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Research article

The effect of limited healthcare access on poor outcomes among hospitalized COVID-19 patients in Honduras: A single center cohort study

César Alas-Pineda [a,c], David Aguilar-Andino [b,c], Francisco Antonio Vallecillo Munguia [d], Gissela María Padilla David [d], Andrea N. Umaña [a], Luis Romero Reyes [d], Alejandro Cárcamo [d], Ana Liliam Osorio [d], Julio Zuniga-Moya [e], Eleazar Montalvan-Sanchez [f], Travis J. Atchley [g], Nicholas Michael Berry Laskay [g], Dagoberto Estevez-Ordonez [g], Orlando Garner [h], Dalton Argean Norwood [b,i,j,*]

[a] *Facultad de Medicina y Cirugía, Universidad Católica de Honduras – Campus San Pedro y San Pablo, San Pedro Sula, Cortés, Honduras*
[b] *Escuela Universitaria de Ciencias de la Salud, Universidad Nacional Autónoma de Honduras en el Valle de Sula, San Pedro Sula, Honduras*
[c] *Departamento de Epidemiología, Hospital Nacional Dr. Mario Catarino Rivas, San Pedro Sula, Honduras*
[d] *Hospital Nacional Dr. Mario Catarino Rivas, San Pedro Sula, Honduras*
[e] *Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI, USA*
[f] *Department of Medicine, School of Medicine, Indiana University, IN, USA*
[g] *Department of Neurosurgery, School of Medicine, University of Birmingham at Alabama, AL, USA*
[h] *Clinical Assistant Professor, Department of Internal Medicine, Texas Tech University Health Sciences Center at the Permian Basin, TX, USA*
[i] *Division of Preventive Medicine, School of Medicine, University of Birmingham at Alabama, AL, USA*
[j] *Minority Health & Health Equity Research Center, University of Birmingham at Alabama, AL, USA*

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ABSTRACT

Background: The COVID-19 pandemic has had a severe impact on the Latin American subcontinent, particularly in areas with limited hospital resources and a restricted Intensive Care Unit (ICU) capacity. This study aimed to provide a comprehensive description of the clinical characteristics, outcomes, and factors associated with survival of COVID-19 hospitalized patients in Honduras.

Research question: What were the characteristics and outcomes of COVID-19 patients in a large referral center in Honduras?

Study design and methods: This study employed a retrospective cohort design conducted in a single center in San Pedro Sula, Honduras, between October 2020 to March 2021. All hospitalized cases of confirmed COVID-19 during this timeframe were included in the analysis. Univariable and multivariable survival analysis were performed using Kaplan-Meier curves and Cox proportional hazards model aiming to identify factors associated with decreased 30 day in-hospital survival, using a priori-selected factors.

Results: A total of 929 confirmed cases were identified in this cohort, with males accounting for 55.4 % of cases. The case fatality rate among the hospitalized patients was found to be 50.1 % corresponding to 466 deaths. Patients with comorbidities such as hypertension, diabetes, obesity, chronic kidney disease, chronic obstructive pulmonary disease and cardiovascular disease had a

* Corresponding author. Division of Preventive Medicine, School of Medicine, University of Birmingham at Alabama, USA.
E-mail address: daltonnorwood@uabmc.edu (D.A. Norwood).

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higher likelihood of mortality. Additionally, non-survivors had a significantly longer time from illness onset to hospital admission compared to survivors (8.2 days vs 4.7 days). Among the cohort, 306 patients (32.9 %) met criteria for ICU admission. However, due to limited capacity, only 60 patients (19·6 %) were admitted to the ICU. Importantly, patients that were unable to receive level-appropriate care had lower likelihood of survival compared to those who received level-appropriate care (hazard ratio: 1.84).

Interpretation: This study represents, the largest investigation of in-hospital COVID-19 cases in Honduras and Central America. The findings highlight a substantial case fatality rate among hospitalized patients. In this study, patients who couldn't receive level-appropriate care (ICU admission) had a significantly lower likelihood of survival when compared to those who did. These results underscore the significant impact of healthcare access during the pandemic, particularly in low- and middle-income countries.

Abbreviations

ABG	Arterial Blood Gases
ANOVA	Analysis of Variance
ARDS	Acute Respiratory Distress Syndrome
CBC	Complete Blood Count
CKD	Chronic Kidney Disease
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	Coronavirus Disease 2019
CRP	C-Reactive Protein
CVD	Cardiovascular Diseases
DM	Diabetes Mellitus
ED	Emergency Department
HFNC	High-Flow Nasal Canula
HR	Hazard Ratio
HTN	Hypertension
ICU	Intensive Care Unit
IQR	Interquartile Ranges
LDH	Lactate Dehydrogenase
LMIC	Low- and Middle-Income Countries
MICE	Multiple Imputations using Chained Equations
MCMC	Markov Chain Monte Carlo
MV	Mechanical Ventilation
NIPPV	Non-Invasive Positive Pressure Ventilation
NSV	Non-Survivor
PSILI	Potentially Lead to Self-Induced Lung Injury
RPM	Respirations Per Minute
RR	Respiratory Rate
rt-PCR	reverse-transcriptase Polymerase Chain Reaction
SaO2%	oxygen saturation
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
SD	Standard Deviation
SOB	Shortness of Breath
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SV	Survivor

1. Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has severely affected the Latin American subcontinent since Brazil reported their first case on February 2020 [1]. The first reported case of COVID-19 in Honduras was reported in a pregnant woman in March 2020 [2]. As of June 2022, Honduras had more than 431,000 confirmed cases and almost 11,000 deaths. San Pedro Sula, the second largest city in the country, accounts for 22·8 % (n = 86,513) of all the cases nationwide [1].

Honduras, like many other Central American countries, has a high prevalence of chronic diseases, a high cardiovascular disease (CVD) score [3], and an under-developed healthcare system. Additionally, the ability of Honduran intensive care units (ICUs) to treat

the severe illness experienced by those affected with COVID-19 is extremely limited. The impact of these factors on the health outcomes of COVID-19 patients in Honduras is not well understood. A report published in early 2020 found that a high proportion of COVID-19 cases in Honduras occurred among young adults with a significant proportion of them being severe and fatal cases [4]. The report also noted that chronic diseases were associated with severe outcomes independent of age and were highly prevalent among Honduran COVID-19 patients [4].

Understanding regional variations in severity of illness and outcomes among patients in the low- and middle-income countries (LMICs) of Central America is important for disease and risk factor control and resource allocation in the region. In this study, we aimed to describe the demographics, clinical characteristics, and factors associated with decreased in-hospital survival in patients admitted to the second largest tertiary referral hospital in Honduras.

2. Study design and Methods

A single-center retrospective cohort study was conducted at a tertiary referral hospital (Hospital Mario Catarino Rivas) in San Pedro Sula, Honduras from October 2020 to March 2021. Located in the second largest city in the country, this hospital serves as the major referral center for the north region in Honduras and is the second largest hospital in the nation. This study was approved by the local Institutional Board Review. Research reported in this manuscript adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines promoted by The EQUATOR Network [5,6].

2.1. Study population

All patients older than 18 years of age who had a positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) reverse-transcriptase polymerase chain reaction (rt-PCR) via nasal swab who were admitted to the hospital within the study period were included in this study. Patients without a rt-PCR confirmation were excluded from the study. We also excluded those who died during transfer or upon arrival to the hospital. In Honduras, there is a lack of electronic medical records; therefore, charts without COVID-19 tests, reported outcome or cause of death were excluded from this report (Fig. 1).

Data were collected by the researchers in paper form, and disease severity was reviewed by two internal medicine attendings. Variables included clinical and epidemiological data recorded in the medical records, such as sociodemographic data (age, sex, comorbidities, contact with COVID-19 patients and date of symptom onset), laboratory data in the first 24 h of admission (complete blood count (CBC), D-dimer, C-reactive protein (CRP), ferritin, lactate dehydrogenase (LDH), arterial blood gases (ABG), procalcitonin), clinical data at admission (symptoms, vital signs ventilatory support, days on invasive mechanical ventilation, and vasopressor support) and outcomes (disease severity, admission to the ICU, length of ICU stay, length of hospital stay and death).

The hospitalization criteria were (Any patient with dyspnea or increase respiratory rate $\geq$30 breaths per min, oxygen saturation $\leq$94 % breathing room air, decrease in saturation to $<$ 90 % with ambulation, or overall clinical concern by Emergency Department (ED) attending for risk of outpatient failure based on high risk for complications from severe COVID-19). Disease severity status at admission was established by the admitting physician using local national criteria (respiratory rate (RR) $>$ 29 respirations per minute (RPM), oxygen saturation (SaO2%) $\leq$88 % within the first hour of patient's evaluation and requirement of oxygen by a high-flow device, or any kind mechanical ventilation), type of ventilatory support was assessed by the highest level of ventilatory support at any point during hospitalization (in order of increasing support: none, face mask, high-flow nasal canula (HFNC), non-invasive positive pressure ventilation (NIPPV), and mechanical ventilation (MV).

2.2. Statistical analysis

This cohort was a convenience sample and power was calculated using Schoenfeld's Methods [7]. This comparative survival analysis had a 0·80 power to detect a hazard ratio (HR) of 0·81 or less and 1·23 or more, assuming a survival rate of 25 % at 30 days. Descriptive statistics and comparison between survivor (SV) and non-survivor (NSV) groups were done using analysis of variance (ANOVA), Mann-Whitney *U* test, χ^2 test, or Fisher's exact test, as appropriate. Quantitative variables are presented in mean and standard deviation (SD) or median and interquartile ranges (IQR), for normal and non-normal distributions, respectively. Kaplan-Meier curves were used for univariable analysis of survival differences among groups of interest as well as variables with known association with survival. Multivariable survival analysis was done using Cox proportional hazard model. Variables for the model were selected *a priori* based on suspected clinical relevance and prior research [8–10]. The proportionality assumptions was assessed using Schoenfeld residuals and through visual inspection by plotting of scaled Schoenfeld residuals versus time (e-Fig. 1 and e-Table 1) [7,11].

Obesity and diabetes mellitus (DM) showed variation from the proportionality assumption; however, we chose to include them in the model due to their known effects upon COVID-19 mortality [12,13]. Sex, which we identified *a priori* as a variable of interest, also violated the proportionality assumption. We assessed the model for goodness of fit using Gronnesby and Borgan test ($p = 0{\cdot}0926$) and visually using Arjas-like plots comparing observed and expected events in groups based on risk score (e-Fig. 2) [14]. HRs with 95 % confidence intervals (CI) are reported, and α was set at 0·05.

There was a high proportion of missing data for RPM (28·9 %) and the following laboratory markers: D-dimer (27·2 %), CRP (29·2 %), ferritin (46 %), LDH (39·2 %) and procalcitonin, (55·1 %). These were factors selected *a priori* for multivariable analysis [15–18]. Complete case analysis, even if excluding laboratory markers, decreased the sample size to 688 (71·9 %) patients reducing power and potentially leading to biased results. We sought to address this limitation through multiple imputations using chained equations

(MICE) [19–21]. We generated 50 imputed datasets using a Markov chain Monte Carlo (MCMC) with random-walk Metropolis-Hasting sampling algorithm (100 burn-in iterations). The algorithm used a congenial logistic model to impute missing data on, platelet, CRP, procalcitonin, D dimer, and LDH categories and an ordered logistic model to impute missing data on RPM and leukocyte categories.

We assessed level of simulation error of the algorithm through jackknife estimation of Monte Carlo Error (e-Table 2 and e-Table 3). Convergence was assessed visually with trace plots to ensure the data augmentation algorithm reached an appropriate stationary posterior distribution (e-Fig. 3). We also inspected the fraction of missing information and relative efficiencies to assess for appropriate number of imputations (e-Table 4). All statistical analyses were done using the statistical package software STATA version 17.0 (Stata Corp, College Station, Texas, USA). This study was approved by the Hospital Mario Catarino Rivas Institutional Review Board under approval number 2020-007.

3. Results

Between October 1, 2020, to February 28, 2021, 5446 patients presented for evaluation of upper and lower respiratory illness at Hospital Mario Catarino Rivas with 1158 (63 %) meeting hospitalization criteria. All these patients were tested for SARS-CoV-2 infection with rt-PCR. Of the patients that met hospitalization criteria, 55 died on arrival and 75 tested negative and were excluded from this study. 1028 (88·8 %) of the hospitalized patients tested positive and were considered for inclusion. However, 99/1028 (9·6 %) had incomplete or lost hospital documentation and were excluded from the cohort (Fig. 1).

At 30 days after hospital admission, 49·8 % (n = 463) had survived their hospitalization and where discharged alive and 50·2 % (n = 466) died. Male patients represented 52·7 % (n = 244) of SV and 58·2 % (n = 271) of NSV. The median age was 59 years [IQR 47–70], 52 years [IQR 42–64], and 64 years [IQR 54–73] for the total population, SV and NSV, respectively. There was a higher proportion of patients older than 70 years old 34·3 % (n = 160) in the NSV group than the SV group 14·7 % (n = 68) $p < 0{\cdot}01$. Self-reported comorbidities were present in 76·2 % (n = 708) and patients with comorbidities were more likely to die during their hospitalization (86·3 % vs 66·1 %; $p < 0{\cdot}01$) (Table 1 and Fig. 1). Patients with hypertension (HTN, 64·2 % vs 37·6 %, $p < 0{\cdot}001$), DM (46·1 % vs 32·2 %, $p < 0{\cdot}001$), obesity (33·3 % vs 18·6 %, $p < 0{\cdot}001$), chronic kidney disease (CKD, 15·2 % vs 5·4 %, $p < 0{\cdot}001$), chronic obstructive pulmonary disease (COPD, 6·9 % vs 3·7, $p = 0{\cdot}03$), and CVD (2·8 % vs 0·9 %, $p = 0{\cdot}03$) were more prevalent in the non-survivor group (Table 1).

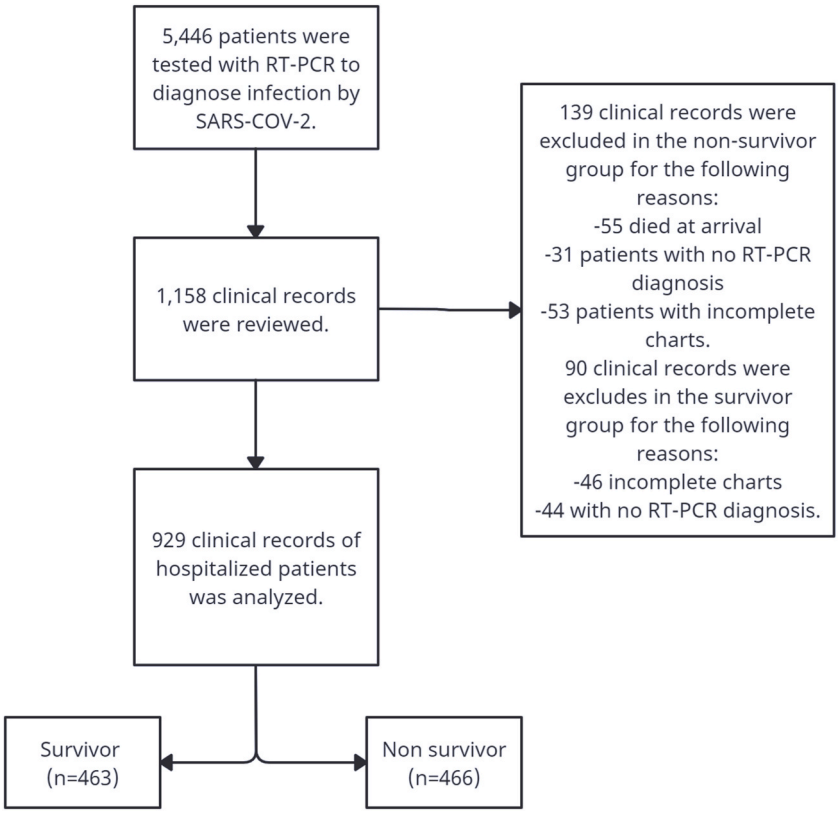


Fig. 1. Patient selection criteria.

Table 1
Table of general Characteristics of the population.

Variable	Total (n = 929)	Survivor (n = 463)	Non-survivor (n = 466)	P value[a]
Age, Median [IQR]	59 [47–70]	52 [42–64]	64 [54–73]	<**0.001**
18-29	33 (3.6)	23 (5.0)	10 (2.1)	
30-39	96 (10.3)	72 (15.6)	24 (5.2)	
40-49	164 (17.6)	109 (23.5)	55 (11.0)	
50-64	292 (31.4)	144 (31.1)	148 (31.8)	
65-74	194 (20.9)	64 (13.8)	130 (27.9)	
75-84	122 (13.1)	42 (9.0)	80 (17.2)	
>85	28 (3.0)	9 (2.0)	19 (4.1)	
Sex				0.09
Male	515 (55.4)	244 (52.7)	271 (58.2)	
Female	414 (44.6)	219 (47.3)	195 (41.8)	
Comorbidity				<**0.001**
Yes	708 (76.2)	306 (66.1)	402 (86.3)	
No	221 (23.8)	157 (33.6)	64 (13.7)	
Comorbidities [b]				
Hypertension	473 (50.9)	174 (37.6)	299 (64.2)	<**0.001**
Diabetes	364 (39.2)	149 (32.2)	215 (46.1)	<**0.001**
Obesity	241 (25.9)	86 (18.6)	155 (33.3)	<**0.001**
CKD	96 (10.3)	25 (5.4)	71 (15.2)	<**0.001**
CAD	58 (6.2)	25 (5.4)	33 (7.1)	0.29
COPD	49 (5.3)	17 (3.7)	32 (6.9)	**0.03**
Asthma	22 (2.4)	11 (2.4)	11 (2.4)	0.98
CVD	17 (1.8)	4 (0.9)	13 (2.8)	**0.03**
Cancer	14 (1.5)	7 (1.5)	7 (1.5)	0.99
Liver disease	10 (1.1)	3 (0.6)	7 (1.5)	0.21
Hypothyroidism	7 (0.8)	3 (0.6)	4 (0.9)	0.71

Data are median [interquartile range], or n (%). Abbreviations: CKD; chronic kidney disease, COPD; chronic obstructive pulmonary disease, CAD; Coronary Artery Disease, CVD; Cerebrovascular Disease.

[a] P values were calculated by Mann-Whitney *U* test, χ^2 test, or Fisher's exact test, as appropriate. χ^2 test comparing all subcategories.

[b] Comorbidities are ordered by prevalence.

3.1. Clinical features of COVID-19 at presentation

The most frequent self-reported clinical symptom at admission for SV and NSV were shortness of breath (SOB), cough, and fever with SOB and cough. Symptoms were more prevalent on the NSV population: SOB (88·4 % vs 66·7 %, p < 0·001), cough (77·7 % vs 70·6 %, p = 0·014), malaise (33·9 % vs 24·8 %, p = 0·002), and fatigue (35·6 % vs 13·8 %, p < 0·001). The median time from onset of symptoms to hospital admission was 5 days [IQR 2,9]. Time from illness onset to hospital admission was significantly shorter in the SV group 3 days [IQR 1–7] versus NSV 7 days [IQR 4–11] (p < 0·001) (Table 2).

Patients in the NSV group had higher white blood count (12,900 cel/L [IQR 8560-17,000 cel/L] vs 9800 cel/L [6700-13,400cel/L], p < 0·001), higher ferritin values (964·25 U/L [630–1500] U/L] vs 860·8 U/L [431–1500]U/L], p < 0·016), D-dimer (623 ng/dL [360·5–1298 ng/dL] vs 492·5 ng/dL [202·5–912·7 ng/dL], p < 0·008) and LDH (564 U/L [407–849 U/L] vs 393 U/L [280–574 U/L], p < 0·08) compared to SV. The procalcitonin level was higher than 0·1 mg/dL in of the NSV group (85·3 % vs 79·9 %) but was not statistically significant (e-Table 6).

In the included population, 430 (46·3 %) patients were categorized as having severe or critical condition (89·5 % vs 2·8 %, p < 0·001 in the NSV and SV group, respectively). Of the 929 patients, 306 (32·9 %) met ICU admission criteria (63·1 % vs 2·6 %, p < 0·001 in the NSV and SV, respectively). However, due to limited capacity, only 19·6 % (60/306) of individuals meeting ICU criteria were able to receive level-appropriate care. It is worth noting that some patients did receive assisted ventilatory support (24·1 %, 14·7 % and 1·2 % with HFNC, NIPPV and MV, respectively) even if they were not admitted to ICU as an attempt to increase ICU capacity. Death within 24 h of admission occurred in 93 (10 %) of patients. Length of care to discharge was 5 days (IQR 2–10) and 5 days (IQR 3–9) for NSV and SV, respectively (p = 0·05). More than half of the patients (80 %) required any type mechanical ventilatory support (e.g., HFNC, NIPPV Invasive ventilation).

3.2. Survival analysis

Kaplan-Meier survival plots for the prognostic factors are presented in Fig. 2. Age (Fig. 1a), Sex (Fig. 1b) and Ventilatory support (Fig. 1c) didn't show to be significantly. Notably, we observed a significant difference in severity on admission (Fig. 2d), access to care (Fig. 2e) and pre-existing comorbidity (p < 0·001) (Fig. 2f). In unadjusted Cox regression analysis, age was associated with decreased survival (HR = 1·02 for every year; CI 95 % 1·01-1·03; p < 0·01), however this association was not observed in our multivariable models. In the multivariable models, CKD (HR = 1·46; CI 95 % 1·12–1·91; p < 0·01) and previous CVD (HR = 2·57; CI 95 %, 1·46–4·54; p < 0·01) significantly decreased survival probability. Other comorbidities were not independently associated with survival in our model. An abnormal respiratory rage of 23–28 RPM (HR = 1·41; CI 95 % 1·02–1·97; p = 0·03) and RR > 28 RPM (HR = 1·48; CI 95 %

Table 2
Clinical characteristics.

	Total (n = 929)	Survivor (n = 463)	Non-survivor (n = 466)	P value[a]
Clinical manifestations (self-reported)				
Dyspnea	721 (77.6)	309 (66.7)	412 (88.4)	<**0.001**
Cough	689 (74.2)	327 (70.6)	362 (77.7)	**0.014**
Fever	681 (73.3)	334 (72.1)	347 (74.5)	0.42
Headache	446 (48.0)	229 (49.5)	217 (46.6)	0.37
Myalgia	273 (29.4)	163 (35.2)	110 (23.6)	<**0.001**
General malaise	273 (29.4)	115 (24.8)	158 (33.9)	**0.002**
Fatigue	230 (24.8)	64 (13.8)	166 (35.6)	<**0.001**
Time from illness onset to hospital admission, days [IQR]	5.0 [2–9]	3.0 [1–7]	7.0 [4–11]	<**0.001**
Vital Signs at admission				
Respiratory rate, Median [IQR]	26 [23–30]	25 [22–28]	28 [24–32]	<**0.001**
≤22 RPM	222 (33.2)	150 (48.1)	72 (20.2)	
23–28 RPM	145 (21.7)	57 (18.3)	88 (24.7)	
≥30 RPM	301 (45.1)	105 (33.6)	196 (55.0)	
Admission SO2% Median [IQR]	88 [80–93]	90 [85–94]	83 [72–90]	<**0.001**
SBP Median [IQR]	130 [120–148]	130 [118–144]	130 [120–150]	0.18
DBP Median [IQR]	80 [70–89]	80 [70–86]	80 [70–90]	0.27
Lowest SO2% Mean [IQR]	82 [70–89]	88 [83–92]	71 [54–80]	<**0.001**
>92 %	244 (26.3)	158 (34.1)	86 (18.5)	
89–92 %	187 (20.1)	123 (26.6)	64 (13.7)	
<88 %	498 (53.6)	182 (39.3)	316 (67.8)	
Severity at admission				<**0.001**
Moderate	499 (53.7)	450 (97.2)	49 (10.5)	
Severe or critical	430 (46.3)	13 (2.8)	417 (89.5)	
ICU admission criteria				<**0.001**
Yes	306 (32.9)	12 (2.6)	294 (63.1)	
No	623 (67.1)	451 (97.4)	172 (36.9)	
ICU admitted [c]				0.79
Yes	60 (6.5)	2 (16.7)	58 (19.7)	
No	246 (26.5)	10 (83.3)	236 (80.3)	
Type of ventilatory Support				<**0.001**
No Support (nasal cannula)	245 (26.4)	189 (40.8)	56 (12.0)	
Face Mask	312 (33.6)	200 (43.2)	112 (24.0)	
HFNC	224 (24.1)	54 (11.7)	170 (36.5)	
NIPPV	137 (14.7)	20 (4.3)	117 (25.1)	
Invasive Ventilation	11 (1.2)	0 (0.0)	11 (2.4)	
Access to Care				
Level-appropriate care	246 (26.5)	10 (2.2)	236 (50.6)	<**0.01**
Unable to receive ICU care	683 (73.5)	453 (97.8)	230 (49.4)	
Hospital length of stay, mean days [IQR]	5 [3–9]	5 [3–9]	5 [2–10]	**0.05**
Range (min – max)	44 (0–44)	29 (1–30)	44 (1–44)	
<7 days	557 (60.0)	278 (60.0)	279 (59.9)	0.52
7–14 days	250 (29.9)	126 (27.1)	124 (26.5)	
14–21 days	86 (9.3)	46 (9.9)	40 (5.6)	
21–28 days	25 (3.0)	9 (1.9)	16 (3.4)	
>28 days	11 (1.2)	4 (0.9)	7 (1.5)	

Data are median [interquartile range], or n (%). Abbreviations: RPM; Respirations per minute, ICU: Intensive Care Unit, SO2%: Saturation of Oxygen, SBP; Systolic Blood Pressure, DBP; Diastolic Blood Pressure, HFNC: High Flow Nasal Cannula, NIPPV: Non-invasive Positive Pressure Ventilation.
[a]P values were calculated by Mann-Whitney *U* test, χ^2 test, or Fisher's exact test, as appropriate. χ^2 test comparing all subcategories.
[b]Comorbidities are ordered by prevalence.
[c]Percentages are for the total population per category. From the patients requiring ICU admission n = 306 only n = 60 (19.6 %) received level appropriate care. Survivor group 2/12 (16.7 %) and Non-survivor group 58/294 (19.7 %).

1·10–2·00; p < 0·01) on admission, were associated with a poor survival (Fig. 3a). No statistical significance was observed for type of respiratory support; however, access to level-appropriate care was associated with survival with those requiring ICU transfer but not able to do so due to limited capacity having worse outcomes (HR = 1·84; CI 95 % 1·51-2·25; p < 0·002). (Fig. 3b)

4. Discussion

During the second outbreak of COVID-19 in Honduras, at which point vaccination was not widely accessible in the region, we identified several factors associated with poor outcomes in our cohort of hospitalized patients with laboratory-confirmed COVID-19. In the multivariate model, patients with comorbidities and high inflammatory markers were more at risk of not surviving, but only CKD and previously diagnosed CVD were independently associated with decreased survival rates. The cohort consisted of more males than females, however, male gender was not found to be associated with mortality, despite previous reports from similar regions noting a 1.7 fold increase in mortality [4]. Most notably, we observed a high case-fatality rate that could be attributed in part to a lack of access

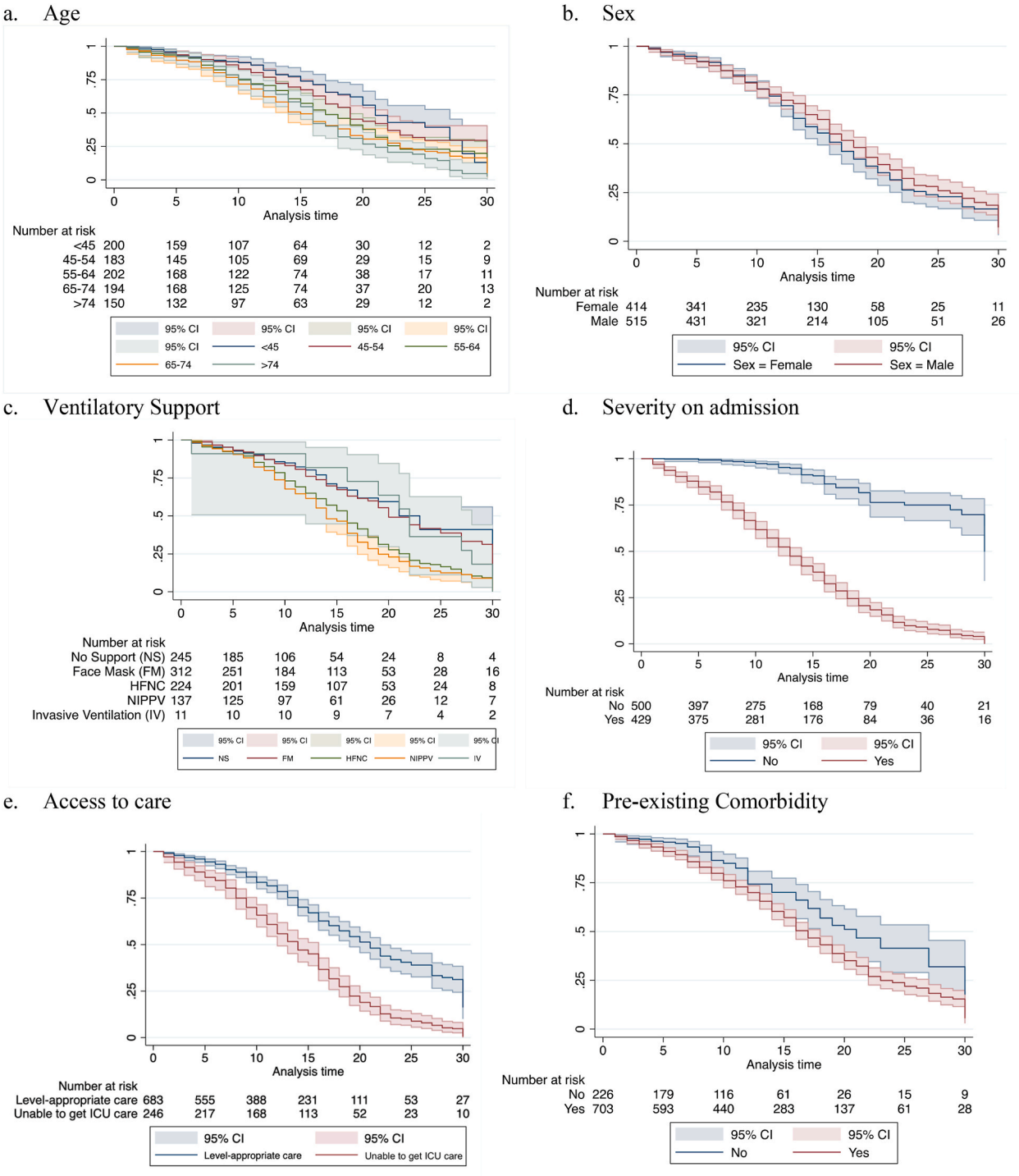
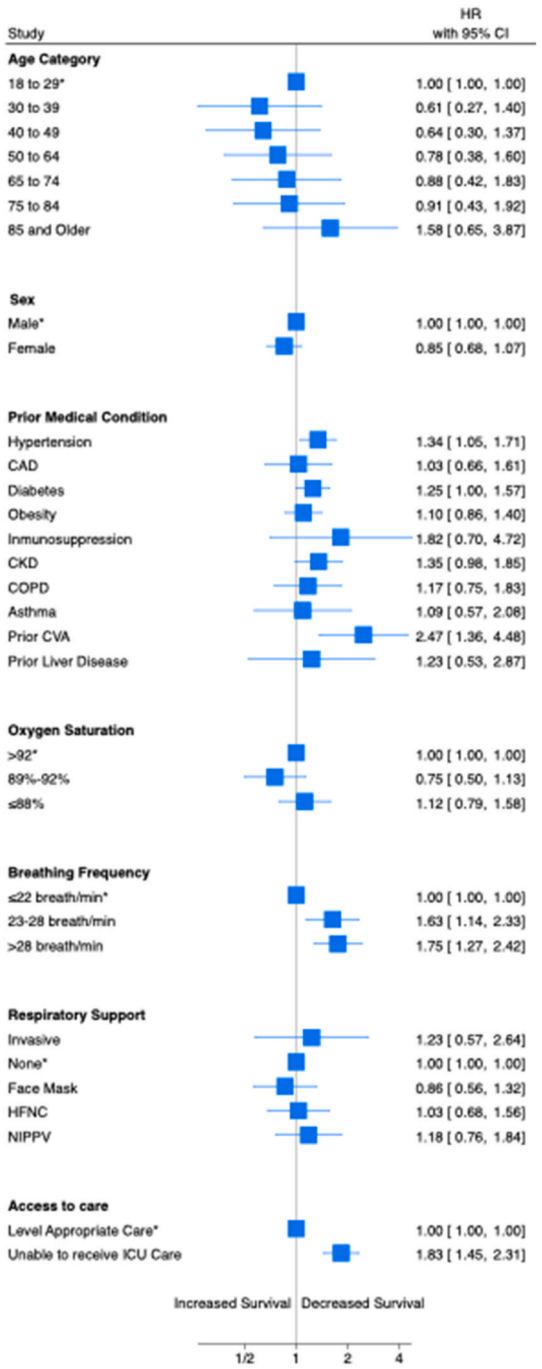


Fig. 2. Kaplan-Meier survival by different factors.

to level-appropriate care.

Studies have reported up to 25 % of hospitalized COVID-19 cases requiring ICU admission [22]. However, a Latin-American multicentric study found a much higher ICU admission rate (64 %) in that part of the world [23]. In our study, 32.9 % of the cohort met the criteria for ICU-level care at some point during their hospitalization. Several previous studies have concluded that the need for MV increases mortality from COVID-19 [24,25], and in our study, 100 % of the patients that required MV died. It is likely that a shortage of ICU beds led to a delay in critical care admissions and the use of MV, causing the high in-hospital case fatality rate that we

a. Complete Case Model (N=668)



b. Multiple Imputations Mode (N=929)

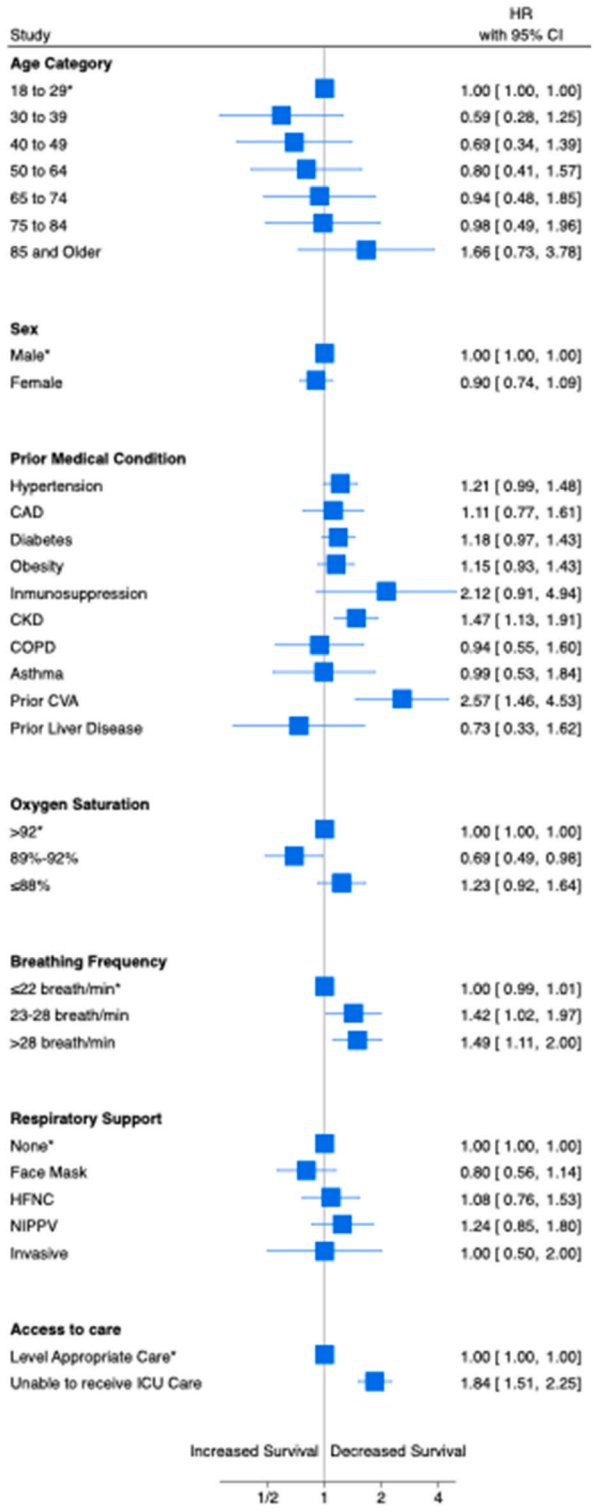


Fig. 3. Multivariable cox proportional hazard model.

observed. Lack of access to level-appropriate care can lead to under recognizing acute respiratory distress syndrome (ARDS) and thus delayed treatment or inability to provide appropriate care for these patients [26,27].

In our study, patients with severe COVID-19 and without access to ICU-level care despite meeting admission criteria had a lower survival rate. The ICU capacity in LMICs is typically very low, with most ICU beds located in referral hospitals in large cities [28]. The healthcare center that was the setting of this study is the second largest referral hospital in the region, with a potential referral population of 3.5 million. The hospital has only 12 adult ICU beds, and 306 (32.9 %) of the patients in our cohort met the ICU admission criteria. As a result, 246 (80.4 %) were not admitted to the ICU due to limited capacity.

In LMICs, limited space and equipment are not the only challenges to accessing care. Patient care is also affected by a shortage of qualified health personnel. In Honduras, it is estimated that there are 0.3 physicians per 1000 habitants [29]. During the study period, staffing in the COVID-19 ward varied. The COVID-19 ward had 60 beds, with a total of 5890 patient days, six nurses per shift (26,064 total staff nurse worked hours), and four general practitioners (two in the morning and two in the evening), resulting in a daily average nurse-to-patient ratio of 1:6.0 and a physician-to-patient ratio of 1:17.8. The COVID-19 ward had 12 ICU beds, but no ICU-trained physicians were available to provide care for these patients, which may be the cause of the 100 % mortality rate of patients requiring IMV and the delayed recognition of the need of MV. Only 12 mechanical ventilators (used for HFNC, NIMV, and Invasive Ventilation) and two dialysis machines were available to COVID-19 patients. In addition, only four of the available ICU beds were being used as intended, with the others used for patients transitioning to the ICU; this was likely due to the low number of staff able to manage ICU patients. Due to the limited capacity, several patients were managed with NIMV and HFNC, which could have led to self-induced lung injury (PSILI) [30–32].

4.1. Limitations

Attempting to establish a correlation between mortality and comorbidities in a cohort of patients residing in LMICs where access to healthcare is constrained and the availability of medical professionals is limited poses considerable challenges. The delayed admission of patients might be attributable to the prominent symptom of "shortness of breath," which tends to manifest in advanced stages of the disease, unless there are other concurrent conditions. Additionally, the numerous complexities associated with managing critically ill patients, particularly those requiring ventilation, could have contributed to the 100 % mortality rate observed in such cases.

This study has several other important limitations, including its retrospective design and the use of data taken from paper medical records in which some variables lacked completeness, making it difficult to extrapolate conclusions. Comorbidities were ascertained based on the patient's medical record and history, and we were unable to use a standardized COVID-19 severity score due to the lack of Arterial Blood Gases and other laboratory variables; this may have resulted in a biased classification of the severity of the disease. In addition, a lack of resources during the pandemic limited access to full laboratory panels in some patients, although we attempted to address this limitation through multiple imputations. Also, these results are from a single location, which limits their generalizability. However, because the study was done at the main referral hospital in Northwestern Honduras, which is also the second biggest hospital in the country, we argue that it provides an accurate representation of the Honduras population [33–36].

5. Interpretation

This is the largest study of inpatient COVID-19 cases in Honduras and Central America and provides valuable insights into the detrimental influence of the pandemic in LMICs. We observed a substantial case fatality rate and identified several factors associated with poor outcomes and survival. In this study, patients who couldn't receive level-appropriate care (ICU admission) had a significantly lower likelihood of survival when compared to those who did (HR: 1.84). Our study highlights the significant effect that poor access to healthcare in LMICs had during the COVID-19 pandemic.

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Data availability statement

All data to support the conclusions data will be made available on request.

CRediT authorship contribution statement

César Alas-Pineda: Writing - review & editing, Writing - original draft, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization. **David Aguilar-Andino:** Writing - review & editing, Writing - original draft, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francisco Antonio Vallecillo Munguia:** Writing - review & editing, Writing - original draft, Investigation. **Gissela María Padilla David:** Writing - review & editing, Writing - original draft, Investigation. **Andrea N. Umaña:** Writing - review & editing, Writing - original draft, Investigation.

Luis Romero Reyes: Writing - review & editing, Writing - original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Alejandro Cárcamo:** Writing - review & editing, Writing - original draft, Resources, Project administration, Conceptualization. **Ana Liliam Osorio:** Writing - review & editing, Writing - original draft, Supervision, Resources, Project administration, Methodology, Conceptualization. **Julio Zuniga-Moya:** Writing - review & editing, Writing - original draft, Software, Data curation. **Eleazar Montalvan-Sanchez:** Writing - review & editing, Writing - original draft, Methodology. **Travis J. Atchley:** Writing - review & editing, Writing - original draft, Methodology. **Nicholas Michael Berry Laskay:** Writing - review & editing, Writing - original draft, Methodology. **Dagoberto Estevez-Ordonez:** Writing - review & editing, Writing - original draft, Validation, Software, Methodology, Funding acquisition, Formal analysis, Data curation. **Orlando Garner:** Writing - review & editing, Writing - original draft, Validation, Supervision, Project administration, Methodology, Conceptualization. **Dalton Argean Norwood:** Writing - review & editing, Writing - original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, 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.heliyon.2024.e24015.

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