World Journal of AIDS, 2023, 13, 28-46
https://www.scirp.org/journal/wja
ISSN Online: 2160-8822
ISSN Print: 2160-8814

Prevalence and Associated Risk Factors of COVID-19 in an Incarcerated Population Burdened with HIV Infections in Port Harcourt

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How to cite this paper: Mike-Ogburia, M.I., Dio, A., Nwogu, V.C., Vito-Peter, B., Hart, G.M., Ideozu, N.O., Albert, O.C., Mike-Ogburia, M.N., Obunwo, C.O., Okoro, O.C., Ogbakiri, P.A., Angala, P.O., Jumbo, U.K. and Mike-Ogburia, A.C. (2023) Prevalence and Associated Risk Factors of COVID-19 in an Incarcerated Population Burdened with HIV Infections in Port Harcourt. *World Journal of AIDS*, **13**, 28-46.
https://doi.org/10.4236/wja.2023.132004

Received: March 21, 2023
Accepted: May 12, 2023
Published: May 15, 2023

Abstract

Background: The burden of COVID-19 and human immunodeficiency virus (HIV) are some of the major and persistent global health challenges of the twenty-first century. HIV and COVID-19 are expected to overlap in high HIV-burden countries, posing several public health challenges as a result. Prisons are overcrowded, have limited space for social distancing and have inadequate ventilation systems, making it difficult to contain the spread of COVID-19 in addition to the high-risk behaviours of inmates which contribute to the spread of HIV within these facilities. This study aimed to determine the prevalence of COVID-19 among inmates in a prison facility with a relatively high HIV burden in Port Harcourt, Nigeria; investigating potential risk factors and co-infection with HIV. **Methodology**: The study employed a descriptive cross-sectional study design sampling 200 inmates from the Port Harcourt Maximum Security Custodial Centre from July to December 2022. A well-structured questionnaire was administered via interviews in addition to screening for HIV-1/2 antibodies as well as COVID-19 antigens using rapid diagnostic test kits. Descriptive statistics and chi-square were carried out on the GraphPad Prism 9 software with statistical significance defined as a

p-value of less than 0.05 at a 95% confidence interval. **Result**: The prevalence of HIV from the current study was 6.5%, COVID-19 prevalence was reported to be 12.5% while HIV/COVID-19 co-infection was 1.5% The duration of incarceration, face mask use, frequent visitations and vaccination against COVID-19 were found to be significantly associated with the prevalence of COVID-19 in the studied population ($p < 0.05$). **Conclusion**: The current study reports a relatively high prevalence of HIV and COVID-19 among the inmates in the study area. It becomes expedient for the administrators of the correctional facility to properly screen new inmates for COVID-19, quarantine and manage cases, as well as provide them with personal protective equipment such as face masks. In-person visitation should be balanced with measures to prevent the spread of the infection, and mass vaccination campaigns should be promoted. Improving access to HIV screening and therapy for all prisoners should be prioritised to identify and manage the incidence of HIV early, reducing the risk of transmission, mitigating comorbidities and improving health outcomes.

Keywords

HIV, SARS-CoV-2, COVID-19, Prevalence, Incarceration, Prison, Risk Factors

1. Introduction

The burden of COVID-19 and human immunodeficiency virus (HIV) is one of the major and persistent global health challenges of the twenty-first century. HIV and COVID-19 are expected to overlap in high HIV burden countries. The intersecting coronavirus and HIV epidemics in countries with a high burden of HIV infections pose several public health challenges. Worldwide, 37.9 million people are living with HIV and 1.7 million people became newly infected with HIV at the end of 2018 [1]. While COVID-19 continues to spread across the world, many areas face the risk of infection with SARS-CoV-2 and the obstacles and challenges to sustaining the continuum of HIV treatment in high-burden HIV countries are increasing [2]. The intersecting coronavirus and HIV epidemics in sub-Saharan African countries where HIV has the highest prevalence and incidence pose many challenges from the point of view of COVID-19 diagnostics, COVID-19/HIV clinical management and post-COVID-19 epidemic. In fact, the pathogenicity of COVID-19 could be accelerated in people living with HIV who have compromised immunity [3]. Studies have found that people with chronic health conditions, such as HIV, may be at greater risk of contracting or experiencing complications from COVID-19 [4] though the data on the association of HIV infection with adverse outcomes in patients with COVID-19 are conflicting [5]. Furthermore, research has shown that new HIV and COVID-19 infections moderately and significantly intersect [6]. Studies have found that people with HIV are at an increased risk of severe and critical COVID-19 ma-

nifestations as well as a higher risk of mortality when compared to HIV-negative individuals [5]. Additionally, people with HIV contend with a heightened risk of cerebrovascular injury due to chronic systemic immune activation and inflammation [7], which could compound the severity of COVID-19 infection. Finally, research has suggested that prior T-cell depletion induced by HIV infection may carry deleterious consequences in the current COVID-19 pandemic [8].

The estimated number of people locked up in prisons throughout the world is 10.7 million, an increase of about 24.3% since the start of the millennium [9]. Sedentary lifestyles, poor diets, inadequate hygiene practices, and drug use all contribute to the development of infectious illnesses among inmates, while the already unstable living conditions in prisons further exacerbate these problems [10]. Reckless drug use, syringe sharing, unsafe sexual behaviour, tattooing, and piercing are all behaviours that can rapidly and severely spread infection in correctional facilities [11] [12].

Overcrowding, inadequate facilities, and restricted access to healthcare services all contribute to the transmission of diseases within the Nigerian prison system, which is already struggling to accommodate an estimated 68,000 inmates [13]. Since Nigeria has more than 148 prisons, it is not uncommon for inmates to be held in overcrowded conditions [14]. Port Harcourt Prison, which is well over a century old, was built to accommodate 804 inmates. Today, however, it is home to as many as 5000 inmates, including adults and minors of both genders, with approximately 3700 awaiting trial [15].

In the context of the COVID-19 pandemic, jails and prisons are at high risk for outbreaks due to hazardous environmental conditions that amplify the risks of exposure for both incarcerated individuals and prison staff [16]. The challenge of social distancing in prisons and jails is compounded by overcrowding and clinical vulnerability, making prisoners particularly vulnerable to severe infection and death from COVID-19 [17]. There is limited data available on the prevalence of COVID-19 among Nigerian prisoners [18]. However, it is known that the prison population in Nigeria is largely composed of pre-trial detainees (72%) [18] and that prisons in Africa have been particularly vulnerable to the spread of COVID-19 due to overcrowding and lack of resources [19]. Nigeria, just like some other African countries like Morocco, Ethiopia, and Algeria have experienced a significantly higher increase in the prison population compared to other African countries [20], suggesting that these countries may be more at risk for a high prevalence of COVID-19 among their prison populations.

Given the aforementioned, the study aimed to determine the prevalence of COVID-19 among inmates in a prison facility with a relatively high HIV burden in Port Harcourt, Nigeria; investigating potential risk factors and co-infection with HIV.

2. Materials and Methods

2.1. Study Design

The research was carried out using a cross-sectional design with multi-stage sam-

pling from July to December 2022. Before any additional stratification, prisoners were separated into male and female groups. Males were assigned random numbers for systematic random sampling, whereas females who were much fewer relative to the males were chosen from all qualified candidates. The sample interval was set at 5 and the starting number was chosen at random.

2.2. Study Area

The study was carried out at the Port Harcourt Maximum Security Custodial Centre which is located in the Port Harcourt City Council Area of Rivers State, Nigeria (**Figure 1**). Throughout the research period, the number of inmates fluctuated around 4000 as new inmates were brought in or released. Approximately 109 square kilometres of land comprise the entire area. This facility accommodates inmates with diverse criminal histories, including those awaiting trial, those convicted, and those sentenced to death [21]. It is a prison facility intended for both male and female convicts, with approximately 85% of the facility designated for male inmates and 15% for female inmates [22].

2.3. Study Population and Sample Size Determination

The study population were incarcerated individuals in the Port Harcourt Maximum Security Custodial Centre, Port Harcourt. These groups of individuals are faced with many challenges, including overcrowding, poor conditions, and limited access to healthcare services, which can contribute to the spread of disease. The sample size was calculated based on the expected prevalence of HIV infection among inmates in the Port Harcourt Maximum-Security Custodial Centre reported by Jeremiah *et al.* (2021) [23] which revealed a prevalence of 3.9% as follows.

Using the formula by Naing *et al.* (2006) [24]

$$n = \frac{z^2 pq}{d^2} \quad (1)$$

where

n = minimum sample size;

Z = standard deviation corresponding to 95% confidence level set at 1.96;

p = proportion = 3.9% = 0.039;

$q = 1 - p = 0.961$;

d = desired precision, 5% (0.05).

Therefore,

$$n = \frac{1.96^2 \left(0.039 \times 0.961\right)}{0.05^2} = 57.3 = 58$$

The sample size was however increased to 200 subjects to account for anticipated drop-out or missing data while carrying out the study in addition to increasing the power of the study. Hence two hundred (200) inmates were enrolled in this study.

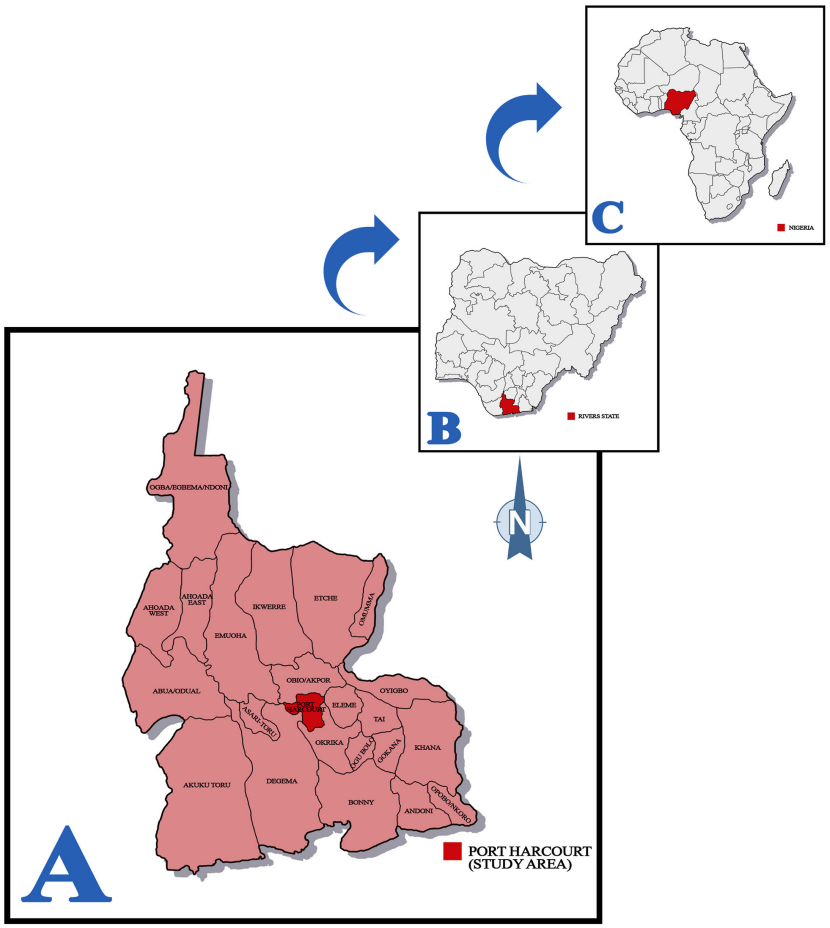

Figure 1. A: map of rivers state highlighting Port Harcourt (study area); B: map of Nigeria highlighting rivers state; C: map of Africa highlighting Nigeria.

2.4. Inclusion and Exclusion Criteria

Inmates who provided informed consent were recruited, while those who were not present at the time of data collection or who refused consent were excluded.

2.5. Data Collection

In assessing sociodemographic information and risk factors for COVID-19 infection, subjects were interviewed and administered a structured questionnaire. The questionnaire which was both open and close-ended was designed by the authors and subsequently subjected to face and content validity. The questionnaire had two sections which were sociodemographic information and risk factors with a total of 13 items. The age, sex, marital status, level of education, occupation, religion, previous incarceration and duration of current incarceration were assessed in the first section while the second section of the questionnaire assessed face mask use, frequent handwashing practice, frequent visitations, vaccination against COVID-19 and number inmates in a cell.

Names were omitted from the questionnaire, and serial numbers were used instead to monitor respondents and results to maintain subjects' anonymity. The

serial number on each questionnaire was replicated on each sample vial to ensure assay findings and responses were matched to the respective subjects.

2.6. Specimen Collection and Assay

Five millilitres (5 ml) of blood were collected from each subject for analysis of HIV. The sample was dispensed into a sterile plain container and allowed to clot. The serum obtained was used for serological diagnosis of antibodies to HIV-1/2. Abbot Determine™ HIV -1/2 immunochromatographic rapid test kit (Abbott Laboratories, Abbott Park, IL, USA), visually read for the qualitative detection of antibodies to HIV-1/2 was used for this investigation.

Nasal swab samples were also collected from the subjects for analysis of COVID-19 using a COVID-19 antigen rapid test device (Abbot Panbio COVID-19 Antigen Rapid Test Device). The subjects were made to sit down comfortably. The subject's head was tilted back slightly. The nasal swab was then inserted less than one inch (about 2 cm) into the nostril and was rotated until resistance was met at the turbinate. The swab was then rotated 5 times against the nasal wall. The above steps were repeated in the other nostril using the same swab. The swab was inserted into an extraction buffer tube. While the buffer tube was being squeezed, the swab was stirred more than 5 times. The swab was then removed while squeezing the sides of the tube to extract the liquid from the swab and the nozzle cap was pressed tightly on the tube. The test device and the desiccant pack in the foil pouch were checked. Five (5) drops of the extracted specimen were applied to the specimen well of the test device and the result was read within 25 minutes. The results were subsequently interpreted and recorded according to the manufacturer's instructions.

2.7. Data Analysis

The collected data were entered into Microsoft Excel and cleaned up before being exported to Graph Pad Prism version 9 for statistical analysis. Frequency tables were produced as descriptive statistics. To find statistically significant relationships between the infections under investigation and sociodemographic and behavioural risk variables, chi-square was employed. The level of significance was set at $p < 0.05$ with a 95% confidence interval.

2.8. Ethical Considerations

Participants were briefed about the study's aim before providing their informed consent, with a focus on maintaining data confidentiality. The investigation was conducted in compliance with international ethical norms.

3. Results

Two hundred (200) inmates were involved in the current study with the majority of them being between the ages of 21 - 30 (43.5%) and 31 - 40 years (36.5%). About 69% of inmates were males while 31% were females. Among the studied inmates, the majority were single (72.5%), 60% of the participant had completed their sec-

ondary school education and 54% of the inmates were self-employed. Christians were preponderant against other religions (94%), and then 26 inmates (13%) had previous incarceration. The majority of the inmates have been in the prison between 1 - 3 years (44%) and 33.5% of them were vaccinated against COVID-19.

The prevalence of HIV from the current study was 6.5%, COVID-19 prevalence was reported to be 12.5% while HIV/COVID-19 co-infection was 1.5% as shown in Figure 2.

The most predominant symptom in the last 14 days reported by the inmates was fever (47%), followed by headaches (25.5%) and cough (19.5%). Chest pain was also reported by a few (13.5%) while only a handful reported some of the classical symptoms of COVID-19 infection such as shortness of breath (5%), loss of smell (4.5%), loss of taste (4%) as shown in Figure 3.

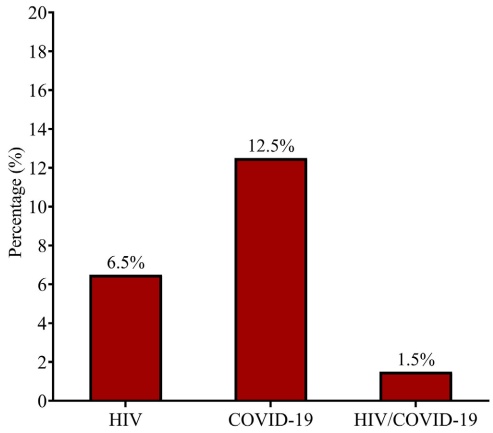

Figure 2. The prevalence of HIV, COVID-19, and HIV/COVID-19 Co-Infection among inmates.

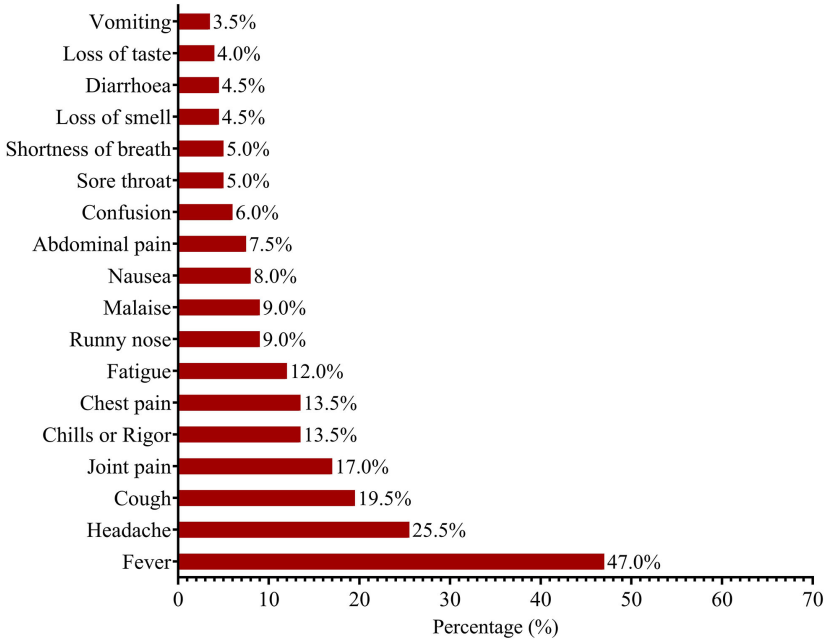

Figure 3. General symptoms reported by inmates within 14 days of sampling.

The duration of current incarceration was the only sociodemographic factor significantly associated with COVID-19 infection ($p = 0.0233$). The prevalence of COVID-19 was predominant among inmates currently incarcerated between 1 - 3 years, with a prevalence of 19.3% reported among inmates in this group. The age, sex, marital status, level of education, occupation, religion, and previous incarceration were not significantly associated with COVID-19 infection ($p > 0.05$) as shown in Table 1.

Table 1. Prevalence of COVID-19 and sociodemographic information of inmates.

Variable	Positive (%)	Negative (%)	Total (%)	χ^2	Df	*p*-value
Age						
≤20	0 (0)	7 (100)	7 (100)			
21 - 30	13 (14.9)	74 (85.1)	87 (100)			
31 - 40	7 (9.6)	66 (90.4)	73 (100)	3.5	4	0.4803
41 - 50	2 (10)	18 (90)	20 (100)			
≥51	3 (23.1)	10 (76.9)	13 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Sex						
Male	19 (13.8)	119 (86.2)	138 (100)			
Female	6 (9.7)	56 (90.3)	62 (100)	0.65	1	0.4185
Total	25 (12.5)	175 (87.5)	200 (100)			
Marital Status						
Single	20 (13.8)	125 (86.2)	145 (100)			
Married	5 (9.8)	46 (90.2)	51 (100)			
Widowed	0 (0)	3 (100)	3 (100)	1.1	3	0.7693
Separated/Divorced	0 (0)	1 (100)	1 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Level of Education						
No formal education	0 (0)	2 (100)	2 (100)			
Primary	7 (16.3)	36 (83.7)	43 (100)			
Secondary	14 (11.7)	106 (88.3)	120 (100)	0.96	3	0.8109
Tertiary	4 (11.4)	31 (88.6)	35 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Occupation						
Student	1 (6.7)	14 (93.3)	15 (100)			
Unemployed	0 (0)	14 (100)	14 (100)	5.1	4	0.2730
Self-Employed	12 (11.1)	96 (88.9)	108 (100)			

Continued

Private Employment	9 (18.8)	39 (81.3)	48 (100)			
Civil servant	3 (20)	12 (80)	15 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Religion						
African Tradition	0 (0)	3 (100)	3 (100)			
Christian	22 (11.7)	166 (88.3)	188 (100)			
Muslim	3 (37.5)	5 (62.5)	8 (100)	5.3	3	0.1542
Judaism	0 (0)	1 (100)	1 (100)			
Total	25 (12.5)	175 (87.5)	200 (100			
Previous Incarceration						
Yes	5 (19.2)	21 (80.8)	26 (100)			
No	20 (11.5)	154 (88.5)	174 (100)	1.2	1	0.2659
Total	25 (12.5)	175 (87.5)	200 (100)			
Duration of Current Incarceration						
<1	6 (13.3)	39 (86.7)	45 (100)			
1 - 3	17 (19.3)	71 (80.7)	88 (100)	9.5	3	0.0233*
4 - 6	2 (4)	48 (96)	50 (100)			
≥7	0 (0)	17 (100)	17 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			

* Statistical significance $p < 0.05$.

Face mask use was significantly associated with COVID-19 infection (p = 0.0112), the prevalence of COVID-19 was 15.3% among those who do not use face masks. The odds of getting COVID-19 were significantly lower for inmates who use face masks compared to those who do not use face masks, with an odds ratio of 0.23 (95% CI: 0.052 - 0.93). A significantly higher prevalence of COVID-19 (21.6%) was reported among inmates who had frequent visitations (p = 0.0001) and the odds of getting COVID-19 were significantly higher for inmates who had frequent visitations compared to those who do not have frequent visitations, with an odds ratio of 0.15 (95% CI: 0.053 - 0.44). A significant association was also found between vaccination against COVID-19 and the prevalence of COVID-19 (p = 0.0149), a higher prevalence of COVID-19 infection (12.1%) was reported among the unvaccinated inmates in the current study with the odds of getting COVID-19 being significantly lower for vaccinated inmates compared to unvaccinated inmates, with an odds ratio of 0.24 (95% CI: 0.073 - 0.74). Frequent handwashing practice, as well as the number of inmates in a cell, was not found to be significantly associated with the prevalence of COVID-19 infection ($p > 0.05$) in the current study as shown in Table 2.

Table 2. Prevalence of COVID-19 and risk factors of inmates.

Variable	Positive (%)	Negative (%)	Total (%)	χ^2, Df	OR 95% CI	*p*-value
Face mask use						
Yes	2 (4)	48 (96)	50 (100)	4.4, 1	0.23 0.052 - 0.93	0.0359*
No	23 (15.3)	127 (84.7)	150 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Frequent Handwashing Practice						
Yes	13 (12.5)	91 (87.5)	104 (100)	0.0, 1	1.0 0.43 - 2.4	>0.9999
No	12 (12.5)	84 (87.5)	96 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Frequent Visitations						
Yes	21 (21.6)	76 (78.4)	97 (100)	14, 1	0.15 0.053 - 0.44	0.0001*
No	4 (3.9)	99 (96.1)	103 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Vaccination against COVID-19						
Yes	3 (4.5)	64 (95.5)	67 (100)	5.9, 1	0.24 0.073 - 0.74	0.0149*
No	22 (16.5)	111 (83.5)	133 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			
Number of Inmates in a Cell						
≤20	1 (7.7)	12 (92.3)	13 (100)	2.8, 4	-	0.5833
21 - 30	1 (10)	9 (90)	10 (100)			
31 - 40	12 (16)	63 (84)	75 (100)			
41 - 50	4 (18.2)	18 (81.8)	22 (100)			
≥51	7 (8.7)	73 (91.3)	80 (100)			
Total	25 (12.5)	175 (87.5)	200 (100)			

* Statistical significance $p < 0.05$.

4. Discussion

The burden of HIV in prisons is a major public health problem, since imprisoned individuals are disproportionately impacted by the virus compared to the general population [25], and prison conditions can facilitate the spread of the infection. The current study reports an HIV prevalence of 6.5%. This finding can be attributed to the increased likelihood of participating in hazardous behaviours such as needle sharing and unprotected sexual activity among incarcerated individuals as reported in previous studies [12] [26]. Stressful prison conditions might lead to increased drug usage and unsafe sexual practices, in addition to inmates having limited access to HIV prevention and treatment programs, which can exacerbate the virus' transmission. This data is comparable to the research conducted in the Lagos prison (9%) [27] but differs from studies

conducted in other correctional institutions in Nigeria [23] [28] [29] [30] as well as findings from a Ghanian prison [31].

The study reported a COVID-19 prevalence of 12.5% among inmates in the study area. This observation is similar to the 12% reported in Connecticut, USA [32] and comparable to the 14% reported in county jails in Massachusetts, USA [33]; the current study was at variance with the findings of an Italian study where a lower prevalence of 2.7% was reported [34], as well as in the study in state prisons in Massachusetts, USA where a 5% prevalence was observed [33]. The study by Chan *et al.* (2021) [35] however, reported a higher prevalence of 58% in New York, USA. The high prevalence of COVID-19 recorded among inmates in the study area can be attributed to several factors, particularly the high incidence of underlying health conditions which contributes to their vulnerability to COVID-19 exposure, infection, and disease severity [36]. Prisons are overcrowded and have limited space for social distancing, making it difficult to contain the spread of the virus [37]. In addition, many correctional facilities lack adequate ventilation systems that can help reduce the risk of transmission [38]. Additionally, the close contact between inmates and staff personnel contributes to the transmission of COVID-19 in prisons. Employees of correctional facilities may get infected with the virus outside of work and unwittingly carry it inside the facility; transmitting the disease to inmates via close contact during regular activities like meals and recreation [38]. Furthermore, there has been no evidence of robust testing and contact tracing for COVID-19 in Nigerian prisons and as a result, asymptomatic individuals who are infected with the virus may go undetected and continue to spread it within the facility.

Fever at 47% was the most prevalent symptom reported by inmates in the current study, followed by headaches (25.5%) and cough (19%). A small number additionally experienced chest pain (13.5%), while even fewer had characteristic COVID-19 symptoms such as shortness of breath (5%), loss of smell (4.5%), and loss of taste (4%). These observations are comparable with the findings of an observational study where prisoners with COVID-19 were more frequently symptomatic with fever [39] with other common symptoms being similar to the common cold and including, tiredness, and dry cough [40]. Some cases may begin with symptoms such as aches and pains, nasal congestion, runny nose, sore throat, diarrhoea, and inability to smell or taste [40] similar to the observation in this study. However, in some cases, prisoners with pre-existing health conditions may develop severe symptoms, leading to hospitalization and even death whereas in some cases, prisoners with COVID-19 may be asymptomatic.

In the current study, the prevalence of COVID-19 was significantly associated with the duration of incarceration ($p = 0.0233$). The infection was predominant among inmates currently incarcerated between 1-3 years, with a prevalence of 19.3% reported among inmates in this group. The reason for this trend is not quite clear as studies have found that both new prison inmates and those incarcerated for longer periods are at high risk of COVID-19 infection [16] [41]. In-

carcerated individuals and prison staff have a higher relative risk for COVID-19 infection than the general population, regardless of how long they have been incarcerated [41]. It is however not entirely out of place to assert that newer inmates may be at a higher risk of being infected with COVID-19 compared to older inmates, given their interactions with potential sources of the virus prior to incarceration; although the risk may vary depending on several factors such as the current prevalence of COVID-19 in the prison, the age and health status of the inmates, and the measures taken to prevent transmission of the virus. New inmates who are incarcerated in a prison may be more likely to be infected with COVID-19 if they were recently exposed to the virus before their incarceration or if they were exposed during the documentation process.

The current study reported a significantly higher prevalence of COVID-19 infection (15.3%) among inmates who do not use a face mask. This could be attributed to the unavailability and improper use of face masks among inmates. Masking policies have been found to slightly reduce COVID-19 prevalence among incarcerated persons [42] and poor face mask use can contribute to the spread of the virus among inmates and staff members through respiratory droplets and aerosols released when talking, coughing, or sneezing. If face masks are not worn properly or consistently, they can become a source of infection themselves. The findings in the study are in line with the assertions by Riback *et al.* (2023) [43] who opined that poor face mask use can be associated with a higher prevalence of COVID-19 infection in prisons. The authors in their study found that most inmates received a mask during their most recent incarceration (90%), but only 40% received counselling on proper mask-wearing (Riback *et al.*, 2023) [43], further suggesting that some prisoners may not be using masks correctly, which could contribute to the spread of COVID-19. Prisons are high-risk environments for COVID-19 transmission due to overcrowding and limited access to personal protective equipment (PPE) [39] [44]. The risk of COVID-19 infection can develop rapidly within prisons, increasing its incidence, morbidity, and mortality [39]. Several studies outside the prison walls have shown that face mask use is associated with a lower risk of COVID-19 on a population scale [45] [46] [47]. The study by Kwon *et al.* (2021) [45] found that self-reported "always" use of face masks was associated with a 62% reduction in the risk of COVID-19 even among individuals living in a community with poor social distancing.

A significantly higher prevalence of COVID-19 (21.6%) was reported among inmates who had frequent visitations (p = 0.0001). Frequent visitations have been associated with higher COVID-19 incidence rates among prisoners [38]. Although maximizing access to in-person visitation can promote correctional and detention facility residents' mental health [48], this can also increase the risk of COVID-19 transmission. The prisoner population is highly vulnerable, suffering from high rates of mental disorders, substance abuse disorders, poor health outcomes, and other factors that increase their risk of COVID-19 infection [38] [49]. Visitors who are unknowingly infected with COVID-19 can transmit the

virus to inmates and staff, increasing the risk of transmission within the facility. In response to this risk, many prisons have implemented restrictions on visitations or have required visitors to undergo COVID-19 testing before entering the facility, but this is yet to be implemented in the study area or anywhere else in the country as a whole.

A significant association was also found between vaccination against COVID-19 and the prevalence of COVID-19 ($p = 0.0149$), a higher prevalence of COVID-19 infection (12.1%) was reported among the unvaccinated inmates in the current study. COVID-19 vaccination has been associated with a lower incidence of COVID-19 among prisoners [50] [51]. According to a study, the Moderna vaccine for COVID-19 is highly effective at preventing SARS-CoV-2 infection among high-risk incarcerated persons [50], though the nature of the vaccine taken by the inmates was not captured in the current study. Additionally, data from California prisons shows that both COVID-19 vaccination and prior SARS-CoV-2 infection reduce the risk of virus transmission [51]. While vaccine refusal rates are not generally worse in prisons than in the general population, vaccination is even more critical in prisons due to the vulnerability of the prisoner population [52]. However, COVID-19 vaccine effectiveness can decrease with the waning of vaccine-derived immunity and emerging SARS-CoV-2 variants of concern [53].

The prevalence of HIV/COVID-19 co-infection in the current study was 1.5%. This finding is comparable to the 2% global pooled prevalence of people living with HIV (PLWH) among COVID-19 cases as reported in a systematic review and meta-analysis [54], however, the same study reported an 11% pooled prevalence of HIV/COVID-19 co-infection within the African continent, varying with the report in the current study. The observed HIV/COVID-19 prevalence in the current study is similar to a retrospective study of COVID-19 cases in Ethiopia where a 1.6% prevalence of PLWH was reported. The study by Erinoso *et al.* (2020) [55] in Nigeria reported an even lower prevalence (0.5%) of PLWH amongst COVID-19 cases whereas in Kenya a 6.7% prevalence of HIV/COVID-19 co-infection was observed among COVID-19 cases [56]. The observed HIV/COVID-19 coinfection in the current study can be attributed to the peculiar nature of the prison setting which is mostly overcrowded with limited space for social distancing and personal protective equipment [36] [38] [43], in addition to lacking adequate ventilation [37] all of which can facilitate the spread of COVID-19 among inmates. The reality of HIV/COVID-19 co-infection is bound to thrive in this population particularly as hazardous behaviours such as needle sharing and unprotected sexual activity remains unchecked.

5. Conclusion

The current study reports a relatively high prevalence of HIV and COVID-19 among the inmates in the study area recording an HIV prevalence of 6.5%, 12.5% for COVID-19 and an HIV/COVID-19 co-infection prevalence of 1.5%. The duration of incarceration, face mask use, frequent visitations and vaccina-

tion against COVID-19 were found to be significantly associated with the prevalence of COVID-19 in the study. It becomes imperative for the management of the correctional facility to properly screen new inmates for COVID-19, quarantine and appropriately manage new inmates with COVID-19 infection in addition to sufficiently providing inmates with personal protective pieces of equipment such as face masks to mitigate the spread of the infection within the facility. The study also highlights the importance to balance the need for in-person visitation with measures to prevent the spread of COVID-19 in correctional facilities as well as promoting mass vaccination campaigns among inmates and also the staff of the correctional centre. Improving access to HIV screening and therapy for all prisoners regardless of their risk level should be prioritised as this can aid in identifying and managing the incidence of HIV early, reducing the risk of transmission and improving health outcomes.

6. Limitations of the Study

The use of rapid diagnostic test kits for the analysis of HIV-1/2 and COVID-19 is a limitation of the current study. Recent infections have a reduced likelihood of being detected using the Abbott Determine HIV-1/2 Rapid Di-agnostic Test kit. This can result in an underestimation of the true prevalence of HIV in the population under study, especially if a large proportion of the population under study has recent infections. The prevalence of cross-reacting antibodies or other conditions that can produce false-positive results may affect the specificity of the test leading to an overestimation of the true prevalence of HIV in the studied population. In some populations, other HIV subtypes or recombinant strains may not be detectable with this test, leading to an underestimation of the true prevalence of HIV in the population under study, especially if the population under study contains individuals with HIV subtypes other than B. While the Abbott Panbio COVID-19 Antigen Rapid Test Device is a useful tool for diagnosing individual cases of COVID-19, the test's sensitivity may vary based on the viral load of the individual being tested, producing false negative results in individuals with low levels of viral antigens in their samples. This can lead to an underestimation of the actual prevalence of the virus in the studied population. This may contribute to an underestimation of the true prevalence of the virus in the population under study.

Another limitation of the present study was the inmate's self-reported COVID-19 vaccination status. In prevalence studies, self-reported COVID-19 vaccination status can be limited by reporting bias, lack of verification, incomplete information and distinct vaccine types. Due to recall or social desirability bias, individuals may not accurately report their vaccination status, and there is no independent verification to confirm the self-reported status. Incomplete information on the vaccine brand or date of administration can also make it difficult to evaluate vaccine efficacy, and different vaccines may have varying efficacy rates, influencing the prevalence of the virus among vaccinated individuals.

Acknowledgements

The authors appreciate the inmates for consenting to participate in this research. We are also grateful to the officials and administrators of the Maximum Security Custodial Centre, Port Harcourt, as well as the Department of Medical Laboratory Science, Rivers State University, Port Harcourt for facilitating this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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