and 52 with event.
[c]Available for 348 patients, 286 event free and 62 with event.
[d]Available for 304 patients, 245 event free and 59 with event.
[e]Available for 235 patients, 183 event free and 52 with event.
[f]Available for 187 patients, 145 event free and 42 with event.
[g]Available for 228 patients, 172 event free and 56 with event. Abnormal troponin T was defined as a value above the 99th percentile upper reference limit.
[h]Available for 144 patients, 110 event free and 34 with event.
[i]Available for 187 patients, 145 event free and 42 with event. Abnormal D-dimer was defined as a value greater than 500 ng/mL FEU.
[j]Available for 347 patients, 285 event free and 62 with event.
Abbreviations: CXR, chest x-ray; FEU, fibrinogen-equivalent units; ICU, intensive care unit; IQR, interquartile range; NT-proBNP, N-terminal pro-B-type natriuretic peptide; SD, standard deviation.
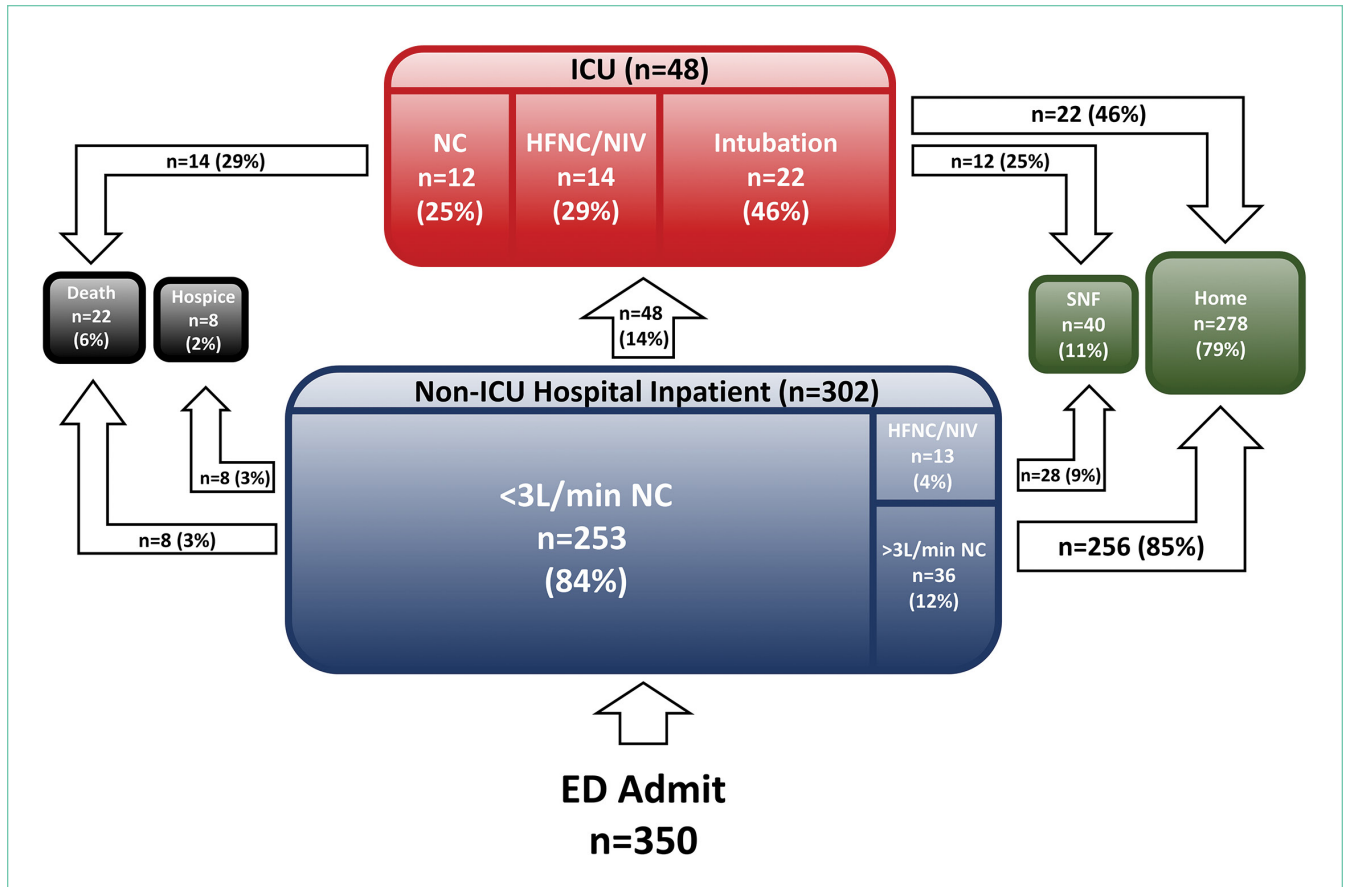
**FIG.** Patient flow chart showing maximum level of respiratory support, intensive care unit (ICU) transfer, and final discharge disposition for 350 patients with COVID-19 initially hospitalized in a non-ICU inpatient bed. Not shown are two patients (1%) who were released against medical advice from the non-ICU setting.

Abbreviations: ED, emergency department; HFNC, high-flow nasal cannula; ICU, intensive care unit; NC, nasal cannula supplemental oxygen; NIV, noninvasive ventilation consisting of continuous or bilevel positive airway pressure; SNF, skilled nursing facility.

setting, with the exception of one patient who was transferred to the ICU for a primary indication of atrial fibrillation with rapid ventricular response, which was treated with amiodarone. No patient with supraventricular tachycardia required emergent cardioversion, and no patient with a bradyarrhythmia or pause required temporary or permanent pacemaker implantation.

The detection of any arrhythmia was more common in patients with a history of cardiac arrhythmia (n = 18/41 vs 21/237; 44% vs 9%; *P* < .001), congestive heart failure (n = 11/36 vs 28/242; 31% vs 12%; *P* = .002), coronary artery disease (n = 12/49 vs 27/229; 24% vs 12%; *P* = .02), hypertension (n = 33/190 vs 6/88; 17% vs 7%; *P* = .02), and an abnormal admission troponin level (n = 13/40 vs 19/142; 33% vs 13%; *P* = .005). Notably, of the 39 patients with cardiac arrhythmias, 35 (90%) had either an abnormal admission troponin level or a history of cardiac arrhythmia, congestive heart failure, coronary artery disease, or hypertension. Of the 17 patients with SVT episodes, 13 (76%) had a known history of atrial fibrillation. Among patients who had a cardiac arrhythmia vs those who did not, there were no differences in levels of C-reactive protein (CRP; 7.3 ± 6.2 mg/dL vs. 7.8 ± 6.8 mg/dL, *P* = .63) or lactate dehydrogenase (LDH; 281 ± 89 U/L vs. 318 ± 142 U/L; *P* = .17). Approximately half of patients were treated with hydroxychloroquine (n = 185; 53%) or azithromycin

(n = 182; 52%); 41% were treated with both (n = 142), with no observed association between any arrhythmia type and treatment with one or both medications (*P* > .05 for all comparisons).

### Discharge Disposition and Adverse Outcomes
After an average length of stay of 6.1 ± 5.9 days, final hospital disposition included discharge to home (n = 278; 79%), discharge to subacute facility (n = 40; 11%), discharge to hospice (n = 8; 2%), death (n = 22, 6%), or release against medical advice (n = 2; 1%) (Figure). The primary composite outcome occurred in 62 patients (18%), including 22 deaths (6%), 48 ICU transfers (14%), and 49 patients with increased oxygen requirements (14%). Only two deaths occurred in the absence of an increased oxygen requirement or ICU transfer.

Increased oxygen requirement was the indication for ICU transfer in 37 of 48 patients (77%), with 22 patients (46%) requiring mechanical ventilation. Of the 48 patients requiring ICU transfer, 14 (29%) died, including 10 of the 22 patients (45%) treated with mechanical ventilation. Of the 302 patients who remained in the non-ICU setting, 8 (3%) died and 8 (3%) were discharged to hospice.

In univariable analyses, the primary composite outcome was more common among older patients (event vs event free, 72 ±

TABLE 3. **Multivariable Analysis of Clinical Factors Associated With the Primary Composite Outcome**[a]

| Variable | Odds ratio | 95% CI | P value |
|---|---|---|---|
| Age | 1.03 | 0.99-1.08 | .18 |
| Body mass index | 1.10 | 0.99-1.22 | .07 |
| Congestive heart failure | 0.76 | 0.17-3.39 | .72 |
| Chronic obstructive pulmonary disease | 1.07 | 0.17-6.79 | .94 |
| Peripheral oxygen saturation on room air | 1.02 | 0.87-1.20 | .82 |
| C-reactive protein level | 1.09 | 1.01-1.18 | .04 |
| Lactate dehydrogenase level | 1.006 | 1.001-1.012 | .03 |
| Abnormal troponin T level[b] | 1.82 | 0.43-7.75 | .42 |
| Abnormal D-dimer level[c] | 0.14 | 0.02-1.25 | .08 |
| Abnormal chest x-ray findings | 0.57 | 0.15-2.18 | .41 |

[a]Primary composite outcome was defined as death, ICU transfer, or increased oxygen requirement.
[b]Abnormal troponin T level was defined as a value above the 99th percentile upper reference limit.
[c]Abnormal D-dimer level was defined as a value greater than 500ng/mL fibrinogen equivalent units.
Abbreviations: ICU, intensive care unit.

13 years vs 63 ± 16 years; *P* < .001); it was also more common in patients with congestive heart failure (n = 14/62 vs 28/288; 23% vs 10%; *P* = .005), chronic obstructive pulmonary disease (n = 9/62 vs 19/288; 15% vs 7%; *P* = .04), lower body mass index (29 ± 5 kg/m² vs 31 ± 7 kg/m²; *P* = .006), lower peripheral oxygen saturation on room air (93% ± 5% vs 95% ± 3%; *P* = .005), higher CRP level (12.0 ± 7.8 mg/dL vs 6.9 ± 6.1 mg/dL; *P* < .001), higher LDH level (358 ± 140 U/L vs 302 ± 133 U/L; *P* = .009), higher troponin level (0.05 ± 0.13 ng/dL vs 0.02 ± 0.06 ng/dL; *P* = .01), abnormal D-dimer level (n = 39/42 vs 102/145; 93% vs 70%; *P* = .003), and abnormal chest x-ray findings (n = 48/62 vs 166/285; 77% vs 58%; *P* = .005) (Table 1 and Table 2). After multivariable adjustment, CRP level (odds ratio [OR], 1.09 per 1 mg/dL increase; 95% CI, 1.01-1.18; *P* = .04) and LDH level (OR, 1.006 per 1 U/L increase; 95% CI, 1.001-1.012; *P* = .03) remained significantly associated with the composite adverse outcome (Table 3). The rate of death, ICU transfer, or increased oxygen requirement was sixfold higher in patients with a CRP level in the fourth quartile (≥11.0 mg/dL) than it was among those in the first quartile (≤ 2.6 mg/dL) (*P* < .001 for trend), and it was fivefold higher in patients with an LDH level in the fourth quartile (≥ 354 U/L) than it was among those in the first quartile (≤ 232 U/L) (*P* = .001 for trend) (Appendix Figure 2). No patient with a CRP level in the reference range (≤ 0.9 mg/dL) experienced the composite adverse event, compared to three patients (n = 3/49, 6.1%) within the reference range for LDH level (≤ 225 U/L), all of whom had an elevated CRP.

## DISCUSSION

In this study of 350 patients initially admitted to a non-ICU hospital bed within a large, nonepicenter healthcare system, the primary outcome of death, ICU transfer, or increased oxygen requirement occurred in 18% of patients and was

independently associated with higher admission CRP and LDH levels on multivariable analysis. Most patients (73%) required 3 L/min or less of supplemental oxygen, while 14% of patients required escalation to HFNC, NIV, or mechanical ventilation. Despite frequent telemetry use (79%), cardiac arrhythmias were uncommon (14%), including no life-threatening ventricular arrhythmias. Clinical deterioration requiring ICU transfer occurred in 14% of patients, most often for an indication of increased oxygen requirement (77%). In-hospital mortality was 6% for the entire cohort, 29% for patients requiring ICU transfer, and 3% for patients who remained in the non-ICU setting.

### Nonepicenter, Non-ICU Mortality

This study offers an assessment of clinical outcomes in patients with COVID-19 hospitalized in a non-ICU, nonepicenter healthcare system operating below capacity. Although such systems account for most institutions caring for patients with COVID-19, this population has been underrepresented in the literature, which has focused on epicenter hospitals and critically ill patients.[3-7] Existing epicenter estimates of in-hospital mortality for patients not requiring ICU-level care range from 6% in Northern California[2] to at least 10% in New York, New York,[3] and 11% in Wuhan, China.[4] The corresponding non-ICU in-hospital mortality in our study was only 3%, supporting the vital role of social distancing in reducing COVID-19 mortality by facilitating care delivery in a non–resource limited hospital setting.

### Oxygen Requirements and Cardiac Arrhythmias in Non-ICU Patients

Beyond nonepicenter mortality estimates, this study is the first to provide a detailed characterization of the clinical course

and resource usage among patients with COVID-19 admitted to the non-ICU setting. Given the predicted persistence of SARS-CoV-2 spread,[11-13] this information is crucial to healthcare systems that must anticipate resource requirements, such as respiratory support and continuous monitoring equipment, for the care of hospitalized patients with COVID-19. Such informed planning takes on even greater importance as prepandemic hospital services resume.

While most patients (73%) with COVID-19 admitted to a non-ICU bed required peak supplemental oxygen of 3 L/min or less, a relevant proportion (14%) developed a need for HFNC, NIV, or mechanical ventilation. Furthermore, among telemetry-monitored patients (79%), cardiac arrhythmias were uncommon (14%), and nearly all (90%) occurred in patients with either a positive troponin or known history of cardiac disease. There were no life-threatening ventricular arrhythmias associated with frequent use of hydroxychloroquine (53%) and azithromycin (52%).

These telemetry findings expand upon a smaller study of non-ICU patients receiving either hydroxychloroquine or azithromycin, in which no life-threatening ventricular tachyarrhythmias were detected.[8] A separate study reported a 5.9% incidence of malignant ventricular tachyarrhythmias in hospitalized patients with COVID-19,[10] but this study did not stratify arrhythmias by illness severity, and a high frequency of critical illness is suggested by the mechanical ventilation rate of 24%, thereby limiting comparison with our non-ICU telemetry findings.

### CRP and LDH Levels as Predictors of Adverse Outcomes

This study supports the utility of obtaining CRP and LDH levels for risk stratification at the time of non-ICU hospital admission. In multivariable analysis, higher CRP and LDH levels were significantly associated with the composite adverse outcome. The adverse event rates was increased sixfold between patients with a CRP in the fourth quartile (≥ 11.0 mg/dL, 36%) and those in the first quartile (≤ 2.6 mg/dL, 5.3%), and it was fivefold higher in patients with an LDH level in the fourth quartile (≥ 354 U/L, 34%) compared with those in the first quartile (≤ 232 U/L, 7%).

These findings are consistent with prior studies that have associated elevated inflammatory markers with poor prognosis and death.[7,9,16] In some cases, COVID-19 may manifest similar to a cytokine storm syndrome, which highlights the importance of inflammation-associated tissue injury and leads to widespread interest in the use of immunosuppressive medications.[17,18] Several studies also have demonstrated an association between LDH level and severe illness,[4,7,19] although this is the first to specifically demonstrate its association with clinical decompensation in the non-ICU hospitalized population. Given that SARS-CoV-2 can infect multiple organs,[20,21] there is biological plausibility for the use of LDH levels as a nonspecific marker of tissue injury for early identification of more severe infection.

Notably, while elevated troponin levels have been strongly associated with the need for mechanical ventilation and

with death, this has primarily been established using either high-sensitivity troponin assays at the time of admission[22] or using peak conventional troponin levels during hospitalization.[10] In this study, while abnormal conventional troponin levels at the time of non-ICU admission were not significantly associated with the primary outcome in multivariable analysis, absolute troponin values were significantly higher in univariable analysis. Incomplete troponin sampling and the lack of routine high-sensitivity troponin assay use may explain the lack of more robust troponin significance in this study.

### Implications for Non-ICU Continuous Monitoring Resource Allocation

Prioritization of non-ICU continuous monitoring resources among patients with COVID-19 has numerous benefits, including reduced consumption of personal protective equipment, fewer healthcare worker exposures, and adequate availability of continuous monitoring for the expansion of prepandemic hospital services. While individualized clinical discretion is still required, the results of this study can be used as a guide for the allocation of continuous pulse oximetry and cardiac telemetry. Patients with a normal presenting CRP level and/or LDH level had a low incidence of clinical decompensation, which suggests that such patients could be monitored with intermittent rather than continuous pulse oximetry. Furthermore, cardiac telemetry could be reserved for patients with a history of cardiac comorbidities or abnormal troponin levels because such patients accounted for 90% of cardiac arrhythmias in this study.

### Limitations

This study was limited to a single health system, and it lacks a direct comparison to nonhospitalized patients and those directly admitted to the ICU. Triage practices and thresholds for hospitalization may differ across institutions and regions, thereby limiting the generalizability of our study. Additional limitations include the lack of selected admission laboratories for all patients, as well as the lack of telemetry monitoring in all patients. However, any resulting selection bias may be more likely to attenuate the magnitude of observed effects given that additional testing and increased telemetry use may be expected in patients who are felt to be higher risk by routine clinical assessment.

### CONCLUSION

In this study of non–critically ill patients hospitalized within a nonepicenter health system, the development of more severe illness or death was significantly associated with higher levels of CRP and LDH on admission. Clinical decompensation was driven largely by respiratory complications, while cardiac arrhythmias were rare. Overall, the non-ICU mortality rate was at least half of that reported in epicenter regions. Altogether, these findings provide valuable information for resource allocation planning while nonepicenter health systems continue caring for patients with COVID-19 as they also resume prepandemic operations.

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