Seroprevalence and Determinants of SARS-Cov-2 Antibodies Among Healthcare Workers in Dar es Salaam, Tanzania.

Erick Mboya[1*], Claudia Hawkins[2], Doreen Kamori[3], Davis Amani[1], Grace Shayo[3], Raphael Z. Sangeda[4], Joan Rugemalila[5], Faraja Chiwanga[5], Sabina Mugusi[3], Upendo Nkwera[3], Mangaro Mabusi[3], Said Aboud[3,6], Ferdinand Mugusi[3], Bruno Sunguya[1], Muhammad Bakari[3], Tumaini Nagu[3].

Affiliation

[1]School of Public Health and Social Sciences, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

[2]Feinberg School of Medicine, Northwestern University, USA

[3]College Campus of Medicine, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

[4]School of Pharmacy, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

[5]Department of Internal Medicine, Muhimbili National Hospital, Dar es Salaam, Tanzania

[6]National Institute for Medical Research, Dar es Salaam, Tanzania

*Corresponding author: alexandererick104@gmail.com

Abstract

Background: Studies from the Sub-Saharan African (SSA) countries suggest an underestimate of SARS-CoV-2 infections early in the pandemic. To understand and inform infection control strategies to protect key and vulnerable populations, this study investigated the seroprevalence and factors associated with anti-SARS CoV-2 seropositivity among healthcare workers (HCWs) in Dar es Salaam, Tanzania.

Methods: This cross-sectional study was conducted in three tertiary and national hospitals in Dar es Salaam, Tanzania. Employed HCWs aged ≥18 years were enrolled between October 2021 and March 2022. Laboratory testing for Immunoglobulin G (IgG) against SARS-CoV-2 nucleocapsid (N) or spike (S) proteins was performed using WHO/FDA pre-qualified SARS-CoV-2 ELISA test kits, and data were collected on demographics and COVID-19-related exposures. Descriptive statistics were used to determine the SARS-CoV-2 antibody prevalence. Multivariable Modified Poisson regression with robust standard errors accounting for clustering within sites was used to test the independent association between HCW characteristics and SARS-CoV-2 serologic status.

Results: A total of 402 participants [mean age (SD) of 37.9 (9.7) years] were included in this study. 150 (37.3%) reported receiving at least one dose of SARS-CoV-2 vaccine. The overall seroprevalence of anti-SARS-CoV-2 antibodies (anti-SARS-CoV-2 IgG (S or N)) was 90.9% (358/394) among those with valid results. HCWs who reported receiving the SARS-CoV-2 vaccine were 1.14 times more likely to have anti-SARS-CoV-2 antibodies compared to those who reported not being vaccinated (aPR (95% CI) = 1.14 (1.03- 1.26)). HCWs who believed to have contracted COVID-19 previously but never tested had an 11% higher risk of being seropositive for SARS-CoV-2 IgG compared to those who thought never to have contracted COVID-19 before

(aPR (95% CI) = 1.11 (1.05- 1.16)). Anesthetists and HCWs working in the laboratory and Obstetrics and Gynecology departments were more likely to have SARS-CoV-2 antibodies than HCWs from the Emergency Medicine Department (EMD).

Conclusion: The seroprevalence of anti-SARS-CoV-2 IgG among HCWs in this study was high in this population indicating high SARS-CoV-2 exposure among HCWs. Our work highlights the need for more effective infection control practices in healthcare settings in future pandemics like these, especially among HCWs at highest risk.

Keywords: Covid-19, SARS-CoV-2, Healthcare workers, Tanzania

Background

The COVID-19 pandemic placed a significant strain on healthcare systems worldwide (1,2). Low- and middle-income countries (LMICs) faced distinct challenges during the COVID-19 pandemic such as limited healthcare, testing, and vaccine access and acceptability (3–5). Healthcare workers (HCWs) on the frontline in the fight against SARS-CoV-2, were also impacted profoundly during the pandemic. Increased occupational exposure to viral particles, inadequate protective equipment and infection control practices, and other stressors such as long working hours, put them at a significantly higher risk of acquiring SARS-CoV-2 compared to the general population (6,7)(7). HCWs also reported experiencing higher workloads, psychological distress, social exclusion (2).

In the US and other settings, up to about 30% of the healthcare workforce was infected with SARS-CoV-2 during the peak of COVID-19 (8,9). According to the World Health Organization (WHO), approximately 115,500 HCWs died in 2021 due to COVID-19-related complications globally (10). Studies examining the prevalence of SARS-CoV-2 infection in LMICs are more limited due to a lack of accessible testing and surveillance (9). The limited data other Sub-Saharan African (SSA) countries suggests the burden of SARS-CoV-2 infections among HCWs was significantly underestimated. Like its neighboring countries, Tanzania imposed measures to prevent the spread of COVID-19 including face masks in densely populated areas, prohibiting large public gatherings, encouraging the use of sanitizer and installing hand-washing facilities in public places and households, assigning isolation and quarantine centers and expanded diagnostic points of service (11). However, Tanzania did not impose curfews, nor complete country lock-down, and encouraged income-generating activities (11,12). The lack of data on the burden and risks associated with infection significantly hinders understanding of the impact of SARS-CoV-2,

73 especially in high-risk individuals like HCWs, and the ability to formulate evidence-based
74 effective interventions for subsequent outbreaks (13).

75 This study investigated the seroprevalence and factors associated with anti-SARS CoV-2
76 seropositivity among HCWs in Dar es Salaam, Tanzania. This data is important, particularly in
77 Tanzania to inform infection control and mitigation policies that best protect these vulnerable
78 workers in future outbreaks.

79

80 Methodology

81 Study design and duration

82 This cross-sectional analysis was conducted among HCWs enrolled in a longitudinal study
83 examining the seroprevalence and seroincidence of SARS-CoV-2 in three tertiary hospitals in Dar
84 es Salaam; the Mloganzila Campus of the National Hospital (Mloganzila Hospital), the Muhimbili
85 National Hospital (MNH), and Amana Regional Referral Hospital (ARRH). Recruitment occurred
86 between October 2021 and March 2022. Specifically, at MNH recruitment was between October
87 6th to November 22^{nd,} 2021, while at Mloganzila Hospital recruitment was between January 21st to
88 February 11^{th,} 2022, and February 22nd to March 11^{th,} 2022 at Amana Regional Referral Hospital.
89 Recruitment of participants Mloganzila and ARRH occured during the peak of the second wave of
90 COVID-19 in the country including Dar es Salaam (Figure 1).

91

92 **Figure 1: Trend of cases and deaths from COVID-19 since March 2020 to the week ending**
93 **on 8th April 2022. Source: Ministry of Health Tanzania COVID-19 Situation report Number**
94 **15 as of April 2022** (14)

Study Setting

The first case of COVID-19 in Tanzania was imported on March 16th, 2020 (15). At the time of this study, there had been four waves of COVID-19 in Tanzania (Figure 1). As of February 2023, 40,000 cases of COVID-19 have been confirmed, mostly in Dar es Salaam (14). Johnson & Johnson vaccine was the widely available vaccine through the COVAX program, free of charge and HCWs were among the prioritized groups (16). Face masks in densely populated areas were recommended, although large public gatherings were not prohibited. Sanitizers and hand-washing facilities in public places were installed and there were assigned isolation and quarantine centers (11). The three hospitals included in this study are public hospitals and were designated COVID-19 centers where patients with severe COVID-19 from lower facilities in Dar es Salaam were referred for treatment and isolation.

Study population

All HCWs 18 years and older working were eligible for inclusion in this study. Students, volunteers/interns, and temporary workers with contracts of less than 7 months left on their contract were excluded from the cohort.

Sampling

Stratified random sampling was used to select participants. Participants were stratified by their institution, cadre, and department. Probability proportional to size was used to allocate the number for each stratum.

Since the estimate for the SARS-CoV-2 exposure was not known, 50% exposure was set to maximize the sample size for a finite population of 3,000 HCWs. Accounting for the non-response of 15% the sample size for this study was calculated to be 393 HCWs to estimate SARS-CoV-2 exposure with 5% absolute precision.

Recruitment

Data on the number of employees were obtained from each institution and were stratified by their cadre (doctors, nurses, laboratory scientists, pharmacists, and allied health workers). Random selection of HCWs was performed using a lottery paper method and those selected were invited to participate in the study. Participants who provided a signed consent to the study were then enrolled and assigned unique study numbers. Participants had their weight and height measured and were administered questionnaires asking about demographics, occupational risks, reported COVID-19 infection, results of any testing, other COVID-19-related exposures, COVID-19 symptom severity, and COVID-19 vaccination details if received. Participants were then asked to provide a single blood sample of 8 ml volume for SARS-CoV-2 IgG testing, which was collected by a trained study staff.

Laboratory procedures

Samples were tested by conventional standard ELISA platform at the MNH Central Pathology Laboratory (CPL), an ISO-certified laboratory, using WHO/FDA pre-qualified SARS-CoV-2 ELISA test kits, testing for SARS-CoV-2 IgG (nucleocapsid and spike). The results of the test were interpreted according to the manufacturer's instructions (17).

The interpretation of the serological results was as follows (17):

a. Positive for both anti-N and anti-S antibodies

i. COVID-19 vaccinated +/- previous SARS-CoV-2 infection.

ii. unvaccinated with previous SARS-CoV-2 infection.

b. Positive anti-N antibody and negative anti-S antibody

i. unvaccinated with previous SARS-CoV-2 infection.

ii. COVID-19 vaccinated with previous SARS-CoV-2 infection but no response to the vaccine or loss of vaccine response.

c. Negative anti-N antibody and positive anti-S antibody

i. COVID-vaccination with no prior SARS-CoV-2 infection.

ii. previous or current exposure to SARS-CoV-2 and/or COVID-19 vaccination

d. Negative anti-N antibody and negative anti-S antibody

i. No prior or current exposure to SARS-CoV-2 or COVID vaccination

ii. Previous or current exposure to SARS-CoV-2 and/or COVID vaccination with no immune response

Data management and analysis

All data was entered electronically using REDCap version 11.1.5 (Vanderbilt University). Data were extracted in Stata format, cleaned, and analyzed using Stata 18. Participants' characteristics were summarized using frequencies and percentages for all patients and disaggregated for each facility. Age was summarized using mean and standard deviation (SD). The overall seroprevalence of SARS CoV-2 (SARS-CoV-2 IgG) was calculated as the proportion of HCWs who tested positive for *either* IgG S or N among all HCWs with the serology results. The proportion of HCWs who tested positive for *both* IgG S and N or IgG S alone was also calculated and disaggregated by sites, vaccination status, and other demographic characteristics. Multivariable Modified Poisson regression with robust variance estimators accounting for clustering within sites was used to test

the independent association between HCWs characteristics and overall seroprevalence of SARS CoV-2 IgG among HCWs in Dar es Salaam. A significance level of <0.05 was used to determine a significant association. All factors that had a p-value of <0.2 in the univariable analysis were included in the multivariable model but were only kept in the final model if they improved the model. The area under the curve (AUC) was used to select a final model (AUC=0.8162).

Results

Characteristics of the study participants

A total of 402 HCWs were included in this study; [mean age (±SD) was 37.9 (±9.7) years; 236 (58.7%) females]. A quarter of the participants, 105 (26.1%) worked in the Internal Medicine department, 78 (19.4%) in the Obstetrics and Gynecology department, and 58 (14.4%) from other surgical departments. By their cadres, 174 (42.5%) were nursing staff, followed by medical officers/dentists 80 (19.6%) and specialists 61 (14.9%). About a fifth of the HCWs, 71 (17.7%), reported spending more than half of their time working in the ICU (**Table 1**).

176 **Table 1: Demographic and occupational characteristics of HCWs by site (N=402)**

Characteristics	MNH (n=269) N (%)	ARRH (n=57) N (%)	Mloganzila (n=76) N (%)	Total (N=402) N (%)
Sex				
Male	94 (34.9)	24 (42.1)	48 (63.2)	166 (41.3)
Female	175 (65.1)	33 (57.9)	28 (36.8)	236 (58.7)
Mean age (SD) (in years)	39.2 (10.3)	36.4 (9.6)	34.8 (6.6)	37.9 (9.7)
Age categories (in years)				
20-35	120 (44.6)	27 (47.4)	52 (68.4)	199 (49.5)
36-50	93 (34.6)	26 (45.6)	22 (28.9)	141 (35.1)
51-65	56 (20.8)	4 (7.0)	2 (2.6)	62 (15.4)
Marital Status				
Married/ Co-habiting	162 (60.2)	37 (64.9)	54 (71.1)	253 (62.9)
Never Married	88 (32.7)	17 (29.8)	22 (28.9)	127 (31.6)
Widowed	11 (4.1)	3 (5.3)	0 (0)	14 (3.5)
Divorced/Separated	8 (3.0)	0 (0)	0 (0)	8 (2.0)
Department				
Emergency Department	25 (9.3)	5 (8.8)	8 (10.5)	38 (9.5)
Internal Medicine	88 (32.7)	6 (10.5)	11 (14.5)	105 (26.1)
Outpatients	16 (5.9)	5 (8.8)	0 (0.0)	21 (5.2)
Surgery, ENT & Dental	29 (10.8)	9 (15.8)	20 (26.3)	58 (14.4)
Laboratory	24 (8.9)	4 (7.0)	1 (1.3)	29 (7.2)
Obstetrics & Gynecology	61 (22.7)	11 (19.3)	6 (7.9)	78 (19.4)
Pediatrics	10 (3.7)	7 (12.3)	7 (9.2)	24 (6.0)
Anesthesia	14 (5.2)	1 (1.8)	4 (5.3)	19 (4.7)
Others	2 (0.7)	9 (15.8)	19 (25.0)	30 (7.5)
Cadre				
Nurse	124 (46.1)	22 (38.6)	28 (36.8)	174 (42.5)
Medical Officer/Dentist	50 (18.6)	17 (29.8)	13 (17.1)	80 (19.6)
Specialist	37 (13.8)	6 (10.5)	18 (23.7)	61 (14.9)
Ward attendant	23 (8.6)	1 (1.8)	0 (0)	24 (5.9)
Lab personnel	14 (5.2)	6 (10.5)	3 (3.9)	23 (5.6)
Others	21 (7.8)	5 (8.8)	14 (18.4)	47 (11.5)
Time working in the Intensive care unit				
None	129 (48.0)	49 (86.0)	25 (32.9)	203 (50.5)
Less than half the time	84 (31.2)	6 (10.5)	38 (50.0)	128 (31.8)

Half the time or more	56 (20.8)	2 (3.5)	13 (17.1)	71 (17.7)
Assigned to work in a COVID-19 floor or ICU in the last 20 months				
No	140 (52.0)	42 (73.7)	56 (73.7)	238 (59.2)
Yes	129 (48.0)	15 (26.3)	20 (26.3)	164 (40.8)
Time working at Emergency/casualty department				
None	169 (62.8)	35 (61.4)	26 (34.2)	230 (57.2)
Less than half the time	63 (23.4)	12 (21.1)	37 (48.7)	112 (27.9)
Half the time or most	37 (13.8)	10 (17.5)	13 (17.1)	60 (14.9)
Time working in Theatre				
None	196 (72.9)	39 (68.4)	36 (47.4)	271 (67.6)
Less than half the time	37 (13.8)	7 (12.3)	21 (27.6)	65 (16.2)
Half to most of the time	36 (13.4)	11 (19.3)	18 (23.7)	65 (16.2)
Time working in Dialysis Unit				
None	223 (82.9)	55 (96.5)	64 (84.2)	342 (85.3)
Less than half the time	24 (8.9)	0 (0)	8 (10.5)	32 (8.0)
Half to most of the time	22 (8.2)	2 (3.5)	3 (3.9)	27 (6.7)

177 MNH- Muhimbili National Hospital, ARRH- Amana Regional Referral Hospital, SD- Standard Deviation, ENT- Ear, Nose and
178 Throat, ICU- Intensive Care Unit,

179

180 Sixty-nine participants (17.2%) reported previous testing for COVID-19 and among them 21
181 (30.4%) tested positive. Twenty-one (5.2%) participants reported to have previously been admitted
182 to the hospital for COVID-19; with 6 of them (28.6%) admitted for less than a week. Among all
183 participants, 150 (37.3%) reported to have received at least one dose of a vaccine against COVID-
184 19; 94% received a dose of the Johnson & Johnson vaccine, **Table 2.**

185

187 **Table 2: COVID-19 experience, testing, and vaccination among HCWs in Dar es Salaam**

188 **(N=402)**

Variable	MNH (N=269) N (%)	ARRH (N=57) N (%)	Mloganzila (N=76) N (%)	Total (N=402) N (%)
Ever tested for COVID				
No	228 (84.8)	42 (73.7)	63 (82.9)	333 (82.8)
Yes	41 (15.2)	15 (26.3)	13 (17.1)	69 (17.2)
Most recent COVID-19 test results[#]				
Negative	27 (10.0)	6 (10.5)	9 (11.8)	42 (10.4)
Positive	9 (3.3)	8 (14.0)	4 (5.3)	21 (5.2)
Indeterminate	5 (1.9)	1 (1.8)	0 (0.0)	6 (1.5)
HCWs COVID-19 experience				
Never had COVID-19	81 (30.1)	9 (15.8)	8 (10.5)	98 (24.4)
Tested Positive for COVID-19	12 (4.5)	7 (12.3)	5 (6.6)	24 (6.0)
Believe had COVID-19 but did not test	176 (65.4)	41 (71.9)	63 (82.9)	280 (69.7)
Duration of hospital admission for COVID-19[*]				
<1 week	4 (1.5)	0 (0.0)	2 (2.6)	6 (1.5)
1-2 weeks	4 (1.5)	2 (3.5)	1 (1.3)	7 (1.7)
>2 weeks-1month	4 (1.5)	0 (0.0)	3 (3.9)	7 (1.7)
More than a month	0 (0.0)	0 (0.0)	1 (1.3)	1 (0.2)
Receipt of vaccination against COVID-19				
No	174 (64.7)	35 (61.4)	43 (56.6)	249 (61.9)
Yes	95 (35.3)	22 (38.6)	33 (43.4)	150 (37.3)
Type of Vaccine received				
Johnson & Johnson	88 (32.7)	20 (35.1)	33 (43.4)	141 (35.1)
Pfizer	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.2)
Sinovac	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.2)
Sinopharm	0 (0.0)	2 (3.5)	1 (1.3)	3 (0.7)
Sputnik light	3 (1.1)	0 (0.0)	0 (0.0)	3 (0.7)
Sputnik	3 (1.1)	0 (0.0)	0 (0.0)	3 (0.7)
AstraZeneca	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.2)
Not Vaccinated	172 (63.9)	35 (61.4)	42 (55.3)	249 (61.9)

189 MNH- Muhimbili National Hospital, ARRH- Amana Regional Referral Hospital, COVID-19- Corona Virus Disease 2019, *N=21,
190 [#]N=69.

191

192 **Seroprevalence of total SARS-CoV-2 Ig-G among HCWs in Dar es Salaam**

193 Among the 402 HCWs, serology results were available for analysis for 394 HCWs. Of the 8
194 participants excluded, 6 had missing results and 2 did not have a unique identifier to link the results
195 with the electronic clinical data.

196 The overall seroprevalence of SARS-CoV-2 IgG (IgG N, IgG S, or both IgG N and S) among
197 HCWs was 91.8%. The overall seroprevalence by site was 89.4%, 98.1%, and 95.8% among
198 HCWs at MNH, Mloganzila and ARRH respectively (Figure 2).

199 Almost half of the HCWs, 189 (48.0%), tested positive for *both* S and N SARS-CoV-2 IgG
200 antibodies. SARS-CoV-2 IgG antibodies against both the N and S proteins were detected among
201 46 (83.6%) and 65 (83.3%) HCWs at Mloganzila hospital and ARRH respectively. At MNH, only
202 (83 (31.1%)) HCWs tested positive for both the S and N SARS-CoV-2 IgG (**Figure 2)**.

203 Overall, 168 (42.6%) HCWs tested positive for SARS-CoV-2 IgG against the S protein only. At
204 the MNH, 151 (57.7%) were positive for SARS-CoV-2 IgG S alone, while 6 (10.9%) HCWs at
205 ARRH and 8 (11.1%) at Mloganzila hospital were positive against S protein alone. **(Figure 2).**

206

207 **Figure 2: Prevalence of SARS-CoV-2 IgG by Site**

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209 Among HCWs who reported to have received at least one dose of vaccine against COVID-19, the
210 total seroprevalence of SARS-CoV-2 IgG was 97.8%. Among HCWs who reported not to have
211 received the COVID-19 vaccine the seroprevalence of SARS-CoV-2 IgG was 86.6%. Similar rates

of both SARS-CoV-2 IgG S and N positivity were present among vaccinated, 46.0%, and unvaccinated HCWs, 47.0% (Figure 3).

Among vaccinated HCWs, 50.7% had IgG S only while only 36.5% of the unvaccinated had IgG S only (Figure 3).

Figure 3: Prevalence of SARS-CoV2 IgG by COVID-19 Vaccination status

Factors associated with SARS-CoV-2 IgG seropositivity (IgG S or N positivity)

After adjusting for sex, marital status, department, cadre, vaccination status, previous COVID-19, and site (hospital) the following factors were independently associated with the risk of being seropositive for SARS-CoV-2 IgG among HCWs in Dar es Salaam: vaccination against COVID-19, department, cadre, previous COVID-19, site (hospital), sex and marital status.

HCWs who reported being vaccinated against COVID-19 had a 14% higher risk of being seropositive for SARS-CoV-2 IgG compared to those who reported not being vaccinated (aPR (95% CI) = 1.14 (1.03- 1.26)). HCWs who believed to have contracted COVID-19 previously but never tested had an 11% higher risk of being seropositive for SARS-CoV-2 IgG compared to those who thought never to have contracted COVID-19 before (aPR (95% CI) = 1.11 (1.05- 1.16)).

Healthcare workers at ARRH and Mloganzila Hospital had a 9% and 7% higher risk of being seropositive for SARS-CoV-2 IgG respectively compared to HCWs at MNH (aPR (95% CI) = 1.09 (1.05- 1.12)) and (aPR (95% CI) = 1.06 (1.01- 1.13)). The risk of being seropositive for SARS-CoV-2 IgG was 19% higher among laboratory HCWs compared to HCWs at the ED (aPR

(95% CI) = 1.21 (1.12- 1.27)). HCWs in Obstetrics and Gynecology had a 19% higher risk of being seropositive for SARS-CoV-2 IgG compared to HCWs at the ED (aPR (95% CI) = 1.19 (1.05- 1.35)). Anesthetists had a 20% higher risk of being seropositive for SARS-CoV-2 IgG compared to HCWs at the ED (aPR (95% CI) = 1.20 (1.10- 1.32)).

Compared to nurses, specialist doctors had a 9% lower risk of being seropositive for SARS-CoV-2 IgG (aPR (95% CI) = 0.91 (0.86 – 0.97)).

HCWs who reported being divorced/ separated had a 13% higher risk of being seropositive compared to those who reported being married/ cohabiting (aPR (95% CI) = 1.13 (1.10- 1.15)) – **Table 3**.

Table 3: Factors associated with SARS-CoV-2 IgG seropositivity among HCWs in Dar es Salaam (n=394)

Variable	cPR (95% CI)	p-value	aPR (95% CI)	p-value
Sex				
Male	Ref			
Female	0.97 (0.94- 1.00)	0.034	0.94 (0.90- 0.99)	0.021
Age Category				
20-35	Ref			
36-50	1.03 (0.97- 1.08)	0.370		
51-65	1.02 (0.98- 1.07)	0.318		
Marital Status				
Married/ Co-habiting	Ref			
Never Married	0.94 (0.91- 0.98)	0.006	0.97 (0.96- 0.97)	<0.001
Widowed	1.01 (0.98- 1.03)	0.662	1.01 (1.00- 1.02)	0.029
Divorced/ Separated	1.08 (1.05- 1.12)	<0.001	1.13 (1.10- 1.15)	<0.001
Department				
ED	Ref			
Internal Medicine	1.12 (0.93- 1.36)	0.233	1.15 (0.99- 1.34)	0.076
OPD	1.12 (0.96- 1.30)	0.154	1.11 (1.01- 1.23)	0.032
Surgery, ENT & Dental	1.08 (0.98- 1.19)	0.111	1.09 (1.00- 1.18)	0.046
Laboratory	1.11 (0.93- 1.33)	0.253	1.19 (1.12- 1.27)	<0.001

Obstetrics & Gynecology	1.17 (1.02- 1.34)	0.026	1.19 (1.05- 1.35)	0.005
Pediatrics	1.12 (1.01- 1.25)	0.034	1.09 (1.00- 1.19)	0.044
Anesthesia	1.23 (1.05- 1.45)	0.010	1.20 (1.10- 1.32)	<0.001
Others	1.15 (0.91- 1.44)	0.250	1.10 (0.91- 1.32)	0.343
Cadre				
Nurse	Ref			
Medical Officer/Dentist	0.99 (0.94- 1.05)	0.843	0.99 (0.97- 1.00)	0.147
Specialist	1.00 (0.94- 1.07)	0.987	0.91 (0.86 – 0.97)	0.002
Ward attendant	0.96 (0.92- 0.99)	0.012	1.01 (1.00- 1.03)	0.086
Lab personnel	0.96 (0.81- 1.12)	0.578	0.93 (0.77- 1.13)	0.450
Others	0.98 (0.89- 1.08)	0.722	0.94 (0.87- 1.01)	0.106
Vaccination status				
Yes	1.13 (1.02- 1.25)	0.017	1.14 (1.03- 1.26)	0.013
No	Ref			
Previous COVID-19 Experience				
Never had Covid-19	Ref			
Tested Positive for Covid-19	1.15 (1.06- 1.24)	0.001	1.12 (0.99- 1.26)	0.064
Believed had COVID-19 but never tested	1.12 (1.05- 1.19)	0.001	1.11 (1.05- 1.16)	<0.001
Site				
MNH	Ref			
ARRH	1.09 (1.02- 1.16)	0.016	1.09 (1.05- 1.12)	<0.001
Mloganzila Hospital	1.06 (0.99- 1.14)	0.085	1.07 (1.01- 1.13)	0.025

Adjusted for: Sex, marital status, department, cadre, vaccination status, previous COVID-19 experience and site; ED- Emergency Department; OPD- Outpatient Department; ENT- Ear, Nose, and Throat; MNH- Muhimbili National Hospital; ARRH- Amana Regional Referral Hospital; cPR- Crude Prevalence Ratio; aPR- Adjusted Prevalence Ratio; CI- Confidence Interval; SARS-CoV-2- Severe Acute Respiratory Syndrome Corona Virus 2.

Discussion

The overall seroprevalence of SARS-CoV-2 antibodies among HCWs was high compared to the global prevalence of HCW infection reported around the time of initial study enrolment [59.2% in September 2021 vs 91.8% among HCWs in our study] (18). The prevalence of SARS-CoV-2 among HCWs in other parts of the world ranged from 11.7% in Canada to 27% in the USA (8,19). In sub-Saharan Africa, SARS-CoV-2 prevalence ranged from 34.7% among HCWs in Mozambique to over 50% in Madagascar (20).

With only about a third of participants vaccinated, the high seroprevalence indicates a high infection rate with SARS-CoV-2 among HCWs in Dar-es-Salaam (17). Nearly 87% of unvaccinated HCWs had SARS-CoV-2 antibodies. These high estimates suggest several contributing factors including suboptimal infection control practise among HCWs in Dar es Salaam (20–24).

This study also revealed site and duration-specific differences in SARS-CoV-2 IgG N and S seroprevalence and IgG S alone. Participants enrolled at MNH (between October and November 2021) had relatively lower IgG N and S rates (31.1%) than participants enrolled from Mloganzila and ARRH (83%) (between January and March 2022). These findings are most likely related to the emergence of the new Omicron wave which coincided with the later recruitment period. The high exposure to SARS-CoV-2 among HCWs from Mloganzila and ARRH could also account for the higher IgG S alone among HCWs from MNH despite reported higher vaccination rates at Mloganzila and ARRH.

The high prevalence of SARS-CoV-2 immunity including among those who were never suspected to have COVID-19 or vaccinated indicates significant underreporting of SARS-CoV-2 cases in Tanzania. This was almost certainly due to the inadequate availability of testing of SARS-CoV-2 as fewer than a fifth of the HCWs in this study ever tested for COVID-19 (13). Underreporting of the SARS-CoV-2 cases could have also been due to a high frequency of asymptomatic infection, although it is notable that over two-thirds of the HCWs believed that they had COVID-19 even though they never tested, suggesting that most were symptomatic. Similar reports have been confirmed in other settings in SSA (25).

These findings highlight the importance of testing for infections like COVID-19 in HCWs and other key populations where occupational exposure is high, to ensure mitigation

strategies/prevention control measures are appropriately implemented. Estimates that rely on the "confirmed" cases underestimate the burden by a large margin when testing coverage is so low and has limited reliability in planning and allocation of resources (25,26). Our study findings also highlight the need for the rapid development of affordable and easily accessible diagnostics in pandemics such as these, particularly in LMICs. (18).

HCW vaccination rates were low in this setting (37.3%). The uptake of the SARS-CoV-2 vaccine among HCWs in Tanzania is low compared to that of high-income countries but comparable to that of the community in Tanzania (27–29). HCWs who were vaccinated were more likely to have antibodies than those who were not vaccinated. It is well known that SARS-CoV-2 vaccines have been shown to protect against severe forms of the disease (30). As one of the ways to ensure that HCWs are protected during pandemics, vaccination should be prioritized and reasons hindering their uptake and acceptability should be examined and quickly addressed (29).

Anesthetists, and HCWs working in the laboratory and Obstetrics and Gynecology departments were more likely to have SARS-CoV-2 IgGs than HCWs from the EMD. Similarly, ward attendants were more likely to have SARS-CoV-2 IgGs than nurses. These findings likely reflect the higher risk of transmission among some cadres where contact with patients is longer, and who tend to be asymptomatic and infection control practices are less likely to be adhered to (7,31). Another notable finding was that female HCWs were less likely to have SARS-CoV-2 antibodies than male HCWs. Studies have shown that although the decay of SAR-CoV-2 anti-N is similar between males and females, females have a steeper decay of SAR-CoV-2 anti-S compared to males (32).

To our knowledge, this is the first study to determine the sero-prevalence of SARS-CoV-2 among HCWs from different cadres in Tanzania, both clinical and clerical, and the burden of SARS-CoV-

2 exposure and infection in this relatively low vaccinated population. There were some limitations. The study was conducted in tertiary-level hospitals located in Dar es Salaam limiting the generalizability of the results to other facilities and regions where transmission dynamics and exposure levels differ. Also, the tests used are limited in their ability to differentiate an active infection from a previous one as well as prior infection vs. vaccination.

In conclusion, the seroprevalence of anti-SARS-CoV-2 IgG among HCWs in this study was high. With only a third of HCWs vaccinated, these findings suggest widespread infection rather than vaccine-induced immunity. The high seropositivity even among those never diagnosed with COVID-19 indicates substantial underreporting, likely due to limited testing availability and potentially high rates of asymptomatic infection. Variations in seroprevalence were observed across hospital sites, the timing of recruitment, and healthcare worker roles, with certain cadres like anesthetists and ward attendants showing higher exposure rates. These findings highlight the critical need for improved infection control in healthcare settings, enhanced testing capacity and accessibility, better vaccination coverage among HCWs, and targeted protective measures for high-risk healthcare cadres.

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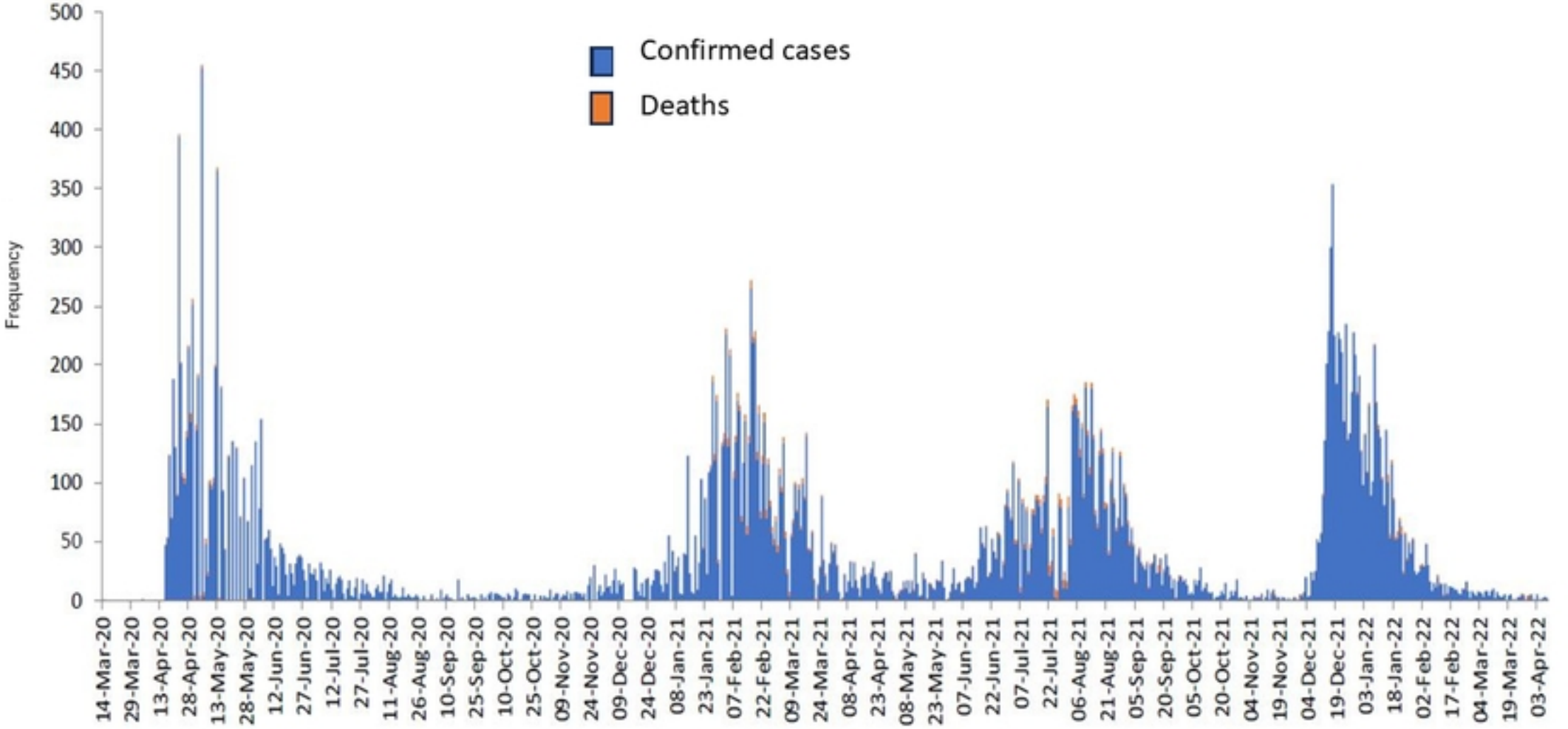
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Deaths
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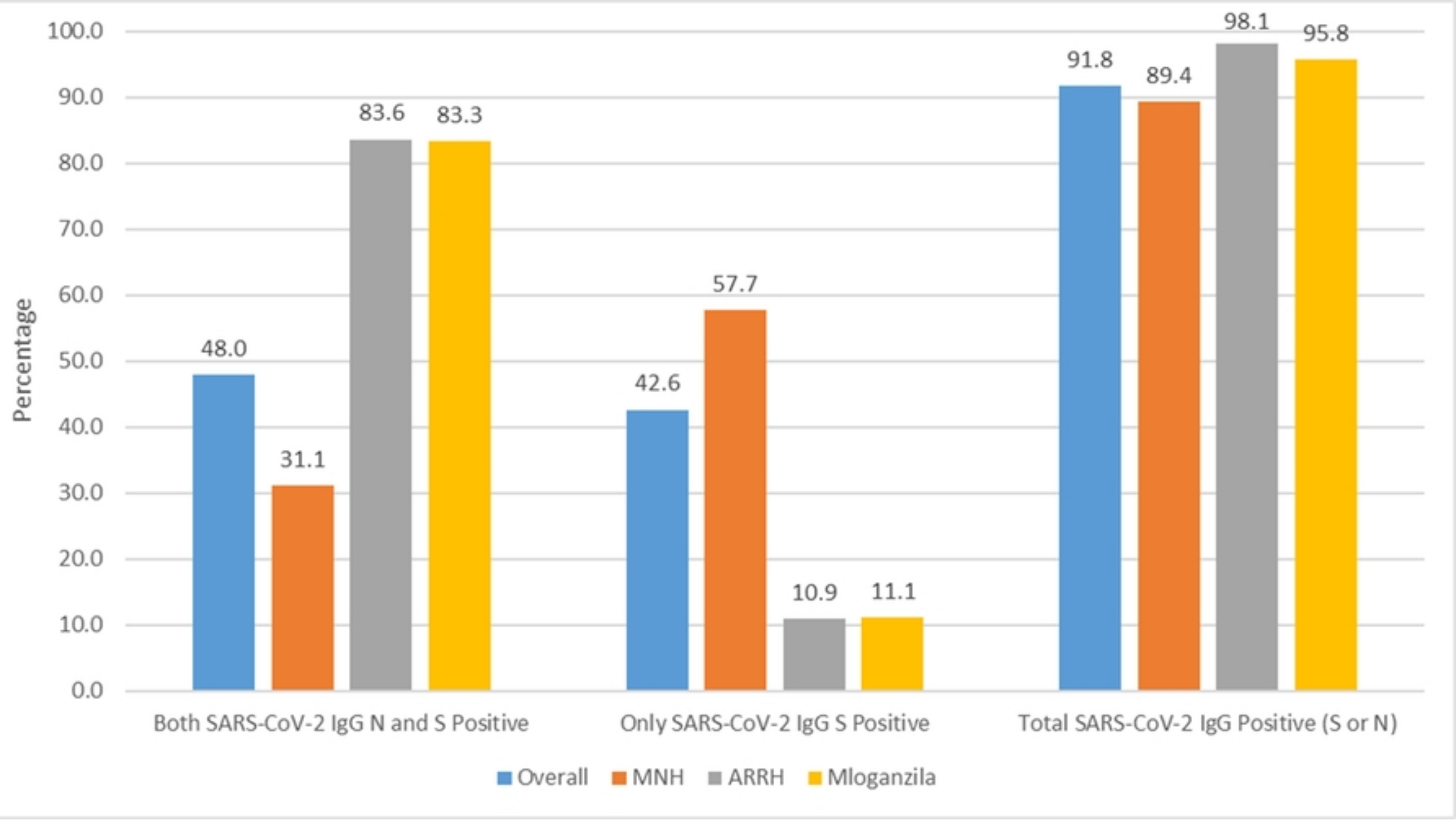
Figure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Both SARS-CoV-2 IgG N and S Positive
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Total SARS-CoV-2 IgG Positive (S or N)
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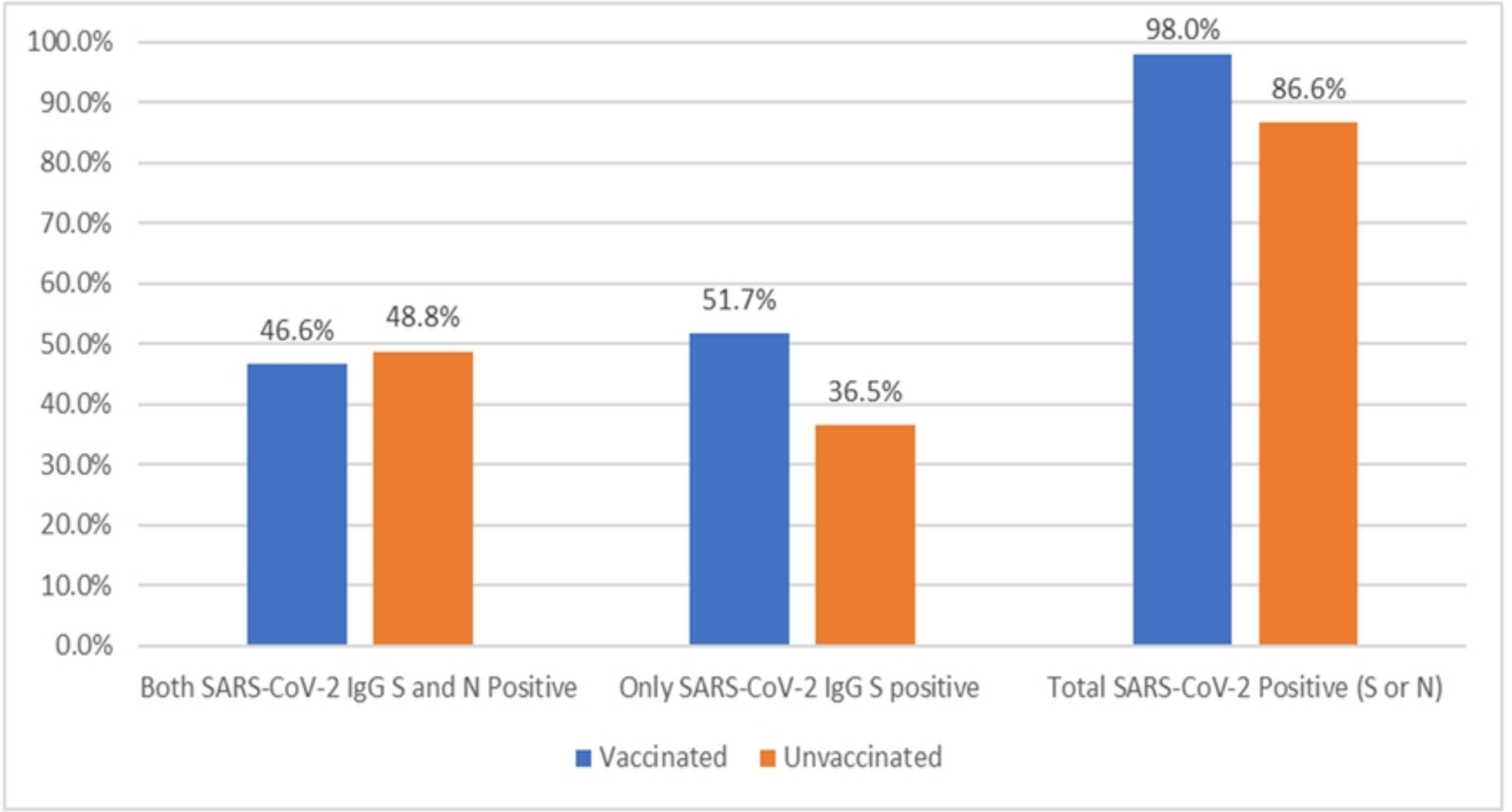
ARRH
Mloganzila

Figure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36.5%
98.0%
86.6%
Both SARS-CoV-2 IgG S and N Positive
Only SARS-CoV-2 IgG S positive
Total SARS-CoV-2 Positive (S or N)
Vaccinated
Unvaccinated

Figure