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Analysis of COVID-19 Infection Amongst Healthcare Workers in Rivers State, Nigeria

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ABSTRACT

Objective: To determine the illness severity and mortality amongst Coronavirus (COVID-19) infected healthcare workers.

Design: A retrospective cohort study using population-level data. Secondary analysis was conducted on collated data from the Public Health Emergency Operations Centre (PHEOC) at the State Ministry of Health, Rivers State, Nigeria. Data were gathered from the COVID-19 patient database of the PHEOC on demographics, place of work, illness severity and outcome.

Participants: The cohort included all documented healthcare workers with confirmed COVID-19 infection (diagnosed by Polymerase Chain Reaction).

Primary and secondary outcome measures: Illness severity defined as 'hospitalisation required', and treatment outcome labelled as 'recovered', 'alive', or 'dead' were the outcomes of interest. Adjusted odds ratio were used to report the measure of association between illness severity, mortality and their respective risk factors.

Results: The mean age was 43 years and 50.5% of the cohort were female. Of the 301 healthcare workers infected, 187 patients were symptomatic with 32 requiring hospitalisation. Seven infected HCWs died of their COVID-19 infection, resulting in a case fatality ratio of 2.3%. Symptomatic cases were more inclined to progress to severe illness ($\chi^2{}_{(1)} = 15.219$, $\alpha = < 0.0001$; aOR, 95% CI = 10.658, 2.494 – 45.552); patients also had greater odds of dying from COVID-19 ($\chi^2{}_{(5)} = 13.7$, $\alpha = 0.003$; aOR, 95% CI = 1.079, 1.02–1.141) per year increase in age adjusted for sex, case class and illness severity.

Conclusions: Frontline healthcare workers are at an increased risk of exposure to COVID-19 infections. In Nigeria, there is a higher risk of experiencing severe illness if symptomatic while infected with COVID-19. It is imperative that preventive strategies, proper education, and awareness are put in place to protect healthcare workers. Future studies to investigate the effect of hospitalisation time on disease severity and mortality is essential and recommended.

Keywords: Coronavirus, COVID-19, Healthcare workers, nosocomial infection, illness, severity, mortality

ARTICLE SUMMARY

Strengths and Limitations of the Study

- To our knowledge, this research is the foremost study representing a relatively comprehensive analysis of COVID-19 related mortality and disease severity in healthcare workers using population-level data.
- The use of population-level data in the study gives a snapshot of the burden of COVID-19 on healthworkers in the study region. Therefore, adding to the scientific evidence on the severity and mortality associated with COVID-19 in Nigeria.
- The reliance on reported infections and deaths limits the study; hence, making it impossible to estimate how many cases were missed by non-reporting.
- The use of electronic health records data for population health studies is still emergent in this region, therefore prior exposure data was not available.

INTRODUCTION

Healthcare workers (HCWs) have a higher risk of encountering infectious agents due to their work environments. With the COVID-19 pandemic, frontline HCWs face a higher risk of infection and mortality as well as being drivers of community-level infection. Recent evidence shows that compared to individuals in the general community, frontline HCWs have a 12-fold risk of testing positive for COVID-19, with higher risk observed for workers with inadequate access to personal protective equipment (PPE) [1]. In addition to increased exposure to COVID-19 in the pandemic, Wang et al. (2020)[2] found that poor sleep quality and higher working pressure can increase the risk of nosocomial SARS-CoV-2 infection amongst HCWs. Hence, it is possible to extrapolate these results to the Nigerian healthcare setting as the density of HCWs (1.95 to 1,000 persons) in the country is reportedly "still very low" to effectively deliver essential health services [3]. The estimated mortality rate amongst HCWs attributed to COVID-19 has increased progressively [4]. In May 2020, the total number of reported HCW deaths from 67 countries was 1413. Consequently, it suggests that for every 100 HCWs that got infected, one died –the deaths were also 0.5% of the total number of 270,426 COVID-19 deaths worldwide [5]. Additionally, a survey of 37 countries estimated median death of 0.05 HCWs per 100,000 population. A report from the Pan American Health Organization (PAHO) in collaboration with the World Health Organization (WHO) stated that approximately 570,000 healthcare workers got infected with COVID-19 with above 2,500 dying from the virus across the American region alone [6]. The World Health

Organization also estimated that between 80,000 and 180,000 healthcare workers died of COVID-19 in the period between January 2020 to May 2021, converging to a medium scenario of 115,500 deaths [7].

A subnational study highlighting the burden of COVID-19 amongst healthcare workers is paramount to understanding the effect of the pandemic on the healthcare workforce in Nigeria. The study aim was to determine the illness severity and mortality amongst COVID-19 infected healthcare workers in Rivers State, Nigeria.

METHOD

Study location

The study was conducted in Rivers State, located in the South-South geopolitical zone of Nigeria.

Study design and population

The study was a retrospective cohort study using population-level data. The cohort included all documented healthcare workers with confirmed COVID-19 infection. The healthcare workers were categorised using the World Health Organization and International Labour Organisation (ILO) International Standard Classification of Occupations (ISCO) [8]. There were five categories based on their roles in patient management and healthcare services:

- Health professionals –medical doctors, nurses, dentist, pharmacists, health safety professionals.
- Health associate professional –all technologists and assistants in health professions, Community Health Workers.
- Personal care workers –health care and home-based care workers.
- Health management and support personnel –administrative and management staff, trade workers, social workers, life science professionals.
- Other health service providers –armed forces staff, interns, and hospital volunteers.

Furthermore, the health facilities were classified on the basis of services rendered. Hospital classification by services: Teaching hospitals –offering tertiary health services; General hospitals –offering secondary health services; Community hospitals –offering primary and community-based care; specialised outpatient clinics –rendering specialty outpatient services like dentistry, radiology, and diagnostic services; Corporate/Occupational health clinics –offering general and occupational health services, restricted to employees only; and Health allied organisations.

Data Source

Secondary data was collated from the data reported to the data centre of the Public Health Emergency Operations Centre (PHEOC) at the State Ministry of Health. The data sources included reports from public and private-owned health facilities, containment centres, offshore platforms, and other health-allied facilities. The duration of data extraction was from 24 March 2020 to 30 November 2021. The dataset characterised demographics, pre-existing comorbidities, symptoms, facility managed, patient status, treatment outcome, and dates of related events, without personal identifiers. Hence, this secondary analysis waived the required individual informed consent. Patient information was retrieved from the dataset based on the occupation of interest –healthcare worker and their respective designation—; alongside demographic data on age, sex; other information collected included the place of work defined as 'health facility', illness severity defined as 'hospitalisation required', case classification defined as 'symptomatic or asymptomatic', knowledge of exposure, place of exposure, and treatment outcome labeled as 'recovered', 'alive', or 'dead'.

Data analysis

Data were analysed using IBM SPSS Statistics for Windows, Version 25 [9]. Descriptive statistics were used to report on the cohort characteristics. Means and standard deviations were reported for continuous variables and proportions for categorical and qualitative response variables. Proportions was used for subgroup analysis of variables. Univariate analysis of categorical variables was conducted using Chi-square (χ^2) –and Fischer's exact test where appropriate. A two-tailed p-value less than 0.05 was statistically significant. Multivariate logistic regression was used to evaluate risk factors of illness severity and mortality among healthcare workers with COVID-19. The adjusted odds ratio (aOR) with 95% confidence interval (95% CI) was used to report the measure of association between the following: illness severity and risk factors –age, sex, and case class; mortality and risk factors –age, sex, illness severity and case class.

Patient and Public Involvement

It was not possible to involve patients or the public in the design, conduct, reporting, or dissemination plans of our research as the study utilised secondary data without personal identifiers.

Ethics Approval

This study was conducted according to the guidelines of the Declaration of Helsinki. The Ethics Committee of the Rivers State Ministry of Health gave approval for this work –Ethics ID: MH/PRS/391/VOL.2/809.

RESULTS

Patient Characteristics

Data on 301 healthcare workers infected with COVID-19 were identified and extracted to a spreadsheet. Demographic and clinical characteristics of the patients is found in Table

1. The mean age was 43 years and 50.5% of the cohort were female. Of the 301 healthcare workers, 187 patients were symptomatic with 10% (32) of the study cohort requiring hospitalisation- a measure of illness severity. 108 healthcare workers were in contact with known probable cases, and 101 persons knowing the place of exposure. From the available data, 7 (26.4%) infected HCWs died of their COVID-19 infection, resulting in a case fatality ratio of 2.3%.

Table 1. Demographics and characteristics of COVID-19 amongst healthcare workers (n = 301)

VARIABLE	n (%)
SEX	
Male	149 (49.5)
Female	152 (50.5)
AGE	43 ± 11.7*
20–29	25 (8.3)
30–39	118 (39.2)
40–49	81 (26.9)
50–59	44 (14.6)
60–69	23 (7.6)
>70	10 (3.3)
CASE CLASS	
Symptomatic	187 (62.1)
Asymptomatic	114 (37.9)
ILLNESS SEVERITY (requiring hospitalization)	
Yes	32 (10.6)
No	269 (89.4)
CONTACT WITH PROBABLE CASE	
Yes	108 (35.9)
No	156 (51.8)
Non-response/Incomplete data	37 (12.3)
KNOWLEDGE OF SUSPECTED EXPOSURE	
Yes	101 (33.6)
No	157 (52.3)
Non-response/Incomplete data	47 (15.7)
EXPOSURE	
Church	12 (4)
Home	12 (4)
Social event	26 (8.7)
Workplace	51 (17)
OUTCOME	
Recovered	294 (97.7)
Dead	7 (2.3)

*Mean ± S.D, Case fatality ratio, CFR = 2.33%

Table 2 shows a subgroup analysis conducted on the health professionals infected – doctors (71.7%), nurses (27.3%), others (1%); and teaching hospitals by ownership: public (78.6%), private (21.4%). The distribution of healthcare workers by the World Health Organization classification[8] and health facilities is located in figure 1 and 2, respectively.

Table 2. Subgroup analysis

Health professionals	**240 (100)**
Doctors	172 (71.7)
Nurses	63 (26.3)
Hospitals by ownership	**276 (100)**
Public	217 (78.6)
Private	59 (21.4)

Predictors of illness severity and mortality amongst healthcare workers

The outcome proportion by risk factors is reported in Table 3. In both outcome analysis, age was categorised for univariate analysis.

Table 3. Outcome proportion by risk factors

Variables, n (%)	**Illness severity (n=32)**	**mortality (n=7)**
Age		
20–29	2 (6.3)	0 (0)
30–39	9 (28.1)	1 (14.3)
40–49	13 (40.6)	0 (0)
50–59	4 (12.5)	2 (28.6)
60–69	3 (9.4)	3 (42.9)
>70	1 (3.1)	1 (14.3)
Sex		
Male	16 (50)	6 (85.7)
Female	16 (50)	1 (14.3)
Case class		
Symptomatic	30 (93.8)	5 (71.4)
Asymptomatic	2 (6.3)	2 (28.6)
Illness severity		
Yes	-	1 (14.3)
No	-	6 (85.7)

The effects of age, sex, and case class on illness severity were evaluated using both univariate and multivariate logistic regression (Table 4). Symptomatic cases were more likely to advance to severe illness ($\chi^2_{(1)} = 15.219$, $\alpha = < 0.0001$; aOR, 95% CI = 10.658, 2.494 – 45.552). The overall model was statistically significant ($\chi^2_{(8)} = 19.112$, $\alpha < 0.0001$) and explained 12.5% (Nagelkerke R^2) of the variance in illness severity and correctly classified 89.4% of cases.

Table 4. Risk factors for COVID-19 illness severity among healthcare workers (n = 301)

Variables	Univariate analysis		Multivariate analysis		
	χ^2	p-value	aOR	95% CI	p-value
Age	4.033	0.519	0.98	0.455 – 2.111	0.959
Sex[a]	0.004	0.952	1.003	0.971 – 1.036	0.859
Case class[b]	15.219	<0.0001	10.658	2.494 – 45.552	0.001

Classification table –89.4% correctly classified, constant = -4.139

AOR – Adjusted Odds Ratio; 95% CI –95% Confidence intervals.
[a]Ref group – female
[b]Ref group – Asymptomatic

Predictors of mortality assessed included age, sex, case class and illness severity (Table 5). The logistic regression model was statistically significant, $\chi^{2,}{}_{(9)} = 16.965,\ \alpha = 0.049$. The model explained 27.6% (Nagelkerke R^2) of the variance in mortality and correctly classified 97.7% of cases. Age ($\chi^2{}_{(5)} = 13.7,\ \alpha = 0.003$; aOR, 95% CI = 1.079, 1.02–1.141 per year increase) was identified as a risk factor for mortality among healthcare workers with COVID-19 patients.

Table 5. Risk factors for COVID-19 mortality amongst healthcare workers (n = 301)

Variables	Univariate analysis		Multivariate analysis		
	χ^2	p-value	aOR	95% CI	p-value
Age	13.7	0.003	1.079	1.02 – 1.141	0.008
Sex[a]	3.76	0.065	4.274	0.486 - 37.582	0.190
Case class[b]	0.264	0.713	1.166	0.198 - 6.869	0.865
Illness severity[c]	0.101	0.549	1.305	0.130 - 13.123	0.821

Classification table –97.7% correctly classified, constant = -8.630

AOR – Adjusted Odds Ratio; 95% CI –95% Confidence intervals.
[a]Ref group – female
[b]Ref group – Asymptomatic
[c]Ref group – No

DISCUSSION

Using a comprehensive data on COVID-19 infections in healthcare workers in Rivers State Nigeria, this study showed a higher mortality of 2.3% in the study cohort compared to available evidence of 0.3%[10]. The difference in mortality is perhaps attributable to the geographical location of studies conducted. Studies on COVID-19 related mortality have mostly been conducted in developed countries (China, Italy, and USA), which showed lower mortality compared to the current study conducted in Nigeria, a developing country. Some of the known predictors of mortality amongst COVID-19 patients were also evaluated. COVID-19 infections that required hospitalisation was the measure of illness severity. Ten per cent of the study cohort experienced severe illness. The result agrees with available evidence from a meta-analysis that reported a 9.9% incidence of severe disease in healthcare workers [10].

In the evaluation of risk factors associated with COVID-19 severity and mortality, age and gender were significantly associated with COVID-19 mortality in healthcare workers. Age is a crucial risk factor in the epidemiology of COVID-19; prior research revealed patients above 65 years are at a greater risk of both disease severity and mortality from infection with COVID-19 [11 12]. Consistent with research findings, mortality was higher in male patients in our study [13 14]; although no significant association was deduced in the cohort evaluated. Also, infection amongst HCWs was typically asymptomatic with 89.4% not requiring hospitalisation; therefore, similar to conclusions from one study that observed less severe manifestations of COVID-19 infection in medical professionals [15].

Our results showed significance between symptomatic cases and illness severity; however, more research is required to determine whether these findings are attributable to the healthy worker bias.

HCWs are the most important human resource for hospitals; the workplace-related mortality in HCWs not only compromise the workforce in healthcare settings but also affects the mental health of colleagues [16 17]. A case fatality ratio (CFR) of 2.33% though comparable with global statistics for healthcare workers [5] is higher than both the CFR of the study area –Rivers state (0.98%) and Nigeria (1.23%) [18]. There is a need for re-evaluation of compliance to the COVID-19 response protocol, the adequacy of personal protective equipment and working conditions in place for healthcare workers in Rivers state. Likewise, consideration must be given to the health-seeking behaviour of the healthcare workers in Nigeria and poor reporting of COVID-19 infection cases within this cohort. There is evidence that the practise of self-medication and reluctancy to obtain medical care is high among doctors and nurses in Nigeria [19-23]. This behavourial pattern emphasises the need for more awareness and education on these issues within this group of healthcare professionals.

To our knowledge, this research is the foremost study representing a relatively comprehensive analysis of COVID-19 related mortality and disease severity in healthcare workers from available state records in Rivers state. Some of the limitations of this study include the reliance on reported infections and deaths, hence it's impossible to estimate how many cases were missed by non-reporting. It was not feasible to have a control or comparison arm of unexposed healthcare workers due to the nature of the disease; and also the use of electronic health records data for population health studies is still emergent in this region, therefore prior data of such information is not available. As an evolving research area in the current pandemic, there are other factors worth considering. For example, the effect of time of hospitalisation on disease severity and mortality. As a secondary analysis, we were unable to analyse this variable. Future studies to investigate this variable is essential.

CONCLUSION

In conclusion, frontline healthcare workers are at an increased risk of exposure to COVID-19 infections. In Nigeria, there is the possibility of a higher risk of experiencing a severe disease if symptomatic while infected. It is imperative that preventive strategies, proper education, and awareness are put in place to protect healthcare workers.

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CONFLICT OF INTEREST

The authors have declared no competing interest –financial or personal that could have influenced the work reported in this paper.

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PATIENT CONSENT FOR PUBLICATION

Not required.

DATA AVAILABILITY STATEMENT

According to the Data Protection Law of the Federal Republic of Nigeria, the authors cannot publicly release the data accessed from the Rivers State Health Records Database. Data are available upon reasonable request with permission from the Rivers State Ministry of Health.

AUTHOR CONTRIBUTIONS

EEC: Conception, design of the work; data collection; data analysis and interpretation; first draft of manuscript; critical revisions of the article. PFA: Drafting the article; data collection, critical revisions of the article. IEO: Data analysis and interpretation; drafting the article; critical revisions of the article. OGC: Conception, design of the work; drafting the article; critical revisions of the article, supervision of work. All authors read and gave final approval of the manuscript version submitted for publication

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FIGURE LEGEND

Figure 1. The distribution of infected Healthcare workers by WHO classification[8]

Figure 2. The proportion of infected healthcare workers by place of work

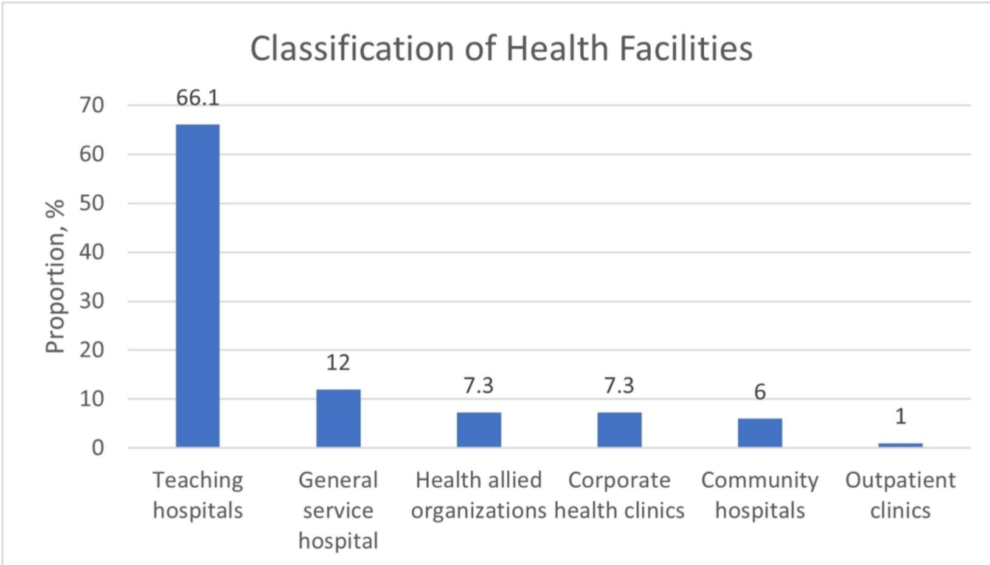

Figure 1. The distribution of infected Healthcare workers by WHO classification

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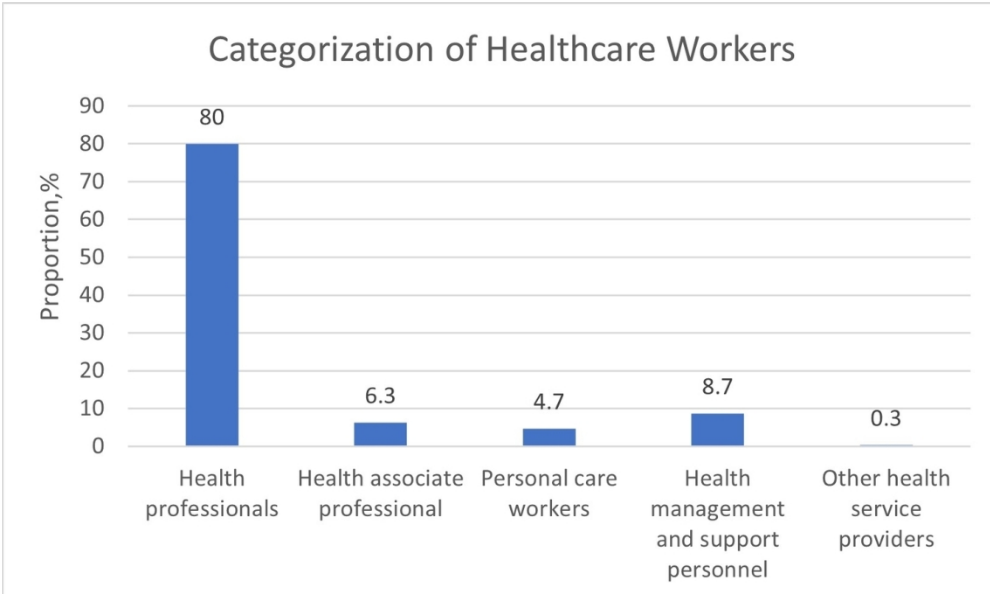

Figure 2. The proportion of infected healthcare workers by place of work

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	5-7
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	na
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than	6

		one group. Give information separately for for exposed and unexposed groups if applicable.	
Bias	#9	Describe any efforts to address potential sources of bias	na
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	
7			
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	7
Statistical methods	#12e	Describe any sensitivity analyses	
7			
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility,	8

		confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	
8			
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	
9-10			
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	
9-10			
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	
11-12			
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	11-12

		interval). Make clear which confounders were adjusted for and why they were included	
Main results	#16b	Report category boundaries when continuous variables were categorized	11-12
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
11-12			
Other analyses	#17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	#18	Summarise key results with reference to study objectives	8-11
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12
Generalisability	#21	Discuss the generalisability (external validity) of the study results	12-14
Other Information			

Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

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A retrospective study of COVID-19 outcomes amongst healthcare workers in Rivers State, Nigeria

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A retrospective study of COVID-19 outcomes amongst healthcare workers in Rivers State, Nigeria

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ABSTRACT

Objective: To determine the illness severity and mortality amongst Coronavirus (COVID-19) infected healthcare workers.

Design: A retrospective cohort study using population-level data. Secondary analysis was conducted on collated data from the Public Health Emergency Operations Centre (PHEOC) at the State Ministry of Health, Rivers State, Nigeria. Data were gathered from the COVID-19 patient database of the PHEOC on demographics, place of work, illness severity and outcome.

Participants: The cohort included all documented healthcare workers with confirmed COVID-19 infection (diagnosed by Polymerase Chain Reaction).

Primary and secondary outcome measures: Illness severity defined as 'hospitalisation required', and treatment outcome labelled as 'alive', or 'dead' were the outcomes of interest.

Results: The mean age was 43 years and 50.5% of the cohort were female. Of the 301 healthcare workers infected, 187 patients were symptomatic with 32 requiring hospitalisation. Seven infected HCWs died of their COVID-19 infection, resulting in a case fatality ratio of 2.3%. Population proportions for age groups, case presentation, and mortality, would be significantly greater than those seen in the study population. Health professionals made up 79.7% (240) of the study cohort, with 68.8% (165) of them working at the teaching hospitals; the association between healthcare workers and health facilities they worked in, was significant. Symptomatic cases were more inclined to progress to severe illness (${\chi^2}_{(1)} = 15.219$, $\alpha = < 0.0001$; aOR, 95% CI = 10.658, 2.494 – 45.552); patients also had greater odds of dying from COVID-19 (${\chi^2}_{(5)} = 13.7$, $\alpha = 0.003$; aOR, 95% CI = 1.079, 1.02–1.141) per year increase in age adjusted for sex, case class and illness severity.

Conclusions: Frontline healthcare workers are at an increased risk of exposure to COVID-19 infections. In Nigeria, there is a higher risk of experiencing severe illness if symptomatic while infected with COVID-19. Preventive strategies, proper education, and awareness must be put in place to protect healthcare workers. **Objective:** To determine the illness severity and mortality amongst Coronavirus (COVID-19) infected healthcare workers.

Keywords: Coronavirus, COVID-19, Healthcare workers, nosocomial infection, illness, severity, mortality

Strengths and Limitations of the Study

Strengths of the Study

- The use of population registry data enabled the representation of the population, giving a snapshot of the burden of COVID-19 on health workers in the study region.
- It also limited bias due to selection and recall

Limitations of the Study

- The use of secondary data also implied that some variables that would have better informed the study were not available
- The reliance on reported infections and deaths made it impossible to estimate how many cases were missed by non-reporting

INTRODUCTION

Healthcare workers (HCWs) have a higher risk of encountering infectious agents due to their work environments. With the COVID-19 pandemic, frontline HCWs face a higher risk of infection and mortality as well as being the drivers of community-level infection. Recent evidence shows that compared to individuals in the general community, frontline HCWs have a 12-fold risk of testing positive for COVID-19, with a higher risk observed for workers with inadequate access to personal protective equipment (PPE) [1]. In addition to increased exposure to COVID-19 in the pandemic, Wang et al. (2020)[2] found that poor sleep quality and higher working pressure can increase the risk of nosocomial SARS-CoV-2 infection amongst HCWs. Hence, it is possible to extrapolate these results to the Nigerian healthcare setting; the density of the health workforce (1.95 to 1,000 persons) in the country[3], in an addition to an estimated doctor-to-patient ratio of 1: 2753[4] is reportedly “still very low” to effectively deliver essential health services [3].

SARS-CoV-2 appears to have tropism for diverse tissues, this underscores the difficulty in predicting the severity of COVID-19. Nevertheless, factors, such as age, comorbidities, immune response, radiographic findings, laboratory markers, and indicators of organ dysfunction might predict worse outcomes independently or collectively [5]. It was suggested that age, gender, and the number of comorbidities, showed a good predictive ability of whether confirmed patients would develop severe disease [6], and evidence showed that advanced age, male sex, current smoking status, preexisting comorbidities (especially chronic kidney, respiratory, and cardio-cerebrovascular diseases) were important predictors associated with mortality [7,8].

The estimated mortality rate amongst HCWs attributed to COVID-19 has increased progressively [9]. In May 2020, the total number of reported HCW deaths from 67 countries was 1413. Consequently, it suggests that for every 100 HCWs that got infected, one died –the deaths were also 0.5% of the total number of 270,426 COVID-19 deaths worldwide [10]. Additionally, a survey of 37 countries estimated median death of 0.05 HCWs per 100,000 population. A report from the Pan American Health Organization (PAHO) in collaboration with the World Health Organization (WHO) stated that approximately 570,000 healthcare workers got infected with COVID-19 with above 2,500 dying from the virus across the American region alone [11]. The World Health Organization also estimated that between 80,000 and 180,000 healthcare workers died of COVID-19 in the period between January 2020 to May 2021, converging to a medium scenario of 115,500 deaths; although HCWs mortality in the African region was estimated at 2,003, it was also acknowledged that several uncertainties and limitations surrounded the measurement of the death toll of HCWs due to COVID-19[12].

A subnational study highlighting the burden of COVID-19 amongst healthcare workers is paramount to understanding the effect of the pandemic on the healthcare workforce in Nigeria. The study's aim was to determine the illness severity and mortality amongst COVID-19 infected healthcare workers in Rivers State, Nigeria.

METHOD

Study location

The study was conducted in Rivers State, located in the South-South geopolitical zone of Nigeria.

Study design and population

The study was a retrospective cohort study using existing population-level records data. The cohort included only healthcare workers with confirmed COVID-19 infection that were reported to the PHEOC. The healthcare workers were categorised using the World Health Organization and International Labour Organisation (ILO) International Standard Classification of Occupations (ISCO) [13]. There were five categories based on their roles in patient management and healthcare services:

- Health professionals –medical doctors, nurses, dentists, pharmacists, and health safety professionals.
- Health associate professional –all technologists and assistants in health professions, Community Health Workers.
- Personal care workers –health care and home-based care workers.
- Health management and support personnel –administrative and management staff, trade workers, social workers, and life science professionals.

- Other health service providers –armed forces staff, interns, and hospital volunteers.

Furthermore, the health facilities were classified based on services rendered. Hospital classification by services: Teaching hospitals –offering tertiary health services; General hospitals –offering secondary health services; Community hospitals –offering primary and community-based care; specialised outpatient clinics –rendering specialty outpatient services like dentistry, radiology, and diagnostic services; Corporate/Occupational health clinics –offering general and occupational health services, restricted to employees only; and Health allied organisations.

Data Source

Secondary data were collated from the COVID-19 case investigation form dataset at the Public Health Emergency Operations Centre (PHEOC) data centre, Rivers State Ministry of Health. The data sources included reports from public and private-owned health facilities, containment centres, offshore platforms, and other health-allied facilities. The duration of data extraction was from 24 March 2020 to 30 November 2021. The dataset characterised demographics, pre-existing comorbidities, symptoms, facility managed, patient status, treatment outcome, and dates of related events, without personal identifiers. Hence, this secondary analysis waived the required individual informed consent. Patient information was retrieved from the dataset based on the occupation of interest –healthcare worker and their respective designation—; alongside demographic data on age, sex, place of work defined as 'health facility', hospitalisation required', and case presentation, knowledge of exposure, place of exposure, and treatment outcome labelled as 'recovered', or 'dead'.

Based on the National Interim Guidelines for Clinical Management of COVID-19 (Nigeria Centre for Disease Control, 2020), all patients requiring hospitalisation at the time of testing were classified as severely ill, and it was the definition for illness severity; case presentation at the time of testing was also categorised as 'symptomatic' or 'asymptomatic'.

Data analysis

Data were analysed using Stata Statistical Software: Release 12[14]. Descriptive statistics were used to report on the cohort characteristics. Means and standard deviations were reported for continuous variables and proportions for categorical variables, qualitative responses, and subgroup analysis of variables. A test of proportions was conducted for both risk factors and outcome proportions. Univariate analysis of categorical variables was conducted using Chi-square (χ^2) –and Fischer's exact test where appropriate. A two-tailed p-value less than 0.05 was statistically significant. Multivariate logistic regression was used to evaluate risk factors of illness severity and mortality among healthcare workers with COVID-19. The adjusted odds ratio (aOR) with a 95% confidence interval (95% CI) was used to report the measure of association between the following: illness severity and risk factors –age, sex, and case presentation; mortality and risk factors –age, sex, illness severity and case presentation.

Patient and Public Involvement

It was not possible to involve patients or the public in the design, conduct, reporting, or dissemination plans of our research as the study utilised secondary data without personal identifiers.

RESULTS

Patient Characteristics

Data on 301 healthcare workers infected with COVID-19 were identified and extracted into a spreadsheet. The demographic and clinical characteristics of the patients are found in Table 1. The mean age was 43 years and 50.5% of the cohort were female. Of the 301 healthcare workers, 187 patients were symptomatic with 10% (32) of the study cohort requiring hospitalisation –a measure of illness severity. 108 healthcare workers were in contact with known probable cases, and 101 persons knew the place of exposure. From the available data, 7 (26.4%) infected HCWs died of their COVID-19 infection, resulting in a case fatality ratio of 2.3%. A test of proportion revealed a significant difference in proportions for age groups, case presentation, illness severity, and outcome. Statistics showed that population proportions for illness severity would be significantly lower than seen in the study population, while they would be significantly greater for age groups, case presentation, and mortality.

Table 1. Demographics and characteristics of COVID-19 amongst healthcare workers (n = 301)

Variable	n (%)	z-test (95% CI) p-value
SEX		
Male	149 (49.5)	-0.17 (-0.12 – 0.10)

Female	152 (50.5)	$H_a \neq 0$: 0.862
AGE	43 ± 11.7*	
20–29	25 (8.3)	
30–39	118 (39.2)	***7.61 (0.38 – 0.60) $H_a \neq 0$: 0.000; $H_a > 0$: 0.000
40–49	81 (26.9)	
50–59	44 (14.6)	
60–69	23 (7.6)	
>70	10 (3.3)	
****CASE PRESENTATION**		
Symptomatic	187 (62.1)	4.08 (0.13 – 0.35) $H_a \neq 0$: 0.000; $H_a > 0$: 0.000
Asymptomatic	114 (37.9)	
****ILLNESS SEVERITY (requiring hospitalization)**		
Yes	32 (10.6)	-10.75 (-0.90 – 0.68) $H_a \neq 0$: 0.000; $H_a < 0$: 0.000
No	269 (89.4)	
CONTACT WITH PROBABLE CASE		
Yes	108 (35.9)	
No	156 (51.8)	
Non-response/Incomplete data	37 (12.3)	
KNOWLEDGE OF SUSPECTED EXPOSURE		
Yes	101 (33.6)	
No	157 (52.3)	
Non-response/Incomplete data	47 (15.7)	
EXPOSURE		
Church	12 (4)	
Home	12 (4)	
Social event	26 (8.7)	
Workplace	51 (17)	
OUTCOME		
Recovered	294 (97.7)	9.94 (0.43 – 1.06) $H_a \neq 0$: 0.000; $H_a > 0$: 0.000
Dead	7 (2.3)	

*Mean ± S.D, Case fatality ratio, CFR = 2.33%
**at the time of testing
***Difference in proportion between 20-49 years and ≥50

The distribution of healthcare workers by the World Health Organization classification[13] and health facilities were cross-tabulated in Table 2 to determine association. Health professionals made up 79.7% (240) of the study cohort, with 68.8% (165) of them working at the teaching hospitals. The teaching hospitals are also the two major government own tertiary facilities in the State; health care workers in these facilities made up 66.1% (199) of the study population. A significant association was portrayed between healthcare workers and the health facilities they worked in.

Table 2. Contingency Table of Healthcare Workers by Health Facility

Healthcare Workers	Health Facility Classification, n (%)						
	Teaching Hospitals	General Service Hospitals	Health Allied Organisations	Corporate Health Clinics	Community Hospitals	Outpatient Clinics	Total
Health Professionals	165 (54.8)	32 (10.6)	9 (3.0)	17 (5.7)	15 (5.0)	2 (0.7)	**240 (79.7)**
Health Associate Professionals	11 (3.7)	0 (0.0)	3 (1.0)	3 (1.0)	1 (0.3)	1 (0.3)	**19 (6.3)**
Personal Care Workers	12 (4.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.7)	0 (0.0)	**14 (4.7)**
Health Mgt & Support Personnel	10 (3.3)	4 (1.3)	10 (3.3)	2 (0.7)	0 (0.0)	0 (0.0)	**26 (8.7)**
Other Health Service Providers	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	**1 (0.3)**
Missing Values	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	**1 (0.3)**
Total	**199 (66.1)**	**36 (12.0)**	**22 (7.3)**	**23 (7.6)**	**18 (6.0)**	**3 (1.0)**	**301 (100%)**

$\chi^2(25) = 72.9883$, $\alpha = 0.000$)

Table 3 is a cross-tabulation of healthcare workers by risk factors and outcomes. Health professionals aged 30-49 years were the most affected subgroup, making up 53.2% of the study population; they also made up 80.7% (151/187) of all symptomatic cases. All mortality cases were also health professionals. The association between healthcare workers and either risk factors, or outcomes were not significant.

Table 3. Contingency Table of Healthcare Workers by Risk Factors and Outcomes

Healthcare Workers	Risk Factors, n (%)										Outcomes, n (%)			
	Age						Sex		Symptomatic		Illness Severity		Mortality	
	20-29	30-39	40-49	50-59	60-69	>70	Female	Male	No	Yes	No	Yes	Alive	Dead
Health Professionals	21 (7.0)	99 (32.9)	61 (20.3)	33 (11.0)	18 (6.0)	8 (2.7)	125 (41.5)	115 (38.2)	89 (29.6)	151 (5[illegible].2)	215 (71.4)	25 (8.3)	233 (77.4)	7 (2.3)
Health Associate Professionals	1 (0.3)	10 (3.3)	5 (1.7)	2 (0.7)	1 (0.3)	0 (0.0)	6 (2.0)	13 (4.3)	7 (2.3)	12 (4.0)	17 (5.7)	2 (0.7)	19 (6.3)	0 (0.0)
Personal Care Workers	1 (0.3)	2 (0.7)	5 (1.7)	2 (0.7)	3 (1.0)	1 (0.3)	9 (3.0)	5 (1.7)	4 (1.3)	10 (3.3)	13(4.3)	1 (0.3)	14 (4.7)	0 (0.0)
Health Mgt & Support Personnel	2 (0.7)	7 (2.3)	9 (3.0)	7 (2.3)	0 (0.0)	1 (0.3)	11 (3.7)	15 (5.0)	13 (4.3)	13 (4.3)	23 (7.6)	3 (1.0)	26 (8.7)	0 (0.0)
Other Health Service Providers	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	1 (0.3)	1 (0.3)	0 (0.0)
***Missing Value**	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)	1 (0.3)	0 (0.0)
Total	**25 (8.3)**	**118 (39.2)**	**81 (26.9)**	**44 (14.6)**	**23 (7.6)**	**10 (3.0)**	**152 (50.5)**	**149 (49.5)**	**114 (37.9)**	**187 (62.[illegible])**	**269 (89.4)**	**32 (10.6)**	**294 (97.7)**	**7 (2.3)**
χ^2	$\chi^2(20) = 27.8331$						$\chi^2(4) = 5.7015$		$\chi^2(4) = 2.8[illegible]23$		$\chi^2(4) = 8.5943$		$\chi^2(4) = 1.7918$	
α	**0.113**						**0.223**		**0.5888**		**0.072**		**0.774**	
Fisher's exact							**0.204**		**0.636**		**0.264**		**1.000**	

***Not included in analysis**

The cross-tabulation of health facilities by risk factors and outcomes showed that health workers aged 30-49 years were also the most dominant in the teaching hospitals, and they made up 44.2% of the total healthcare workers. The majority of symptomatic patients – 73.2%, persons who required hospitalisation at testing –87.5%, and six out of the seven mortality cases were also staff of the teaching hospitals. Age and case presentation were significantly associated with the health facilities and are shown in Table 4.

Table 4. Contingency Table of Healthcare Facilities by Risk Factors and Outcomes

Health Facility	Risk Factors, n (%)										Outcomes, n (%)			
	Age						Sex		Symptomatic		Illness Severity		Mortality	
	20-29	**30-39**	**40-49**	**50-59**	**60-69**	**>70**	**Female**	**Male**	**No**	**Yes**	**No**	**Yes**	**Alive**	**Dead**
Teaching Hospitals	14 (4.7)	79 (26.3)	54 (17.9)	34 (11.3)	14 (4.7)	4 (1.3)	101 (33.6)	98 (32.6)	62 (20.6)	137 (45.5)	171 (56.8)	28 (9.3)	193 (64.1)	6 (2.0)
General Service Hospitals	7 (2.3)	9 (3.0)	10 (3.3)	4 (1.3)	4 (1.3)	2 (0.7)	21 (7.0)	15 (5.0)	20 (6.6)	16 (5.3)	32 (10.6)	4 (1.3)	35 (11.6)	1 (0.3)
Health Allied Organisations	1 (0.3)	8 (2.7)	3 (1.0)	6 (2.0)	2 (0.7)	2 (0.7)	7 (2.3)	15 (5.0)	11 (3.7)	11 (3.7)	22 (7.3)	0 (0.0)	22 (7.3)	0 (0.0)
Corporate Health Clinics	2 (0.7)	13 (4.3)	7 (2.3)	0 (0.0)	1 (0.3)	0 (0.0)	8 (2.7)	15 (5.0)	14 (4.7)	9 (3.0)	23 (7.6)	0 (0.0)	23 (7.6)	0 (0.0)
Community Hospitals	1 (0.3)	6 (2.0)	7 (2.3)	0 (0.0)	2 (0.7)	2 (0.7)	13 (4.3)	5 (1.7)	6 (2.0)	12 (4.0)	18 (6.0)	0 (0.0)	18 (6.0)	0 (0.0)
Outpatient Clinics	0 (0.0)	3 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.7)	1 (0.3)	1 (0.3)	2 (0.7)	3 (1.0)	0 (0.0)	3 (1.0)	0 (0.0)
Total	**25 (8.3)**	**118 (39.2)**	**81 (26.9)**	**44 (14.6)**	**23 (7.6)**	**10 (3.0)**	**152 (50.5)**	**149 (49.5)**	**114 (37.9)**	**187 (62.1)**	**269 (89.4)**	**32 (10.6)**	**294 (97.7)**	**7 (2.3)**
χ^2	$\chi^2(30) = 37.7053$						$\chi^2(5) = 9.9447$		$\chi^2(5) = 15.3283$		$\chi^2(5) = 10.3373$		$\chi^2(5) = 2.0203$	
α	**0.049**						**0.077**		**0.009**		**0.066**		**0.846**	
Fisher's exact							**0.067**		**0.007**		**0.068**		**1.000**	

Table 5 shows a subgroup analysis conducted on the health professionals infected –doctors (71.7%), nurses (27.3%), others (1%); and teaching hospitals by ownership: public (78.6%), private (21.4%).

Table 5. Subgroup analysis

Health professionals	**240 (100)**
Doctors	172 (71.7)
Nurses	63 (26.3)
Hospitals by ownership	**276 (100)**
Public	217 (78.6)
Private	59 (21.4)

Predictors of illness severity and mortality amongst healthcare workers

The outcome proportions by risk factors were reported in both Table 6 and Table 7. The effects of age, sex, and case class on illness severity were evaluated using both univariate (Table 6) and multivariate logistic regression (Table 7) respectively. Symptomatic cases were more likely to advance to severe illness ($\chi^2(1) = 15.219$, $\alpha = < 0.0001$; aOR, 95% CI = 10.658, 2.494 – 45.552). The overall model was statistically significant ($\chi^2(8) = 19.112$, $\alpha < 0.0001$); it explained 12.5% (Nagelkerke R^2) of the variance in illness severity, and correctly classified 89.4% of cases.

Table 6. Contingency Table of Outcomes by Risk Factors

Outcome	**Risk Factors, n (%)**											
	Age						**Sex**		**Symptomatic**		**Illness Severity**	
	20-29	**30-39**	**40-49**	**50-59**	**60-69**	**>70**	**Female**	**Male**	**No**	**Yes**	**No**	**Yes**
Illness Severity, n=32	3 (9.4)	13 (40.6)	4 (12.5)	6 (18.8)	5 (15.6)	1 (3.1)	16 (50)	16 (50)	2 (6.3)	30 (93.8)	-	-
χ^2	$\chi^2(5) = 6.2195$						$\chi^2(1) = 0.0036$		$\chi^2(1) = 15.2187$		-	
α	0.285						0.952		0.000		-	
Fisher's exact	0.199						1.000		0.000		-	
Mortality, n=7	0 (0.0)	1 (14.3)	0 (0.0)	2 (28.6)	3 (42.9)	1 (14.3)	1 (14.3)	6 (85.7)	2 (28.6)	5 (71.4)	6 (85.7)	1 (14.3)
χ^2	$\chi^2(1) = 19.240$						$\chi^2(1) = 3.7596$		$\chi^2(1) = 0.2636$		$\chi^2(1) = 0.1007$	
α	0.002						0.053		0.608		0.751	
Fisher's exact	0.003						0.065		0.713		0.549	

Predictors of mortality assessed included age, sex, case class and illness severity. The logistic regression model was statistically significant, $\chi^2(9) = 16.965$, $\alpha = 0.049$. The model explained 27.6% (Nagelkerke R^2) of the variance in mortality and correctly classified 97.7% of cases. Age ($\chi^2(1) = 19.24$, $\alpha = 0.002$; aOR, 95% CI = 1.079, 1.02–1.141 per year increase) was identified as a risk factor for mortality among healthcare workers with COVID-19 patients.

Table 7. Multivariate Analysis of Risk factors for COVID-19 Outcomes

Outcome	Risk Factors	aOR	95% CI	p-value
Illness Severity	**Age**	0.98	0.455 – 2.111	0.959
	Sex[a]	1.003	0.971 – 1.036	0.859
	Case class[b]	10.658	2.494 – 45.552	0.001
Classification table –89.4% correctly classified, constant = -4.139				
Mortality	**Age**	1.079	1.02–1.141	0.008
	Sex[a]	4.274	0.486 - 37.582	0.190
	Case class[b]	1.166	0.198 - 6.869	0.865
	Illness severity[c]	1.305	0.130 - 13.123	0.821

DISCUSSION

Using comprehensive data on COVID-19 infections in healthcare workers in Rivers State Nigeria, this study showed a mortality proportion of 2.3% in the study cohort of 301 participants. Health professionals and HCWs in the teaching hospitals made up a majority of the study population, and HCWs between 30-49 years were the most affected. It was also noted that the most probable source of infection was the workplace, followed by a social event. Ten per cent of the study cohort experienced severe illness, the result agrees with available evidence from a meta-analysis that reported a 9.9% incidence of severe disease in healthcare workers [15]. Age and gender are predictors with established association with COVID-19 mortality. Age is a crucial risk factor in the epidemiology of COVID-19; our study found an association between age and mortality; prior studies revealed patients above 65 years are at a greater risk of both disease severity and mortality from infection with SARS-CoV2 [16 17]. Consistent with research findings, mortality was higher in male patients in our study[18 19]; although no significant association was deduced in the cohort evaluated. Also, infection amongst HCWs was typically asymptomatic at the time of testing, with 89.4% not requiring hospitalisation, this might be due to the active tracing and testing of contacts of positive cases in the State; however, more research is required to determine whether these findings are attributable to the healthy worker bias. The results were similar to conclusions from a study that observed less severe manifestations of COVID-19 infection in medical professionals [20]. Our results also showed a significant association between symptomatic cases and illness severity; prior evidence found an association between prolonged SARS-CoV-2 RNA shedding and the interval between illness onset and treatment [21], and may be indicative of a high viral load in these persons.

The proportion of mortality in the study cohort was higher, compared to available evidence of 0.5%[22]. The difference in mortality is perhaps attributable to the geographical location of studies conducted and may be suggestive of better working conditions and workforce. Studies on COVID-19-related mortality have mostly been conducted in developed regions (Asia, Europe, and the USA), and showed lower mortality compared to the current study conducted in Nigeria developing country. Health Professionals being the most infected subgroup aligns with various evidence[12], as they are mostly involved in patient-facing roles. A difference in our study though was most infections were seen in doctors as against nurses in other studies; the doctors were the front line responders for COVID-19 response in the State, and that may be the reason for this observation. Other plausible explanations are that all exposures were not in the workplace, and there was an indication that HCWs were infected to a greater extent in the community than in the workplace [23]; thoughts are also to be given to the adherence to infection prevention and control (IPC) protocol among the healthcare workers, and their willingness to work during the COVID-19 pandemic [24 25].

A random selection of studies using healthcare workers as study participants conducted in the study region depicts a workforce majorly aged under 50[26-29]; although no association can be inferred, it is suggestive of a mostly younger age distribution of healthcare workers and was indicated in our results. Also indicated, were persons aged above 70, still in service. Although the constitutional retirement age ranges between 60–70 years from civil service depending on the profession (70 years for the medical professional), the Civil Service Commission offers contract appointments to pensioners. Due to several challenges, evidence showed that Nigerians generally have a poor attitude towards retirement; with a preference to continue working privately in some capacity, after retirement from the civil service[30-32].

The use of routinely collected data is beneficial in this scenario as the data was readily available and could be representative of the study population, following the integrated testing and reporting approach used in data collection. The completeness of the data also minimises the effects of selection bias due to non-response and loss to follow-up. The independent mode of prospective data collection reduces recall bias on exposure[33]. This study gives a snapshot into the impact of COVID-19 on the healthcare workforce of Rivers State and serves as a model for a more holistic research.

The existent significant challenge in giving an accurate report on deaths due to COVID-19, let alone those among HCWs for several reasons, was acknowledged by the World Health Organisation[12]. As applicable to our setting, reports were for deaths with a confirmed COVID-19 test; hence, untested individuals and persons who died outside a hospital facility would not have been included in the death counts. The reliance on reported infections and deaths implies that there is a probability of missing unreported cases and mild cases of COVID-19. Some reasons for non-reporting may include: the fear of stigmatisation from colleagues [34], and poor health-seeking behaviour among this cohort –the practice of self-medication and reluctance to obtain medical care [35 36]. The health-seeking behaviour of the healthcare workers in Nigeria and poor reporting of COVID-19 infection cases within this cohort is to be considered. There is evidence that the practice of self-medication and reluctance to obtain medical care is high among doctors and nurses in Nigeria [35-39]; therein lies the possibility of non-reporting of mild cases. This behavourial pattern emphasises the need for more awareness and education on these issues within this group of healthcare professionals. These are limitations to this study. The viral load of SARS-CoV-2 and co-morbidities are useful markers for assessing disease severity and prognosis[21]; the availability of information on these variables would have better informed the study. Data on the interval between illness onset and treatment onset would have given a more concise inference of disease severity also.

HCWs are the most important human resource for hospitals; the workplace-related mortality in HCWs not only compromises the workforce in healthcare settings but also affects the mental health of colleagues [40 41]. A case fatality ratio (CFR) of 2.33% though comparable with global statistics for healthcare workers [10] is higher than both the CFR of the study area –Rivers state (0.98%) and Nigeria (1.23%) [42]. There is a need for re-evaluation of compliance to the COVID-19 IPC protocol, the adequacy of personal protective equipment and working conditions in place for healthcare workers in Rivers state; because, exposure to numerous infected individuals, may demonstrate that HCWs, if infected, could be characterized by higher viral load, thereby, associated with worse clinical outcomes[21]. The results from the study also further emphasise the need to protect healthcare workers; ensure they are knowledgeable in both infection prevention and control, and that the healthcare space is safe against nosocomial infections. The density of HCWs in the state and country at large is also a point of concern; although it is estimated that 74,543 doctors and 301,579 nurses are registered in Nigeria, the Medical and Dental Council Of Nigeria stated that only about 59% of the doctors and 35% of nurses are in active service. Nigeria has also suffered a mass exodus of healthcare workers over the years; in 2020 during the height of COVID-19, it was reported that 7,256 Nigerian nurses migrated from Nigeria[43-45]. Better working conditions for health workers need to be advocated, to regulate the export of human capital.

To our knowledge, this research is the foremost study representing a relatively comprehensive analysis of COVID-19-related mortality and disease severity in healthcare workers from available state records in Rivers State. As an emerging research area in the current pandemic, there are other factors worth considering. For example, the effect of time of hospitalisation on disease severity and mortality, and viral load count. As a secondary analysis, we were unable to analyse this variable. Future studies to investigate this variable is essential. The impact of nosocomial versus community transmission is also a vital area of research. A national study is required to extrapolate the findings from this study to the nation, as surveillance of the impact of COVID-19 by occupation and industry will benefit not only HCWs but all workers in the nation.

CONCLUSION

In conclusion, frontline healthcare workers are at an increased risk of exposure to COVID-19 infections. In Nigeria, there is the possibility of a higher risk of experiencing a severe disease if symptomatic while infected. It is imperative that preventive strategies are established and implemented, alongside proper education, and awareness to protect healthcare workers.

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CONFLICT OF INTEREST

The authors have declared no competing interest –financial or personal that could have influenced the work reported in this paper.

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DATA AVAILABILITY STATEMENT

According to the Data Protection Law of the Federal Republic of Nigeria, the authors cannot publicly release the data accessed from the Rivers State Health Records Database.

Data are available upon reasonable request with permission from the Rivers State Ministry of Health.

AUTHORS' CONTRIBUTIONS

EEC: Conception, design of the work; data collection; data analysis and interpretation; first draft of the manuscript; critical revisions of the article. PFA: Drafting the article; data collection, critical revisions of the article. IEO: Data analysis and interpretation; drafting the article; critical revisions of the article. OGC: Conception, design of the work; drafting the article; critical revisions of the article, supervision of work. All authors read and gave final approval of the manuscript version submitted for publication

ETHICS APPROVAL

This study was conducted according to the guidelines of the Declaration of Helsinki. The Ethics Committee of the Rivers State Ministry of Health approved this work –Ethics ID: MH/PRS/391/VOL.2/809.

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Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1

Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	#4	Present key elements of study design early in the paper	5
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	5-7
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	na
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than	6

		one group. Give information separately for for exposed and unexposed groups if applicable.	
Bias	#9	Describe any efforts to address potential sources of bias	na
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	
7			
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	7
Statistical methods	#12e	Describe any sensitivity analyses	
7			
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility,	8

		confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	8
Participants	#13c	Consider use of a flow diagram	
8			
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	
9-10			
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	
9-10			
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	
11-12			
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	11-12

		interval). Make clear which confounders were adjusted for and why they were included	
Main results	#16b	Report category boundaries when continuous variables were categorized	11-12
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
11-12			
Other analyses	#17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	#18	Summarise key results with reference to study objectives	8-11
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	12
Generalisability	#21	Discuss the generalisability (external validity) of the study results	12-14
Other Information			

Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15