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COVID-19 vaccine effectiveness against severe acute respiratory infections (SARI) hospitalisations associated with laboratory-confirmed SARS-CoV-2 in Ghana, June 2022 to March 2024☆

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ABSTRACT

Background: The use of vaccines to urgently respond to the COVID-19 pandemic generated the need for monitoring vaccine effectiveness in the context of new viral variants and changing epidemiology. This study measured the COVID-19 vaccine effectiveness (VE) against laboratory-confirmed SARS-CoV-2 in hospitalised patients diagnosed with severe acute respiratory infections (SARI) in Ghana.

Methods: This was a test-negative, case-control study, among patients aged ≥15 years, attending 32 hospitals that participate in influenza surveillance system between June 2022 and March 2024. Naso-and oropharyngeal swabs were tested for SARS-CoV-2 by PCR. Medical and vaccination data were obtained. VE was estimated as one minus adjusted odds of vaccination among participants, expressed as a percentage, and the reference was either unvaccinated cases (absolute VE) or unvaccinated plus those vaccinated >12 months prior to symptom onset (annual VE).

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Results: Of 1974 SARI patients, 1796 (91%) were enrolled, including 929/1796 males (52%) and 867/1796 females (48%); 41% were above 60 years old. At least one chronic medical condition was reported in 167/1796 (9%) participants. A total of 118/1796 (7%) tested positive for SARS-CoV-2, of whom 29 (25%) have received at least one dose of vaccine (Sputnik V, Vaxzevria, JCovden, or Comirnaty). Of the 1678 (93%) who tested negative for SARS-CoV-2, 412 (25%) received at least one dose of vaccine. Among pregnant women ($n = 50$), 5 (10%) tested positive for SARS-CoV-2 Absolute and annual VE against COVID-19 SARI hospitalization were respectively 22% (95% CI, −107–70) and 19% (95% CI, −113%–50%) for last dose of vaccine received up to 179 days prior but waned after 6 months.

Conclusion: COVID-19 vaccines may have prevented COVID-19-associated SARI hospitalizations in the first 6 months over the study period in Ghana, and a pattern of protective effective was observed, consistent with report from other settings, although effect estimates were imprecise.

1. Introduction

The outbreak and the spread of SARS-CoV-2 infection in Wuhan, China, in December 2019 not only caused a heavy medical burden and economic stress but became a serious threat to human survival. The World Health Organization (WHO) declared COVID-19 infection a public health emergency of international concern (PHEIC) on 30 January 2020, and on 11 March 2020, declared it a global pandemic [1]. In January 2022, WHO had recorded more than 298 million confirmed cases and over 5.4 million deaths globally [2]. To curb transmission and save lives, public health measures including restriction of movement were instituted in many countries [3].

COVID-19 vaccines were developed with stunning speed in 2021 and were deployed globally under emergency use authorization to contain the pandemic. In the African region, the first COVID-19 vaccinations were administered in March 2022 [4]. By August 2021, 18 vaccines had been approved and licensed and 105 were in clinical development [5–7]. The deployment of the COVID-19 vaccines amid the evolving epidemiology of the disease required effective monitoring of vaccine effectiveness (VE). The WHO Regional Office for Africa (AFRO) established a technical network of partners and countries in May 2021, known as the African Region Monitoring Vaccine Effectiveness (AFRO-MoVE) Network. This network initiated and provided technical and financial support for COVID-19 VE studies, promoted knowledge-sharing and fostered collaborations [8].

Ghana's first case of COVID-19 was detected on 12 March 2020, and available data from the Ghana Health Service (GHS) indicated that, by 13 December 2021 when the study began, there had been 132,132 confirmed cases including 1258 deaths reported and there were 1174 active cases [9]. All 16 administrative regions in Ghana recorded COVID-19 cases and deaths. COVID-19 vaccination in Ghana started a year after the first case detection on 01 March 2021 and all persons living within the geographical boundaries of Ghana, who were in the vaccine target group of those aged 15 years and older were vaccinated. By 20 December 2021, 6,924,267 persons had been vaccinated with 5,181,753 (26% of the entire population) receiving a single dose and 2,005,844 (10%) receiving two doses of the primary series [4,10]. The vaccines administered included Vaxzevria (Oxford-AstraZeneca), JCovden (Johnson and Johnson), Spikevax (Moderna), Sputnik V (Gam-COVID-Vac), and Comirnaty (Pfizer-BioNtech). In general, Ghana recorded medium vaccination coverage with mostly primary series, but occasional booster doses. Primary schedules were more frequently administered as homologous schedules, with different products used as boosters.

Monitoring and evaluating the performance of COVID-19 vaccines post-licensure is critical, as several factors can impact real-world VE, including transportation and storage conditions, vaccine administration, vaccine recipient's age, presence of underlying medical conditions, and previous SARS-CoV-2 infection [11]. In addition, post-licensure evaluations of pandemic vaccines allow public health authorities not only to understand the duration of protection of the vaccines and thus advise on the need for re-vaccination but also to estimate the level of protection against severe disease or death, assess the relative effectiveness of different vaccine types and doses, and evaluate VE against new and emerging virus variants [12,13].

The nationwide COVID-19 vaccination campaign was carried by the Ghana Health Service

(GHS) personnel with vaccination taking place in hospitals and community setting, including house-to-house delivery. Individuals were vaccinated depending on the types of vaccine available and were free to decide whether to go for vaccination. As and when booter vaccines became available, they were given to the population.

Emerging data on vaccine protection against severe disease caused by SARS-CoV-2 has been mixed [14,15]. Some immunological studies showed evidence of immune evasion by some variants of the COVID-19 virus, especially Omicron, with decreased neutralization from either vaccine sera or monoclonal antibodies compared with previous variants such as Alpha, Beta, etc. [16,17]. Recent evidence suggests a rapid decline over time in antibody titres after booster doses [18].

With severe disease as the main outcome, this study aimed to leverage existing viral disease surveillance in Ghana to measure overall and product-specific COVID-19 vaccine effectiveness (CVE) against laboratory-confirmed SARS-CoV-2 in hospitalised severe acute respiratory infection (SARI) patients, aged 15 years and older.

2. Material and methods

2.1. Study settings

The study was conducted in 32 hospitals and leveraged the National Influenza Surveillance scheme which has been running for more than a decade and is part of the WHO Global Influenza Surveillance and Response System (GISRS). GISRS is a surveillance system comprising of laboratories and collaborating hospitals that collect and analyse specimens from patients with influenza-like illness during influenza season with the sole objective to protect global public health by monitoring influenza viruses in circulation. The surveillance system serves as a global alert mechanism for the emergence of novel influenza viruses with pandemic potential and this system was used for COVID-19 surveillance [19].

The National Influenza Centre (NIC) of the Noguchi Memorial Institute for Medical Research (NMIMR) of the University of Ghana (UG), Legon, in conjunction with the Ghana Health Service (GHS), WHO, US CDC, Ghana Armed Forces Health Directorate and US NAMRU-3, conducts surveillance for influenza virus year-round in Ghana. The surveillance sentinel sites are distributed across all 16 regions in the country and are categorised into the Ghana Health Service and Military Sites. Existing staff who were knowledgeable in sample collection and completion of the study tools were trained for the study procedures. These staff used the existing sample storage and transport system to quickly send samples for analysis at the NMIMR, using established testing protocols [20]. This study was augmented with a REDCap data collection tool that seamlessly combined extracted hospital records from the sentinel sites results and sample laboratory results

from NMIMR [21,22].

2.2. Study design and recruitment

A test-negative, case-control designed was employed, where cases were the hospitalised SARI patients who tested positive for SARS-CoV-2 and controls were hospitalised patients who tested negative for SARS-CoV-2 by real-time (RT) PCR. The WHO AFRO-MoVE network protocol was adopted [20]. We defined SARI as a hospitalised patient with history of fever or measured fever of ≥38 °C and cough, with onset of symptoms within 10 days of admission, swab taken for a COVID-19 test and a minimum of 24 h in hospital [23]. We defined SARI patients as vaccinated if they had received their last primary dose at least 7 days prior to symptom onset, and we excluded patients from the analysis if they had received their last vaccine less than 7 days before their symptom onset. Participants meeting inclusion criteria were recruited between June 2022 and March 2024. The surveillance team, comprising medical doctors, nurses, and other health professionals, systematically screened hospitalised patients in the general medical wards, using the SARI case definition and the inclusion criteria. All those who fulfilled these inclusion criteria provided informed consent and were enrolled into the study. All eligible patients were swabbed at enrolment within 24 h at admission after which clinical and vaccination data were collected electronically using the Redcap App on a hand-held tablet. Vaccination records were verified using patients' vaccination records (i.e. COVID-19 vaccination cards) and hospital records, as Ghana does not have a national vaccine registry for verification. Patients who did not have their vaccine cards at the time of recruitment were followed up at home and their status verified. Prior COVID-19 infection data for patients were not available.

Nasopharyngeal or oropharyngeal respiratory samples were collected from the enrolled patients who met the study criteria. All samples were preserved in viral transport medium and were packaged and transported in carrier boxes within 3 days to a centralized laboratory at the NMIMR for PCR testing for SARS-CoV-2.

2.3. Laboratory testing and analysis

Viral RNA was extracted from the patient samples, following the manufacturer's extraction kit protocol [24]. Briefly, viral RNA was extracted from 140ul of each sample using the Qiagen viral RNA mini kit (Qiagen, Germany). All purified RNA extracted were first tested by one step RT-PCR, using the AgPath-ID one-step RT-PCR kit (Applied Biosystem, USA) or SuperScript III Platinum One-Step quantitative RT-PCR kit (Invitrogen, USA). Viral antigen detection, characterization and subtyping was conducted using specific primers and probes described by the United States Centre's for Disease Control and Prevention (US.CDC) for SARS CoV-2 [25] using Multiplex RT-PCR. PCR results were analysed using standardised cycle threshold values which were exported to excel and synchronised into REDcap for analysis.

2.4. Statistical analysis

Descriptive statistics were described as absolute frequencies (n) and relative frequencies (%) for the study's categorical variables. Chi-squared analysis was performed for the participants' sociodemographic characteristics and the SARS-CoV-2 status. Statistical significance was accepted as $P < 0.05$. All analyses were made with IBM SPSS statistics version 22.0.

For our primary analysis, we estimated VE for any vaccine received within the previous 12 months, regardless of the number of doses. Logistic regression analysis was used to assess the relationship (odds ratios) of demographic factors with SARS-CoV-2 status, and we compared the odds of vaccination between test-positive cases and test-negative controls. Adjustment for time (date of swab modelled as month or as restricted cubic spline), sex, age group and presence of at least one of the 11 underlying chronic conditions relevant to COVID-19 (diabetes, heart disease, chronic lung disease and asthma, disorders of lipid metabolism, immunodepression, hypertension, renal disease, cancer, liver disease, obesity) was carried out in the regression model. Vaccine effectiveness was estimated as one minus the adjusted odds of vaccination among cases and controls, expressed as a percentage.

For this analysis, annual and absolute VE were calculated. The annual VE takes into account that all patients who had received a vaccine dose more than 12 months previously would have less protection from the vaccine. Therefore, the reference group used was those who have not been vaccinated plus those who received their last dose of vaccine more than 12 months prior to symptom onset. The absolute VE considered only those who had never received any vaccines as reference group. No adjustment could be made with respect to previous COVID-19 infection, as these data were unavailable.

2.5. Ethics statement

Written informed consent for sampling and questionnaire administration was obtained from each of the participants. The protocols and consent forms were reviewed and approved by the Kintampo Health Research Institutional Ethics Review Committee (Federal Wide Assurance number: KHRCIEC/2022–6) and the Ghana Health Service Ethics Review Committee (Federal Wide Assurance number, GHS-ERC:010/01/22) prior to study implementation.

3. Results

3.1. Demographic and clinical characteristics of study participants

Out of the 1974 SARI patients hospitalised and screened for SARS-CoV-2 between 21 June 2022 and 31 March 2024 in the 32 sentinel hospitals, 1796 were eligible for inclusion in the study. One hundred and eighteen (6.6%) patients tested positive by PCR for SARS-CoV-2 with only 29 (24.8%) being vaccinated with at least one dose of COVID-19 vaccine. One thousand, six hundred and seventy-eight (93.4%) patients tested negative for SARS-CoV-2, of whom 412 (24.6%) had received at least one dose of vaccine and 1266 had not received any COVID-19 vaccine [Fig. 1].

The median ages of cases and controls were 42 and 44 years, respectively. There were more male (929/1796, 51.7%) than female (867/1796, 48.3%) SARI patients, but more female SARS-CoV-2 cases (60/118, 50.8%) [Table 1]. Among pregnant women aged 15–49 years ($n = 50$), only 5 (10%) tested positive for SARS-CoV-2. In total, 167/1796 (9.3%) SARI patients had one or more chronic condition: chronic conditions were significantly less frequent among SARS-COV-2 positive cases than controls ($p = 0.0003$) (Table 1).

The number of vaccinated patients among cases and controls were 29/118 (24%) and 412/1678 (24.6%) respectively. No booster vaccine doses were received by any patients included in the analysis (Table 1). The median days since last vaccine dose were the same for both groups (329 days). The main vaccines taken by the patients include Pfizer, Oxford, Sputnik-V and Moderna. Less than 5% of patients reported having been vaccinated with either Modena or Sputnik-V and for cases, none had received Moderna either as partial or complete primary series (Table 1).

Compared with controls, a higher proportion of cases 4/118 (3.4%) were admitted to intensive care for clinical support and observation ($p = 0.46$) (Table 1). The median length of hospital stay was similar in cases and controls ($p = 0.77$). The proportion of deaths was higher among cases 7/118 (5.9%) than controls 54/1678 (3.2%); $p = 0.11$) (Table 1).

Over the 2-year period, the enrolment of cases peaked during the dry season of 2022 where B.1.1.529 and BA predominated [26] and continued with intermittent smaller peaks throughout 2023. The enrolment of controls was highest in 2022 but was also high during the

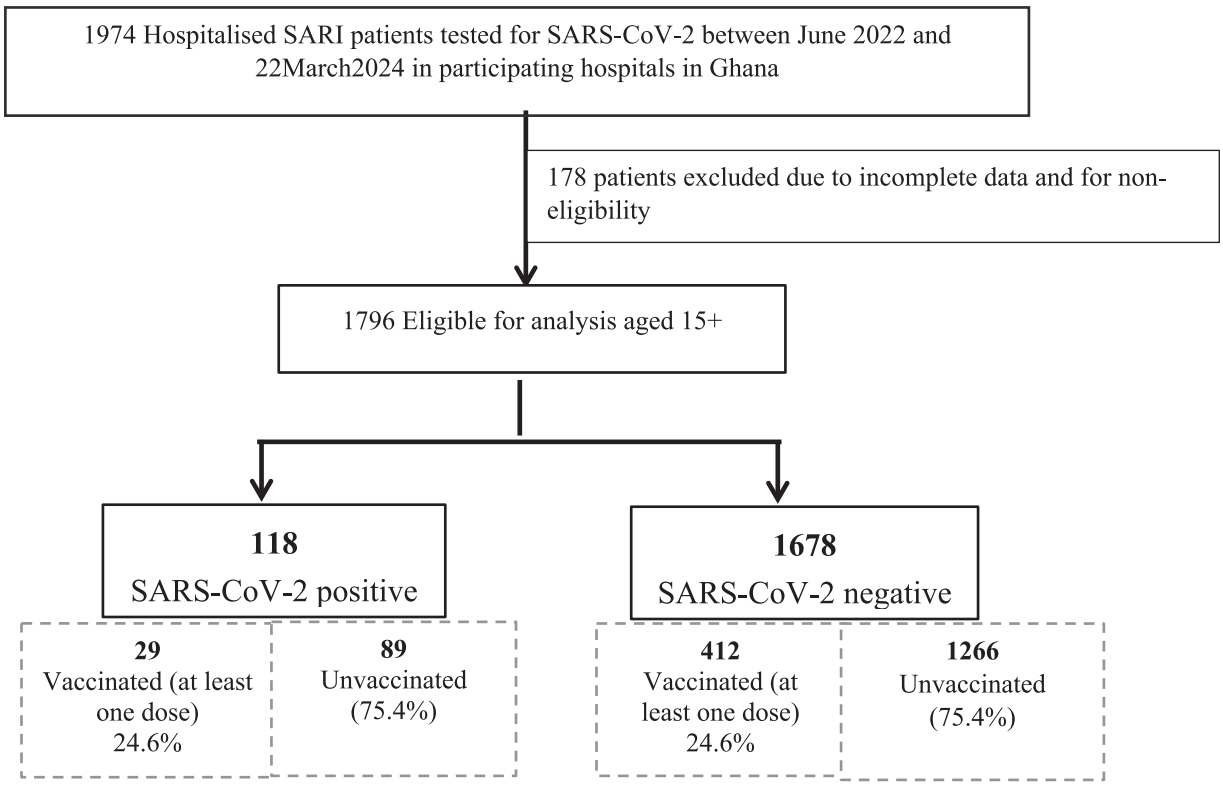

Fig. 1. Recruitment, exclusion and status of participants, June 2022–March 2024, Ghana.

dry months of 2022 and later in 2023 (Fig. 4).

3.2. *Vaccine effectiveness by time since vaccination of last vaccine dose received*

The annual VE against COVID-19 between 7 and 179 days (the first 6 months) of vaccine administration was 19.3% (95% CI, −113.2% to 50.2%), whilst the absolute VE was 21.6% (95%CI, −107.0 to 70.3%). After 6 months (180–364 days) of receiving the vaccine, the annual VE was 5.6% (95% CI, −83.0 to 51.3%) and absolute VE was 8.6% (95% CI, −77.6% to 53.0%) (Fig. 2).

A similar VE was observed for those receiving two doses of primary series (Fig. 3). In all cases, the wide confidence interval indicates the low precision of the VE estimate as a result of the small number of SARS-CoV-2 positive cases detected during the study (See Fig. 5).

The year and weekly sample collection for all participants for the study period.

4. Discussion

This study evaluated the effectiveness of COVID-19 vaccines administered to Ghanaians aged 15 years and older from June 2022 to March 2024. Analysis of 1796 vaccinated and unvaccinated patients estimated that COVID-19 vaccination (overall) prevented one in five COVID-19-associated SARI hospitalizations in the first 6 months following vaccination, however the effect estimates were imprecise due to a limited sample size, in particular a small number of participants testing positive for SARS-CoV-2. The study also could not measure effect of vaccination for the 6–12 months post-vaccination timeframe.

The results also showed a moderate VE for the last dose of any COVID 19 vaccine received against SARI hospitalization during the Omicron circulation at the time COVID-19 vaccines were deployed in Ghana [27]. The waning protective effectiveness observed is consistent with reports from other settings [28]. A differential analysis performed showed similar results between annual and absolute VE estimates (Fig. 2) within 6 months of vaccine administration and beyond. In estimating annual VE, unvaccinated individuals together with those who received their last vaccine more than 12 months before symptom onset were made as reference, consistent with the 2023 SAGE recommendations. Evaluating "annual" vaccination could be used in the future to align with the recent WHO COVID-19 vaccine recommendation where high-risk individuals should receive another COVID-19 vaccine every 6–12 months, regardless of their previous vaccination history.

In Ghana, COVID-19 vaccines were administered in a nationwide mass vaccination campaign initiated in 2021 where individuals received the approved vaccines based on vaccine availability. The campaign continued during Omicron circulation from 2022 to 2024, achieving a national vaccine coverage of 47% as of February 2024 [29]. In this study, a quarter of respondents had received at least a COVID-19 primary series (PS) vaccine while nearly 75.4% (1355/1796) had not received any kind of COVID-19 vaccine (PS or booster) in the 12 months prior to symptom onset. WHO recommended that more than 70% of any population should be vaccinated, and models supported the need for very high vaccine coverage to provide herd immunity [30], but this has proven unachievable in Ghana due to operational, logistical, and vaccine acceptance challenges. In March 2021, Ghana received its first batch of million doses of AstraZeneca and other vaccine types through the COVID-19 Vaccine Global Access (COVAX) global sharing program [31]. However, due to irregular supply and logistical setbacks, the country started rationing doses received, which led to a non-continuous vaccine availability, affecting the total number of people vaccinated over time. This could account for many people not getting vaccinated over the period. The low vaccine coverage in the study population could be attributed to vaccine rejections and hesitations, coupled with anti-vaccine activities in some communities which may have affected individuals' intentions to vaccinate against COVID-19 [32,33].

Our estimated VE was low compared to other studies. A study of similar design conducted in Eastern Europe between 2022 and 2023 estimated COVID-19 VE at 60% in the first six months following vaccination. The same study also could not measure a protective effect after

Table 1
Demographic and clinical characteristics of SARI patients stratified by SARS-CoV-2 cases and controls, June 2022 to March 2024 ($N = 1796$).

Patient characteristic	All SARI patients (N = 1796)		SARS-CoV-2 cases ($n = 118$)		Test negative controls ($n = 1678$)	
	Number	%	Number	%	Number	%
Median age (years), IQR	44 (30–60)		42 (30–60)		44 (30–60)	
Age groups (years)						
15–59	1051	58.5	86	76.8	1241	77.7
60–79	624	34.7	24	21.4	324	20.3
≥80	121	6.8	8	6.8	113	6.7
Sex						
Male	929	51.7	58	49.2	871	51.9
Female	867	48.3	60	50.8	807	48.1
Pregnant (among females aged 15–49 years)	$N = 514$		$n = 40$		$n = 474$	
No	464	90.3	35	87.5	429	90.5
Yes	50	9.7	5	12.5	45	9.5
At least one chronic condition[a]						
No	1629	90.7	316	31.3	1611	38.8
Yes	167	9.3	693	68.7	2545	61.2
Obesity						
No	1728	96.2	113	95.8	1615	96.2
Yes	68	3.8	5	4.2	63	3.8
COVID-19 vaccination status						
Unvaccinated	1355	75.4	89	75.4	1266	75.4
Partial primary series (one dose only)	128	7.1	9	7.6	119	7.1
Complete primary series (two doses)	313	17.5	20	16.9	293	17.5
Median days since last dose (IQR)	344 (230–542)		329 (215–523)		329 (210–483)	
Time since last dose for vaccinated (days)	$N = 441$		$n = 29$		$n = 412$	
7–179	75	17.0	5	17.2	70	17.0
180–364	163	37.0	11	37.9	152	36.9
>365	203	46.0	13	44.8	190	46.1
Vaccine product (last dose received) among partially vaccinated ($n = 127$ missing = 1)						
Oxford	87	68.5	6	75.0	81	68.1
Pfizer (BNT162b2)	36	28.3	2	25.0	34	28.6
Moderna	0	0.0	0	0.0	3	2.5
Sputnik-V	0	0.0	0	0.0	1	0.8
Vaccine product (last dose received) among those with complete primary series ($n = 300$ missing = 13)						
Oxford	203	69.6	11	61.1	192	66.4
Janssen	70	20.0	6	33.3	54	18.7
Pfizer (BNT162b2)	36	12.0	1	5.6	35	12.1
Moderna	1	0.3	0	0.0	1	2.8
Required oxygen in hospital						
No	1432	79.7	96	81.4	1336	79.6
Yes	349	19.4	22	18.6	327	19.5
missing	15	0.9	0	0.0	15	0.9
Admitted to intensive care						
No	1753	97.6	114	96.6	1636	97.5
Yes	45	2.4	4	3.4	41	2.4
missing	1	0.0	0	0.0	1	0.1
Mechanical ventilation and/or ECMO and/or Intubation in hospital						
No	1333	74.2	93	78.8	1240	73.9
Yes	434	24.2	25	21.2	409	24.4
missing	*29*	*1.6*	*0*	*0.0*	*29*	*1.7*
Outcome						
Discharged home	1735	96.6	111	94.1	1624	96.8
Died in hospital	61	3.4	7	5.9	54	3.2
Median length of hospital stay in days (IQR)	5 (3–9)		4 (3–8)		5 (3–9)	
Length of hospital stay (days)						
1–7	1255	69.9	88	74.6	1167	69.6
≥ 8	541	30.1	30	25.4	511	30.4

[a] At least one of the following 11 chronic conditions: anaemia, asthma, cancer, diabetes, heart disease, immunodepression, liver disease, chronic respiratory disease, obesity, rheumatic disorders, renal disease.

six months following vaccination [34]. In a surveillance conducted for nearly 2.5 years in Europe, many lives were saved (1.4 million) by COVID-19 vaccination in adults by first booster dose during the Omicron period (WHO European Respiratory Surveillance Network, 2024) [35]. A staggered cohort study in the UK, Spain, and Estonia showed the positive effect of COVID-19 vaccination in risk reduction for long-term COVID symptoms [36].

A survey in Ontario found the effectiveness of two doses of COVID-19 vaccines against symptomatic infection to be substantial for Omicron, with estimated VE of 61% after 7 days. Against severe outcomes, including hospitalization and death, the VE following a third dose for Omicron was estimated at 95% [95% CI 87–98%] [37].

Waning in protection was evident after 6 months of vaccination in both the annual and absolute evaluations, consistent with reports in other settings [34]. An observational study in Malaysia demonstrated waning COVID-19 VE for BNT162b2 and CoronaVac COVID-19 vaccines [38]. A substantial waning of COVID-19 VE against symptomatic infection was observed in Qatar following administration of two vaccine doses [39]. A test-negative, case-control study in the US similar to the current study and also in the Omicron period, demonstrated waning of mRNA vaccines over time against moderate and severe COVID-19 by the fourth to fifth month after vaccination [40].

Vaccines against the ancestral strain of SARS-CoV-2 showed lower VE than against previous stains [28]. Moreover, adenovirus-vector vaccines performed poorly compared to mRNA vaccines, and waning of protection was rapid in the absence of booster. The study was carried out during a period of Omicron variant dominance, which likely contributed to the low effectiveness measured. In addition, close to 70% of participants had been vaccinated with adenovirus-vector vaccines (Oxford or Janssen products) and only few received mRNA-based vaccines (Table 1). Booster vaccination showed an important role in protecting against SARS-CoV-2 Omicron-related disease but were rare in Ghana. A report by the US Centres for Disease Control (CDC) indicates that VE against COVID-19-associated emergencies and hospitalizations had been higher after the third dose but waned with time. During the Omicron-predominant season, the VE against COVID-19 hospitalizations was high, particularly 2 months after a third dose, but there were down trend effects after the fourth dose [41,42]. In this study, a single VE was measured for the first six months post- vaccination, which also may have led to a lower estimate.

Older age and the presence of chronic conditions are factors that can reduce the effect of vaccination. Among this study's participants, less than 10% of SARI patients reported chronic medical conditions and less than 30% of patients were aged >60 years. These factors are therefore unlikely to be contributing factors for the low VE measured in this study, even if comorbidities may be under-reported in SARI surveillance data.

The waning protection as observed in this and other studies highlights the need for booster vaccinations, regardless of previous number of doses received, especially for high-risk individuals [43,44].

As pockets of COVID-19 cases are occasionally reported in some geographical regions of Ghana, especially the Greater Accra and Kumasi enclaves [45,46], the Ghanaian health authorities could implement annual vaccination in the national program to align with recent WHO COVID-19 vaccine recommendation. It is important that the Ghana Government source funding to ensure continuity in COVID-19 vaccine supply for equity in the vaccine distribution, as new viral strains keep resurfacing and also against the backdrop that vaccine supplies from COVAX are gradually dipping after the pandemic.

It is possible that people's attitudes to COVID-19 vaccination in Ghana will change over time as more pro-vaccination information is provided by health authorities and policymakers, especially regarding the vaccine effectiveness and safety. The integration of the COVID-19 vaccine into the national immunization programs will ensure easy access and availability to majority of the people, including the high-risk groups.

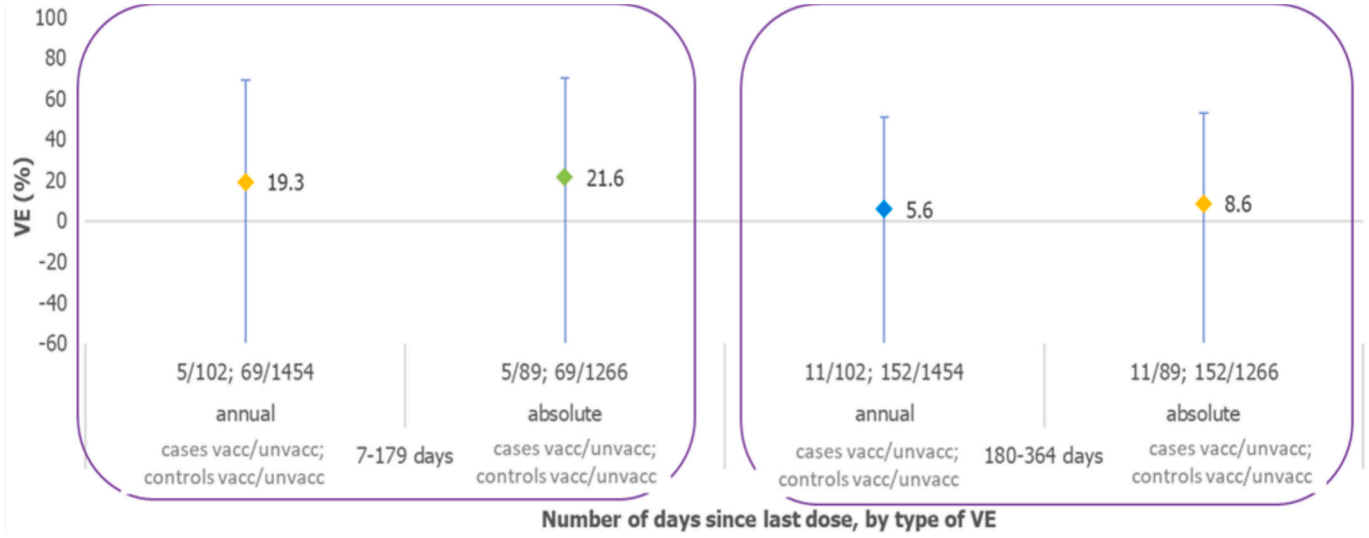

Fig. 2. Annual and Absolute COVID-19 vaccine effectiveness against SARS-CoV-2-confirmed hospitalization for SARI, among adults aged ≥15 years old, by 6-month intervals since date of last vaccine, 2022–2024, Ghana (n = 1454 (annual VE) vrs 1266 (absolute VE) in the 7–179 days group and same numbers in the 180–364 days group).

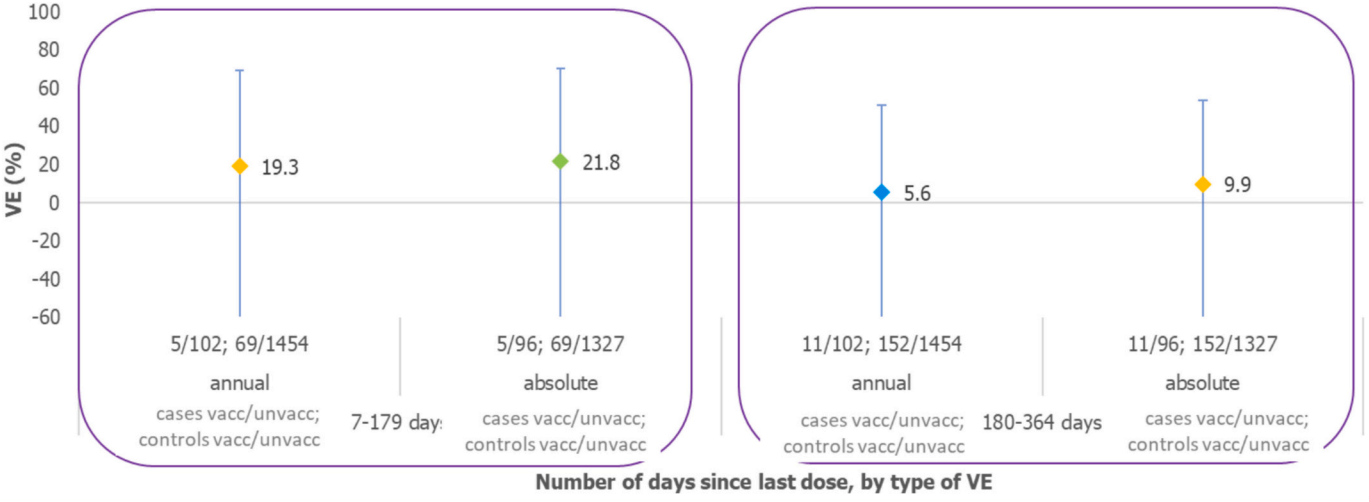

Fig. 3. Annual and absolute COVID-19 vaccine effectiveness among adults aged ≥15 years old, by 6-month intervals for patients who received two doses of vaccine, 2022–2024, Ghana (n = 1454, annual VE) vrs 1327 (absolute VE) in the 7–179 days group and same numbers in the 180–364 days group).

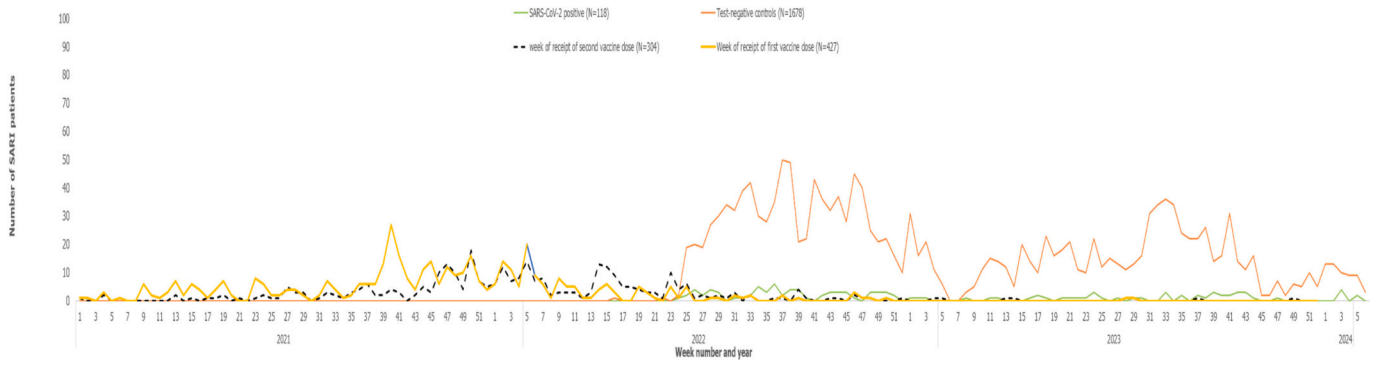

Fig. 4. Year and week of sample collection of SARS-CoV-2-positive cases and SARS-CoV-2-negative controls, dates of receipt of first and second vaccine doses, among vaccinated SARI patients included into the study from, June 2022–March 2024.

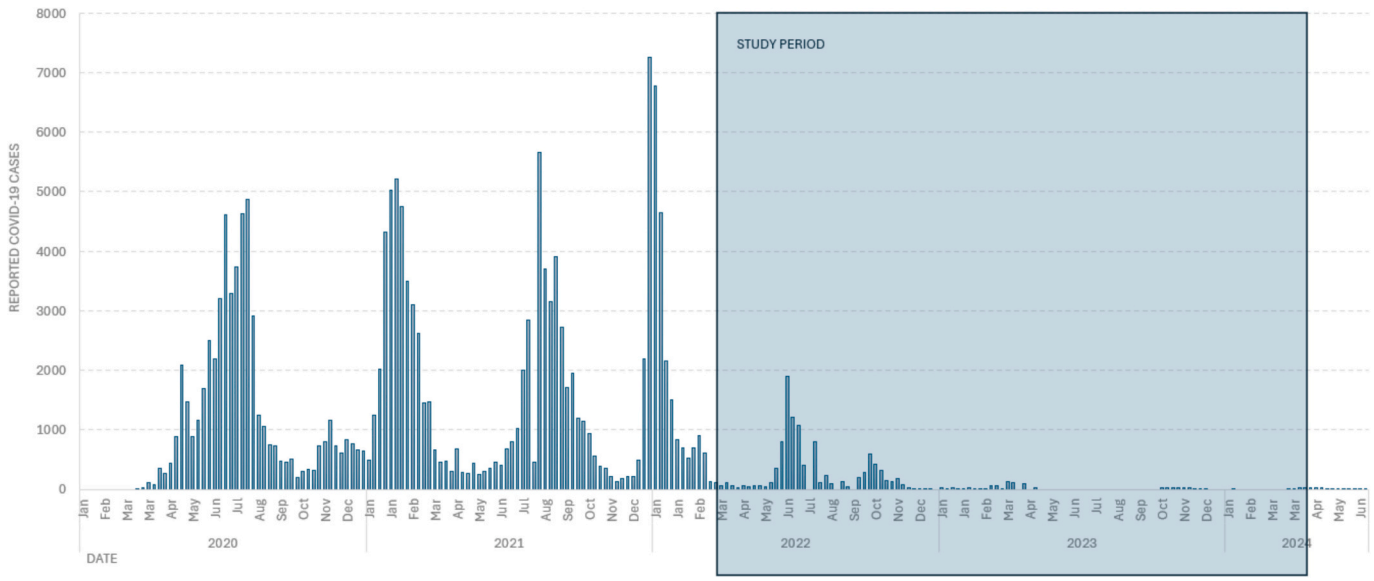

Fig. 5. Weekly number of cases of COVID-19 reported to WHO by Ghana, January 2020 to Jun 2024 (adapted from WHO Dataset https://data.who.int/dashboards/covid19/data, accessed 27 June 2025).

4.1. Limitations

As per study design, the SARS-CoV-2 test was performed after enrolment and test outcome determined categorization as either a case or control. The study was limited by the small number of COVID-19 cases relative to the control group. The small sample size resulted in wide confidence intervals [Fig. 3]. 9% of patients were excluded from analysis for not meeting analyses criteria and those not enrolled because of no evidence of vaccination at admission, which could present sampling bias. The long study duration, combined with low vaccine coverage and low booster uptake led to long median time since vaccination, resulting in low VE. The individuals used as reference might have acquired protection through natural infection and could impact the VE estimated. The limited samples size restricted analysis by age strata, vaccine product or estimate of adherence to infection prevention and control principles. Moreover, the lack of clear COVID-19 seasonality witnessed in Ghana creates a challenge for selection of optimal timing for an annual vaccine administration.

5. Conclusion

Moderate COVID-19 VE with wide 95% CIs was observed in our study, likely due to the limited sample size. Between 2022 and 2024, the vaccines deployed in Ghana may have reduced COVID-19 associated SARI hospitalization in the first 6 months after vaccination. However a waning in protective effectiveness was observed after six months, consistent with reports from other settings and reflecting potential benefit from booster vaccination.

5.1. Recommendation

Administration of booster doses should be widely promoted to address waning immunity. The moderate VE reported is a useful guide to health authorities in reviewing COVID-19 vaccination strategies in Ghana. Efforts towards effective and successful future vaccinations should focus on understanding the people's concerns about the new vaccines and the bottlenecks around the vaccine deployment and that, appropriate measures should be instituted to ensure a sustainable solution to overcome them. AFRO-MoVE and the surveillance network should be maintained and supported for monitoring of current and further VE efforts.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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