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Low Oxygen Saturation of COVID-19 in Patient Case Fatalities, Limpopo Province, South Africa

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Abstract: On 1 August 2020, South Africa's Minister of Health announced that more than half of a million coronavirus cases were confirmed in the country. South Africa was by far the hardest-hit country in Africa, accounting for half of all infections reported across the continent. The prevalence of underlying conditions such as fever and blood oxygen saturation (SpO2) has been known known to be a significant determinant in the hospitalisation of COVID-19 patients. Low oxygen saturation on admission was reported as a strong predictor of in-hospital mortality in COVID-19 patients. The study sought to assess the association between body temperature and other clinical risk factors with low SpO2 among COVID-19 inpatient case fatalities. A quantitative retrospective study was carried out in Limpopo Province, employing secondary data from the Limpopo Department of Health (LDoH) on COVID-19 inpatients case fatalities across all districts in the province. The chi-square test and Pearson's correlation coefficient were used to assess the relationship between body temperature and clinical risk factors with SpO2 levels. The findings of this paper indicated that age (older age), chills, sore throat, anosmia, dysgeusia, myalgia/body aches, diarrhoea and HIV/AIDS were associated with low SpO2 in-hospital mortality in COVID-19 patients. Nasal prongs and a face mask with a reservoir for respiratory support cannula were commonly used patient interfaces to provide supplemental oxygen, with the use of only a high-flow nasal cannula (HFNC) being minimal (7%). The majority of COVID-19 inpatient fatalities had normal body temperature (<38 °C) and SpO2, with no correlation between the two variables. Considering temperature screening as a possible strategy to combat the spread of COVID-19 or suspicious COVID-19 cases appeared, then, to be a pointless exercise. This study aimed to recommend new clinical criteria for detecting COVID-19 cases.

Keywords: COVID-19; oxygen saturation; body temperature; fever; mortality

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1. Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was discovered in January 2020. The virus has since spread exponentially and caused human suffering throughout the world [1–3]. By March 2020, the World Health Organization (WHO) had declared the spread of the coronavirus disease (COVID-19) a pandemic because of the high number of deaths. As of February 2022, this highly infectious pathogen has infected most of the individuals throughout the world, with over 426 million confirmed cases of COVID-19 and a large number of patients requiring hospitalisation [4]. On 1 August 2020, South Africa's Minister of Health announced that more than half a million coronavirus cases had been confirmed in the country [5,6]. South Africa was by far the hardest-hit country in Africa, accounting for half of all infections reported across the continent [5,6].

As the pandemic continues to wear on, more deaths are expected unless proper management is put in place in terms of prevention, transmission control and treatment of the disease. COVID-19 is characterised by bilateral pneumonia, progressing in several cases to acute respiratory syndrome (ARDS), with the subsequent need for intensive care unit (ICU) admission and a high mortality rate [7,8]. An increased respiratory rate, decreased oxygen levels or an increased supplementary oxygen requirement are all clinical indicators of respiratory failure. Patients may also report chest tightness and/or an inability to breathe deeply, as well as an increasing appearance and/or feeling of anxiety [9]. These symptoms, along with psychological distress and fear, exacerbate breathlessness by raising the respiratory rate even more, necessitating immediate medical attention. Blood oxygen saturation (SpO2) and/or arterial or capillary oxygen partial pressure (PaO2 or PcO2) are used to determine oxygen levels [9]. Unless hypercapnia is a concern, SpO2 is preferred during COVID-19 because it is simple and quick to monitor [9,10].

Adults with COVID-19 who are receiving supplemental oxygen have an optimal SpO2 that is unknown [10]. However, a target SpO2 of 92 to 96 percent seems reasonable, given that indirect evidence from patients without COVID-19 suggests that SpO2 levels of 92 to 96 percent may be harmful [10]. The prevalence of underlying conditions, such as fever and SpO2, is known to be a significant determinant in the hospitalisation of COVID-19 patients [9–11]. In addition, several studies have reported hospitalised COVID-19 patients with low oxygen saturation [10,12,13]. Low oxygen saturation on admission is reported as a strong predictor of in-hospital mortality in COVID-19 patients [12]. COVID-19-related complications and mortality rates reported in various countries have varied considerably. Clinicians have noted that patients with suspected COVID-19 had a fever, shortness of breath, myalgia and relatively low oxygen saturation [14,15]. In Italy, Toniati et al. reported that a large number of patients were admitted to hospitals with pneumonia and acute respiratory failure [16]. In a study in Wuhan in China, high fever (body temperature > 39 °C) was associated with a higher likelihood of acute respiratory distress syndrome [17]. However, a study conducted on children treated in the paediatric emergency department (PED) at the Shaare Zedek Medical Center found that body temperature in children was associated with decreased SpO2 [18]. There are few published studies that have looked at clinical risk factors and body temperature as potential markers for low oxygen saturation among COVID-19 inpatients in Limpopo Province, South Africa. Therefore, the purpose of this study was (1) to determine the correlation between body temperature and oxygen saturation in COVID-19 inpatient case fatalities, and (2) to investigate the clinical risk factors associated with low oxygen saturation.

2. Materials and Methods

2.1. Study Setting, Period and Design

A clinical retrospective study was carried out in Limpopo Province employing secondary data from the Limpopo Department of Health (LDoH) on COVID-19 inpatients across all districts of the province. The LDoH's COVID-19 response consisted of surveillance and epidemiology, with data collected and analysed between March 2020 and June 2021. Limpopo Province has 41 public hospitals that admit patients who have been referred from their homes, from clinics or other hospitals. The study included 1119 patient clinical records of laboratory-confirmed COVID-19 cases and excluded non-laboratory-confirmed COVID-19 cases (30 patients). Out of a total 1149 patients, the proportion of the sampling units included was 97%. Permission to conduct a research study was granted by the Limpopo Provincial Health Research Committee (LP_2021-11-017).

2.2. Statistical Analysis

The data were extracted from LDoH databases, coded, recorded and entered into Microsoft Excel before being imported into the Statistical Package for Social Science (SPSS) version 26 (IBM, Armonk, New York, NY, USA) for analysis. The data were presented in the form of percentages and frequencies. The chi-square test and Pearson's correlation

coefficient were used to assess the relationship between body temperature and clinical risk factors with SpO2 levels. SPSS version 26 was used for all statistical analyses.

2.3. Data Collection and Validation

This study used mortality audit data to examine all deaths caused in hospitalised COVID-19 patients between the first (16 March 2020 to 31 October 2020) and second (1 November 2020 to 31 March 2021) pandemic waves. The LDoH developed the COVID-19 in-patient mortality audit tool, which was thoroughly validated by LDoH officials, with the help of the WHO COVID-19 provincial support team. The tool was administered and completed by each hospital audit team. The audit was done in a group setting with the help of a senior clinical manager and a nursing service manager. The data were collected from 41 hospitals in all five districts of Limpopo Province, namely: Waterberg, Mopani, Capricorn, Vhembe and Sekhukhune.

3. Results

Table 1 summarises the demographic and clinical characteristics of hospitalised patients. Of the 1119 patients, the majority were aged 60 years and above (69%), followed by those aged 50–59 (15%), in all districts. The majority of patients (53%) were hypertensive in all districts, with the exception of the Vhembe District. Diabetes mellitus prevalence was more than 50% in both the Capricorn and Mopani districts. In terms of clinical presentation, most patients had a fever (55%), a cough (81%), shortness of breath (84%) and myalgia/body aches (60%). In terms of gender, more females (52.7%) were hospitalised compared to males (47.3%).

Table 1. Demographic and clinical characteristics of hospitalised patients with COVID-19.

	Overall	Percentage	Capricorn	Mopani	Sekhukhune	Vhembe	Waterberg
Age							
20–29	10	1%	9 (1.8%)	2 (0.9%)	0 (0%)	2 (0.7%)	0 (0%)
30–39	62	6%	17 (3.4%)	14 (6.4%)	6 (6.4%)	22 (7.9%)	3 (5.3%)
40–49	101	9%	46 (9.2%)	23 (10.5%)	8 (8.5%)	24 (8.6%)	5 (8.8%)
50–59	172	15%	65 (13%)	31 (14.2%)	12 (12.8%)	55 (19.7%)	11 (19.3%)
60+	774	69%	362 (72.5%)	149 (68%)	68 (72.3%)	176 (63.1%)	38 (66.7%)
Gender							
Male	544	47.3%	226 (45.3%)	102 (47%)	52 (55.3%)	133 (47.7%)	30 (52.6%)
Female	604	52.7%	273 (54.7%)	116 (53%)	42 (44.7%)	146 (52.3%)	27 (47.4%)
Comorbid Conditions							
HIV/AIDS	141	19%	60 (20.3%)	31 (24.4%)	15 (18.8%)	27 (13.2%)	8 (16.7%)
TB	37	5%	15 (6%)	4 (3.9%)	1 (1.3%)	10 (5%)	7 (14.6%)
COPD	18	3%	13 (5.3%)	1 (1%)	0 (0%)	2 (1%)	2 (4.2%)
Hypertension	586	64%	263 (69.9%	127 (73%)	57 (62%)	111 (49.1%)	28 (53.8%)
Diabetes Mellitus	450	52%	199 (56.9%)	95 (62.5%)	28 (33.3%)	105 (46.9%)	23 (42.6%)
Asthma	35	5%	17 (6.6%)	5 (5.2%)	2 (2.7%)	8 (4.1%)	3 (6.3%)
Obesity	81	12%	42 (15.3%)	22 (20.4%)	3 (4.1%)	6 (3%)	8 (16%)
Cancer	23	4%	9 (3.5%)	5 (5.2%)	4 (5.6%)	4 (2%)	1 (2.1%)
Respiratory distress	919	91.5%	432 (93.5%)	164 (87.2%)	76 (95%)	199 (91.3%)	48 (85.7%)
Clinical Presentations							
Fever	266	55%	108 (41%)	72 (27%)	26 (10%)	31 (12%)	29 (11%)
Chills	148	33%	54 (36%)	34 (23%)	25 (17%)	26 (18%)	9 (6%)
Cough	650	81%	313 (48%)	114 (18%)	55 (8%)	138 (21%)	30 (5%)
Sore throat	137	32%	52 (38%)	25 (18%)	29 (21%)	15 (11%)	15 (11%)
Shortness of breath	714	84%	309 (43%)	116 (16%)	63 (9%)	180 (25%)	46 (6%)
Anosmia	65	16%	21 (32%)	9 (14%)	20 (31%)	6 (9%)	9 (14%)
Dysgeusia	83	20%	24 (29%)	13 (16%)	19 (23%)	18 (22%)	9 (11%)
Myalgia/body aches	374	60%	186 (50%)	69 (18%)	40 (11%)	54 (14%)	25 (7%)
Diarrhoea	145	31%	59 (41%)	27 (19%)	26 (18%)	22 (15%)	11 (8%)
Chest Pain	55	8%	28 (51%)	6 (11%)	10 (18%)	10 (18%)	1 (2%)
Loss of appetite	65	9%	32 (49%)	10 (15%)	9 (14%)	10 (15%)	4 (6%)

Figures 1 and 2 show the SpO2 levels in hospitalised COVID-19 patients' mortality by age group and ward. COVID-19 patients' mortality with SpO2 levels less than 95% were seen in greater numbers in all wards than those COVID-19 patients' mortality with SpO2 levels greater than or equal to 95%. COVID-19 patients' mortality with an SpO2 level of less than 95% were seen in greater numbers in their 40s and older. The majority of COVID-19 mortality patients had a body temperature of less than 38 °C and the majority of them were aged 60 and over (see Figure 3).

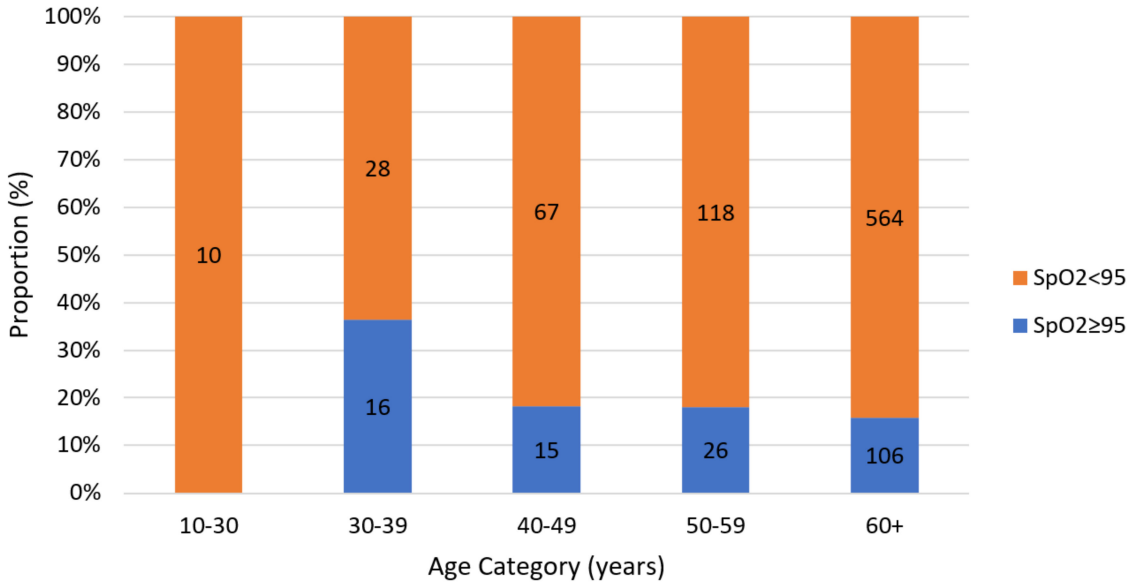

Figure 1. SpO2 level in COVID-19 hospitalised patients' mortality by age group.

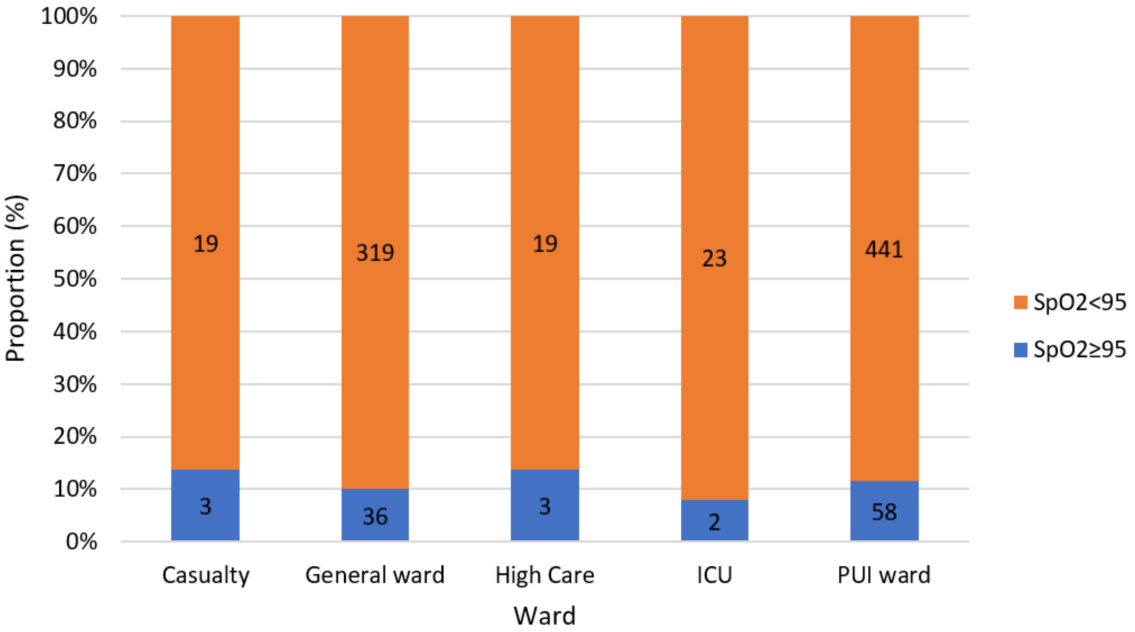

Figure 2. SpO2 level in COVID-19 hospitalised patients' mortality by ward.

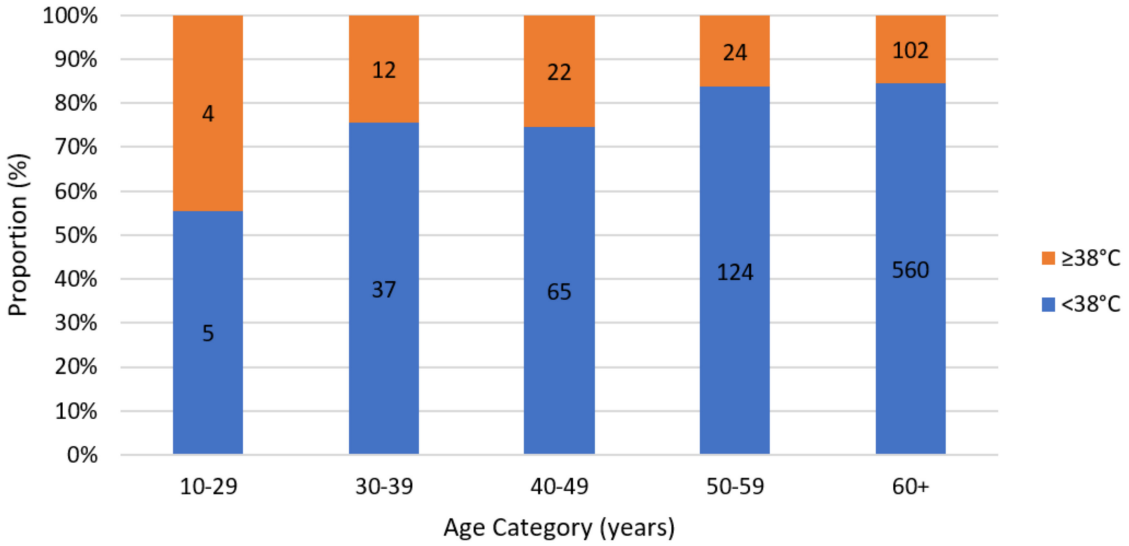

Figure 3. Body temperature by age group in COVID-19 hospitalised patients' mortality.

Figure 4 illustrates the correlation between body temperature and SpO2. The scatterplot indicates that there was no relationship between body temperature and SpO2. Furthermore, the significant Spearman correlation coefficient value of 0.06 confirmed the conclusion illustrated in the graph; there appeared to be no correlation between the two variables. Adjusting for age and comorbidities, the Spearman correlation coefficient values were 0.052 and 0.050, respectively.

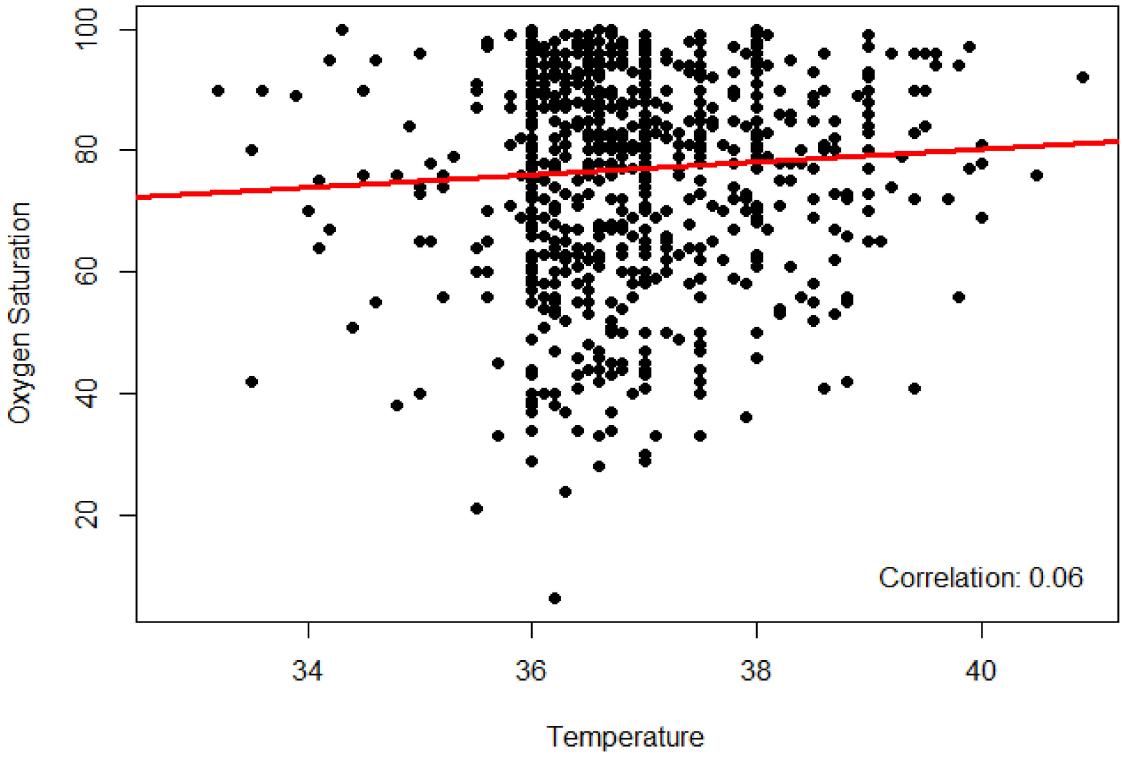

Figure 4. Spearman's correlation between body temperature and SpO2.

Table 2 presents the results of the chi-square analysis of the differences in clinical risk factors associated with SpO2. COVID-19 mortality patients in the normal SpO2 group were significantly more likely to have chills, a sore throat, anosmia, dysgeusia, myalgia/body aches and diarrhoea (p-value < 0.05). COVID-19 mortality patients in the normal SpO2

group were significantly more likely to be living with HIV than those in the SpO2 less than 95% group (p-value < 0.05). COVID-19 mortality patients with SpO2 of less than 95% groups were significantly more likely to be 60 years or older than those patients with normal SpO2. Gender, TB, COPD, hypertension, diabetes mellitus, asthma, obesity, cancer, fever, cough, shortness of breath, chest pain and loss of appetite were also investigated for association with SpO2 levels; however, the results were not significant.

Table 2. Clinical risk factors associated with SpO2 among COVID-19 mortality patients.

	SpO2 < 95 n(%)	**SpO2 ≥ 95 n(%)**	**Chi-Square Test Value**	***p*-Value**
Age			**14.488**	**0.006 ***
20–29	10 (1.3%)	0 (0.0%)		
30–39	28 (3.6%)	16 (9.8%)		
40–49	67 (8.5)	15 (9.2%)		
50–59	118 (15.0%)	26 (16.0%)		
60+	564 (71.7%)	106 (65.0%)		
Gender			0.007	0.935
Male	369 (46.9%)	86 (52.8%)		
Female	418 (53.1%)	77 (47.2%)		
Comorbid Conditions				
HIV/AIDS	92 (17.5%)	27 (26.5%)	4.526	0.033 *
TB	24 (5.1%)	6 (6.7%)	0.368	0.544
COPD	13 (2.8%)	2 (2.3%)	0.061	0.806
Hypertension	411 (64.2%)	94 (68.6%)	0.958	0.328
Diabetes Mellitus	317 (52.7%)	71 (56.8%)	0.714	0.398
Asthma	28 (5.9%)	5 (5.7%)	0.005	0.943
Obesity	62 (12.4%)	11 (12.4%)	0.001	0.986
Cancer	19 (4.0%)	3 (3.6%)	0.041	0.839
Clinical Presentations				
Fever	191 (55.7%)	40 (64.5%)	1.671	0.196
Chills	101 (32.7%)	31 (50.0%)	6.754	0.009 *
Cough	491 (83.1%)	86 (81.9%)	0.087	0.768
Sore throat	88 (29.5%)	31 (54.4%)	13.265	<0.001 *
Shortness of breath	520 (84.1%)	108 (87.1%)	0.693	0.405
Anosmia	28 (10.2%)	24 (43.6%)	38.439	<0.001 *
Dysgeusia	46 (16.1%)	24 (43.6%)	21.465	<0.001 *
Myalgia/body aches	251 (59.1%)	68 (72.3%)	5.733	0.017 *
Diarrhoea	88 (27.2%)	34 (54.0%)	17.559	<0.001 *
Chest Pain	47 (8.9%)	6 (7.4%)	0.206	0.650
Loss of appetite	46 (8.7%)	9 (11.1%)	0.492	0.483

* indicates significant differences (p-value less than 0.05)

Patients with respiratory failure should be promptly identified and evaluated for possible escalation of respiratory support. Most patients were put on oxygen for less than 24 h, with 6% of patients put on mechanical ventilation (Table 3).

Table 3. COVID-19 patients' duration on oxygen.

	Frequency	**Percentage**
Duration on oxygen		
24 h	14	46%
24–72 h	145	19%
3–7 days	185	25%
8–14 days	61	8%
>14 days	14	2%
Mechanical ventilation	67	6%

Nasal cannula and prongs, a simple face mask, a face mask with a reservoir or CPAP/NIV titrate oxygen therapy up and down to reach targets and mechanical ventilation are all possibilities (Figure 5). Most patients were on nasal prongs (35%) followed by face masks with reservoirs (29%). The majority of COVID-19 patients were given antibiotics (31%), followed by those given steroids (27%), as shown in Figure 6.

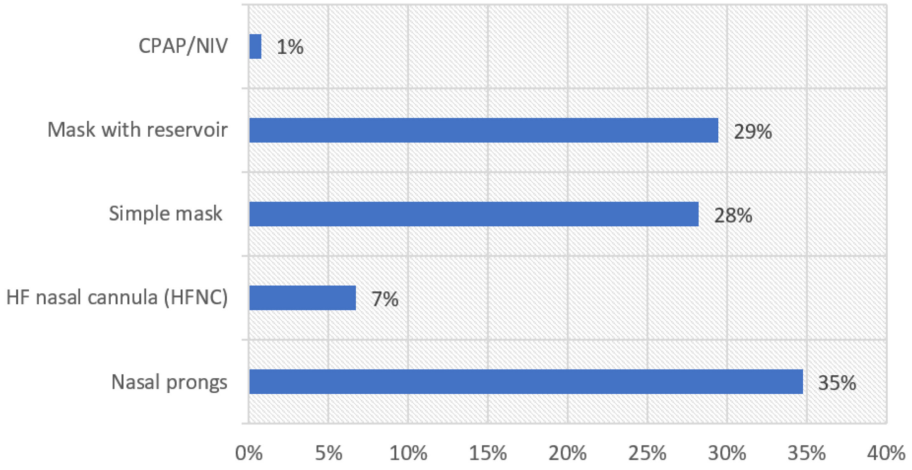

Figure 5. Respiratory support for hospitalised COVID-19 patients in Limpopo Province.

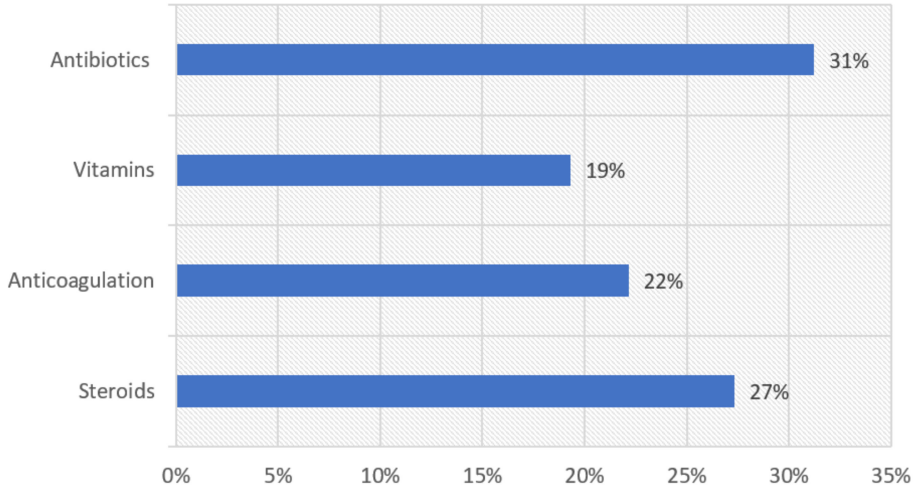

Figure 6. Treatment of hospitalised COVID-19 patients in Limpopo Province.

4. Discussion

In our analysis, we examined the influence of body temperature on SpO2 in hospitalised COVID-19 patients using secondary data from LDoH. The main finding of the study indicated that there existed no relationship between body temperature and SpO2 in hospitalised patients. This was in contradiction to previous studies by Lahav et al. and Wu et al., since they found that body temperature in children and adult patients with COVID-19 was associated with SpO2 [17,18]. Concerning low SpO2 levels on admission, our statistical analyses revealed that patients in the age group 60 years and above were more likely to present SpO2 levels less than 95% and were at high risk of dying from COVID-19, in agreement with the findings of previous studies [19–22].

A large number of patients who were reported to have died of COVID-19 had a body temperature of less than 38 °C. The lack of association between body temperature and SpO2 level related to COVID-19 mortalities in our study was in line with the findings of previous studies related to COVID-19 mortalities [14,23,24]. Although seen as an efficient and safe consultation for patients with fever or respiratory symptoms, COVID-19 screening

using fever or respiratory symptoms was not found to be effective in combating COVID-19 mortality. Despite the convenience of the use of COVID-19 screening, Kim and Lee discovered that walkthrough screening could increase infection rates at each level of the screening procedure, including booths and adverse reactions to booth decontamination [25].

In our study, fever, cough, shortness of breath and myalgia were the most common symptoms displayed by hospitalised COVID-19 patients, corroborating previous findings [26–28]. It was also notable that more than half of the hospitalised patients were females. The absence of the relationship between fever and mortality related to COVID-19 in our study corroborated the findings of previous research [23,24]. In contrast, Iftimie et al. and Qiu et al. reported contradictory findings [29,30]. This could be attributed to the different cohorts of hospitalised patients and groups sampled in these studies.

Comorbidities showing a significant relationship with COVID-19 mortalities were HIV/AIDS, hypertension and diabetes mellitus. The most common comorbid condition in our hospitalised patients was hypertension and diabetes mellitus. The results were in agreement with a recent longitudinal study [29]. The probable explanation for high rates of underlying chronic diseases in COVID-19 patients lies in South Africa's socioeconomic inequality and lack of access to quality health care facilities [31]. On the other hand, we found that SpO2 in COVID-19 mortalities was associated with clinical risk factors such as old age, chills, sore throat, anosmia, dysgeusia, myalgia/body aches, diarrhoea and HIV/AIDS. Eskandarian and Sohrabi et al. reported similar findings in their prospective and multicentre descriptive studies [19,24]. With regards to clinical presentations, fever, obesity, shortness of breath, chest pain and loss of appetite were not found to be significantly associated with SpO2 levels, in contrast to the findings of Sohrabi et al. [19]. The reason for this could be attributed to differences in hospital facilities, age groups and, once again, the methodologies used in the studies.

We found that older age was associated with a higher risk of hospital admission and COVID-19 mortality, regardless of body temperature. By comparison, our demographics of hospitalised patients from all five districts of Limpopo Province indicated that 69% of hospital admissions were patients who were 60 years and above in age. Vanhems argued that this could be due to a lack of sufficient knowledge about the consequences of COVID-19 in elderly populations during the initial waves of the pandemic [27]. The findings of the multicentre descriptive study of the Iranian population by Sohrabi et al. were in agreement with the findings of our study results, since they found age (60 years and above) to be among the positive predictors of mortality as a result of COVID-19 [19].

The use of an HFNC has been shown to improve oxygenation in COVID-19 patients; however, if used on patients with acute hypoxaemic respiratory failure, its use may increase bioaerosol dispersion in the environment, which could aid disease transmission [10,32,33]. There appears to be uncertainty about—and a trend towards avoiding—the use of an HFNC on COVID-19 patients, leading to an increase in early intubation rates and potentially associated harms, such as sedation and prolonged ICU stay, as well as the intubation procedures themselves, which pose a high risk of viral exposure [32]. Nasal prongs and a face mask with a reservoir for respiratory support were used on the majority of patients in the study, with the use of an HFNC being minimal. According to recent studies, HFNC should be used in a negative pressure room, when possible. Additionally, devices should be used in a single room, when possible [33], and using a surgical mask on a patient's face who has already been treated with an HFNC might benefit hypoxaemic COVID-19 patients without added risk to the environment [32,34]. The study's findings added to the body of knowledge about factors associated with SpO2 in adults with COVID-19 and could be used by policymakers to develop relevant and appropriate intervention strategies to combat the disease.

5. Conclusions

The findings of this paper indicated that age (older age), chills, sore throat, anosmia, dysgeusia, myalgia/body aches, diarrhoea and HIV/AIDS were associated with low SpO2

in in-hospital mortality in COVID-19 patients. Nasal prongs and face masks with reservoirs for respiratory support cannulas have been commonly used as patient interfaces to provide supplemental oxygen. Uses of HFNC were minimal (7%). The majority of COVID-19 in-patient fatalities had normal body temperature (<38 °C) and SpO2 levels, with no correlation between the two variables. Considering temperature screening as a possible strategy to combat the spread of COVID-19 or suspicious COVID-19 cases thus appears to be a pointless exercise. This study recommended new clinical criteria for detecting COVID-19 cases.

Author Contributions: Conceptualisation, P.M.M.; methodology, P.M.M. and M.E.S.-S.; software, P.M.M.; validation, P.M.M.; formal analysis, P.M.M.; resources, P.M.M. and M.E.S.-S.; data curation, M.E.S.-S.; writing—original draft preparation, P.M.M. and A.F.M.; writing—review and editing, P.M.M., S.F.M. and A.F.M.; visualisation, P.M.M.; project administration, M.E.S.-S. and S.F.M. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study will be conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of University of Limpopo (protocol code TREC/293/2021: IR).

Informed Consent Statement: Patient consent was waived because the study used secondary data from the Limpopo Department of Health.

Data Availability Statement: The dataset for participants generated and analysed during the original study is available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declare no conflict of interest.

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