Received: 28 July 2022 | Revised: 8 December 2022 | Accepted: 12 December 2022

DOI: 10.1002/hsr2.1012

ORIGINAL RESEARCH

Health Science Reports Open Access WILEY

Prevalence of common adverse events experienced following COVID-19 vaccination and its associated factors in Ghana: Cross-sectional study design

Naa A. A. Boi-Dsane[1] | Bartholomew Dzudzor[1] | Yakubu Alhassan[2] | Justice M. K. Aheto[2,3]

[1]Department of Medical Biochemistry, University of Ghana Medical School, Korle-Bu, College of Health Sciences, University of Ghana, Accra, Ghana

[2]Department of Biostatistics, School of Public Health, College of Health Sciences, University of Ghana, Accra, Ghana

[3]WorldPop, School of Geography and Environmental Science, University of Southampton, Southampton, UK

Correspondence

Justice M. K. Aheto, Department of Biostatistics School of Public Health, College of Health Sciences, University of Ghana, Accra, Ghana.
Email: justiceaheto@yahoo.com and jmkaheto@ug.edu.gh

Abstract

Background and Aims: The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (COVID-19) pandemic devasted the general life of people and various human activities across the globe, and Ghana is of no exception. This led to development of vaccines within record time to combat morbidity and mortality associated with the virus. In Ghana, COVID-19 vaccines were introduced in addition to existing COVID-19 protocols. However, the vaccines have adverse events among those who received them. In this study, we determined the prevalence of some common adverse events of the COVID-19 vaccines and its associated socio-demographic factors in Ghana.

Methods: An online snowball cross-sectional survey was conducted between April and June 2021 among 240 people who had taken at least one dose of any of the COVID-19 vaccines approved in Ghana. The penalized binary logistic regression model was used to assess the factors associated with experience of at least one adverse event and the experience of number of adverse events using Stata version 16.

Results: Among the 240 participants, 88.2% had experienced at least one adverse event. The most common adverse event after the first dose was pain at injection site (65.8%), headache (57.5%), tiredness (55.8%), fever (51.7%), chills (39.6%), and muscle pains (38.3%). Experience of adverse events was 16 times higher among those who took their vaccines in Ghana (adjusted odd ratio [AOR]: 16.2, 95% confidence interval [CI]: 1.98–132.56, $p = 0.009$), 94% less among those who took AstraZeneca (India) compared to AstraZeneca (Oxford) (AOR: 0.06, 95% CI: 0.01–0.37, $p = 0.002$) and 86% less among 40–49 years compared with less than 30 years old (AOR: 0.14, 95% CI: 0.03–0.58, $p = 0.007$).

Abbreviations: AUROCC, area under the receiver operating characteristics curve; VIF, variance inflation factor.

Naa A. A. Boi-Dsane and Bartholomew Dzudzor contributed equally to this work.

Conclusion: Pain at the injection site, headache, tiredness, fever, chills, and muscle pains were the most frequently reported adverse events. The study identified country of vaccination, country of origin of AstraZeneca vaccine and age to be associated with adverse events of vaccination.

KEYWORDS

adverse events, adverse events predictors, COVID-19, COVID-19 diagnosis, SARS-CoV-2, vaccination, vaccine

1 | BACKGROUND

Coronavirus disease 2019 (COVID-19) virus is a well-known respiratory virus all over the world as one of the most damning pandemics ever to occur among others.[1,2] Since the first confirmed case in December 2019 in Wuhan province of China,[3] over half a billion (510 million) infections and 6.2 million case fatalities has been recorded as at end of April 2022.[4–6] In Ghana, over 160,000 cases of COVID-19 and 1400 deaths has been recorded within the same period since the first reported cases in March 2020.[7,8]

The effect of the pandemic has been gravely felt across the world especially in the first 2 years. Aspect of human life including socioeconomic[9,10] and psychosocial well-being[11–13] as well as health systems[14–16] among others has been negatively impacted by the pandemic. The case of Ghana is no different from the rest of the world in terms of the negative impact.[17–21] During the pandemic, lock down of major cities was enacted in the country, schools, businesses, and places of worships were closed, and restrictions of markets places were imposed. This affected the livelihood of the common Ghanaian gravely causing significant changes to the normal life of people as we knew it.

The severity of the pandemic lead to the development of vaccines to help reduce COVID-19 morbidity and mortality which led to an expedited formulation of vaccines to help protect and prevent the rate of transmission from the infected to the uninfected. Unlike previously developed vaccines, COVID-19 vaccinations were developed with record time, thus less than a year since the first case of the virus were reported.[22] Various pharmaceutical companies developed various vaccine doses to curb the transmission of the virus.[23]

The time taken to develop the vaccine was very short which brought about skepticism among people across the globe.[24,25] Why others, questioned the motives of the vaccines, others questioned the effectiveness of the vaccines. Others also questioned the long term and short-term negative effect of the vaccines on the general health of the vaccinated. Vaccines in general has been known to show some adverse events once taken.[26] However, these adverse events are normally short term usually lasting for 1–2 days.[27] In very rare cases, the adverse events of vaccine can be severe or fatal.[28,29]

Of the 13million people estimated to receive the vaccine by the World Bank, a total of 381,000 (2.9%) were fully vaccinated with Astrazeneca vaccines as of June 24, 2021 in Ghana, but the perception of taking the vaccines is mixed up among the general populace just like the rest of the world.[30–34] While some were eager to take up the vaccine doses, others were hesitant due to various reasons including effectiveness of the vaccines, short term adverse event, long term effect on their health whilst others questioned the general motives for issuing out the COVID-19 vaccines from foreign organizations to Ghanaians.[32,33]

Literature on the side effect (in our case, adverse events) of vaccination such as pain at injection site, tiredness, fever, and headache is well known across the world,[35–37] but literature is very scanty so far as Ghana is concerned.[38] The most recent information concerning side-effects of the Pfizer, Moderna, Johnson & Johnson and Novavax (after Phase III trials in June 2021) with over 30,000 participants with 50% getting the vaccine and the other half obtaining the placebo showed that the main side-effects were pain, fatigue and headache. Also, it was reported that 100,000 people worldwide who got the AstraZeneca COVID vaccine had thrombotic thrombocytopenia (a clotting disorder) and there have been 19 deaths from these in the UK. This same clotting disorder has been reported in Johnson & Johnson COVID-19 vaccine recipients. The usual period of occurrence of these known side-effects is 6 days to 2 weeks but usually not exceeding a month after vaccination. Rarer side-effects (about one in a million) include myocarditis which is when the heart muscle gets inflamed which has been reported in Pfizer and Moderna COVID-19 vaccine recipients. Also, according to the FDA in July 2021, about 100 people out of the 12.8 million people in the United States who received the Johnson & Johnson vaccine had symptoms of Guillain–Barre syndrome (presents like an ascending paralysis) which usually occurred in men >49 years and 2 weeks postvaccination.[39] What is unknown is which components of these individual vaccines might be causing these adverse drug reactions or side-effects. It is also not really known how the Delta variant or further mutations of the coronavirus would respond to vaccination. However, a study by Public Health England stated that two-doses of Pfizer-BioNTech was 88% effective people who had the Delta variant but with asymptomatic disease.[40] There is not much known in our region (Ghana) concerning side-effects of the vaccines especially since most of them were developed fairly recently and studies are still ongoing concerning this.

There is paucity of data on postvaccination safety to support adverse events following COVID-19 vaccination which is a driver of

vaccine hesitancy because the adverse events of COVID-19 vaccination in populations could lead to vaccination unwillingness which may act as a barrier to control the pandemic with its associated negative impacts.[41,42] Therefore, understanding expectations relating to adverse events following COVID-19 vaccination and its predictors is critical to increasing vaccine uptake in the population. This study therefore aims to describe the prevalence and profile the various adverse events experienced among people taking the COVID-19 vaccines in Ghana. This study further described the number of the adverse events and assessed the factors associated with the prevalence and the number of adverse events among people taking the COVID-19 vaccine.

2 | METHODS

2.1 | Study population

The study utilized cross-sectional study design to elicit the required data from the study participants. Recipients of at least one dose of vaccine were assessed for the adverse events. The data collection was done between April 12 and June 28, 2021. The data collection via google forms was adopted because of COVID-19 restrictions in place, and the difficulty in seeking approval for ethical clearance to do face-to-face interviews at the time of the study. Considering the COVID-19 protocols in Ghana and globally at the time, our approach completely supports social distancing, limit physical contact with participants and eliminates movements of researchers. Our approach also helped obtain responses very quickly amidst the COVID-19 pandemic. A structured questionnaire was developed on google form and distributed via social media platforms such as WhatsApp, Facebook, Instagram, and Twitter. Informed consent was sought by asking the participants to click on "agree" if they accept to be part of the study. This was accomplished by sending a standardized general invitation letter with the survey link to accept or decline participation to those who took the COVID-19 vaccine. Participants who declined consent were not permitted to open the survey and participate in the study, and participants who accepted to participate are directed to a page that included brief introduction to the aim and purpose of the study and could withdraw from the survey at any time. The study did not provide any incentives or compensations to the participants. To reach out to more participants, a snowball method was employed by encouraging participants to distribute the online survey link with their contacts who received at least of dose of the vaccines.

The survey was conducted among people who had taken at least one dose of any of the COVID-19 vaccines approved in Ghana. Data was collected on 240 participants. The study collected data on COVID-19 vaccination status, and number of doses taken, type of COVID-19 vaccines taken, adverse events and the number of the adverse events, age, sex, education, employment status, country of vaccination, nationality, and year of diagnosis of COVID-19.

2.2 | Outcome variables

The primary outcome variable for this study was experience of at least one adverse event among those receiving at least one dose of COVID-19 vaccine. The secondary outcome variables included the various forms of adverse events experienced and the number of the adverse events. Number of the adverse events was defined in this study as those experiencing no adverse event (i.e., none), 1–2 adverse events, 3–5 adverse events, 6–7 adverse events, 8–9 adverse events, and 10 or more adverse events. We then dichotomize the number of events as 8 or more coded as one (1) and 0–7 coded as zero (0) for our logistic regression model for the number of adverse events.

2.3 | Independent variables

The independent variables considered in this study included age, sex, highest level of education, category of employment, type of COVID-19 vaccines, number of COVID-19 vaccine doses taken, country of vaccination, and nationality.

2.4 | Sampling and sample size

The sample was obtained via a snowballing technique which is based on secondary referrals due to the sensitive nature and stigmatization associated with COVID-19 and due to the fact that the data was collected via an online questionnaire distributed on social media platforms (WhatsApp, Twitter, Facebook, and Instagram). Recruiting via social media at a time where the COVID-19 pandemic was at its peak was more appropriate for the sensitive topic under study because the respondent can decide to answer the questions at his or her own will and avoids physical contact with the interviewer who might be reading the questions to the respondent and ticking answers or looking at the respondents answers hence the interviewer might get to know if the respondent has had COVID-19 or not; whereas with the method of social media, there are no names on the google form that can identify the respondent, making the respondent unidentifiable. Thus, the snowballing approach is more suitable to this study than other sampling approaches due to the sensitive nature of the study.[43] Using a significance level of 5%, a margin of error of 4.6%, and based on a side effect prevalence of 84.3%[42] for first dose of COVID-19 for AstraZeneca, a sample size of 240 participants was obtained using the sample size formula for one population proportion.[44]

2.5 | Statistical analysis

Socio-demographic and other characteristics of the study participants were described using frequency and percentages. The various adverse events experienced by study participants after both the first and second doses of vaccines were described using the bar charts.

The Pearson Chi-square test was performed to assess the association between the characteristics of respondents and history of COVID-19 infection. In cases, where the Pearson Chi-square assumption is violated, the Fisher's exact test was used.

The number of the adverse events was also described using the pie charts. The bivariate analysis was performed using the Pearson Chi-square test or the Fischer's exact test where appropriate to assess the association between outcome variables and independent variables.

The penalized binary logistic regression model was used to assess the crude and adjusted odds of experience of at least one adverse event, and experience of number of adverse events due to low prevalence of eight or more adverse events used in the study. We examined multicollinearity using variance inflation factor (VIF) and VIF below 10 was considered acceptable to declare lack of presence of multicollinearity. The goodness of fit of the final model was examined using Hosmer and Lemeshow method. The 95% confidence interval (CI) and the corresponding *p*-values of all odds ratios estimated in the study were also presented. The area under the receiver operating characteristics curve (AUROCC) was used to assess the performance of the final multivariable penalized binary logistic regression models in the study. Stata IC version 16 (Stata Corp) was used to analyse the data in this study. A p-value < 0.05 together with 95%CI was used to declare statistical significance.

2.6 | Ethical approval

Informed consent was obtained from all study participants. In the online questionnaire, there was a place on the google form that sought informed consent from all participants explaining what the study was all about, benefits and risks of the study and a portion to click "I agree" if the participants want to continue and the fact that the participant was under no obligation to continue answering the questions if at any point in time, the participant did not want to. It is appropriate to collect the data via social media because of COVID-19 restrictions in place, and the difficulty in seeking approval for ethical clearance for face-to-face interviews at the time of the study. Furthermore, considering the COVID-19 protocols in Ghana and globally at the time, the social media data collection approach completely supports social distancing, avoid physical contacts, non-identifiability of respondents, and eliminates movements of researchers. All methods were carried out in accordance with relevant guidelines and regulations. Given the COVID-19 restrictions in place and the difficulty in seeking approval for ethical clearance to do face-to-face interviews at the time of the study, and that there will be no human interaction and the methods do not pose any harm to individuals, and that no identifiable information was collected from the participants, the authors therefore judged it ethically appropriate to proceed in order not to lose the opportunity for implementing the study to provide timely, relevant and critical data on adverse events of the vaccines introduced in the country.

3 | RESULTS

3.1 | Sample characteristics

A total of 240 vaccinated persons participated in this study. Majority of them were in the age range 20–29 years (75.4%) and with more than half being males (51.2%). A high majority had tertiary level of education, with 55.8% working as health scientist. The percentage of participants ever diagnosed of COVID-19 was 12.5% with 6.7% of the 30 ever diagnosed having been diagnosed twice.

AstraZeneca (Oxford) vaccine (78.8%) was the most common vaccine type vaccinated among the participants. Less than a fifth (18.8%) of them had received second vaccine dose at time of study. Most of the vaccination was received in Ghana (85.0%). 90.4% of the study participants were Ghanaian. Also, 90.4% experienced some form of symptoms after the vaccination (Table 1).

3.2 | Adverse events experienced after first dose of COVID-19 vaccines

Pain at the injection site (65.8%) was the most common adverse event experienced among about two-third of the participants after the first vaccine. Headache (57.5%), tiredness (55.8%), and fever (51.7%) were also experienced among more than half of the participants. Chills (39.6%) and muscles pains (38.3%) were also experienced among more than a third whilst swelling at the injection site was common among 11.3% if the participants after their first dose of vaccine (Figure 1).

3.3 | Adverse events experienced after second dose of COVID-19 vaccines

Among the 45 participants who had received their second dose of vaccines, pain at injection site (55.6%) was the commonest adverse event while tiredness (33.3%) was common among a third, followed by muscle pain (22.2%), headache (20.0%), fever (13.3%), and then chills (11.1%). Nausea (4.4%), swelling at the injection site (4.4%) and redness at the injection site (2.2%) were other symptoms experienced among a few of the participants (Figure 2).

3.4 | Number of adverse events

After the first dose of vaccines, 12.1% did not experience any kind of adverse event, whilst 13.8% experienced 1–2 adverse events, 27.9% experienced 3–5 adverse events, 25.8% experienced 6–7 adverse events, 18.8% experienced 8–9 adverse events and 1.7%

TABLE 1 Descriptive characteristics of study participants

Variables	Frequency	Percentage
N	240	
Age group		
10–19	4	1.7
20–29	181	75.4
30–39	37	15.4
40–49	11	4.6
>49	7	2.9
Sex		
Female	117	48.8
Male	123	51.2
Highest level of education		
Senior high/Lower	6	2.5
Tertiary/University/college	222	92.5
Nonresponse	12	5
Category of employment		
Health science	134	55.8
Others	65	27.1
Unemployed	41	17.1
Ever been diagnosed of COVID-19		
No	210	87.5
Yes	30	12.5
Number of times diagnosed of COVID-19		
1	28	93.3
2	2	6.7
Year of Diagnosis of COVID-19		
2020	15	50
2021	15	50
Type of vaccination received		
AstraZeneca (Oxford)	189	78.8
AstraZeneca (India)	8	3.3
Moderna	13	5.4
Pfizer-BioNTech	15	6.3
Sputnik-V	2	0.8
I don't know what vaccine I received	13	5.4
Number of COVID-19 vaccination doses received		
1	195	81.3
2	45	18.8
Country of vaccination		
Ghana	204	85.0
United States of America (USA)	20	8.3
Canada	4	1.7
Nigeria	4	1.7
United Kingdom (Britain inclusive)	2	0.8
Saudi Arabia	1	0.4
Nonresponse	5	2.1
Nationality		
Ghana	217	90.4
Nigeria	9	3.8
United States of America (USA)	4	1.7
Cameroon	2	0.8
Belgium	1	0.4
Ethiopia	1	0.4
The Gambia	1	0.4
Nonresponse	5	2.1
Experienced any adverse events after COVID-19 vaccination		
No	23	9.6
Yes	217	90.4

Abbreviation: COVID-19, coronavirus disease 2019.

experienced 10 or more adverse events. Also, among the 45 that received their second dose of vaccines, 24.4% did not experienced any form of adverse event, 40.0% experienced 1–2 adverse events, 28.9% experienced 3–5 adverse events, 4.4% experienced 6–7 adverse events, and 2.2% experienced 8–9 adverse events. None of those who received their second vaccine dose experienced 10 or more adverse events (Figure 3).

3.5 | Association between history of COVID-19 diagnosis and characteristics of study participants

None of the characteristics of the study participants observed in this study showed significant association with history of COVID-19 diagnosis. All the participants who had history of COVID-19 infection had tertiary level education. Among those with no history of COVID-19 diagnosis, 19.5% had received two doses of vaccines compared to 13.3% among those who have history of COVID-19 diagnosis. All the participants who had history of COVID-19 diagnosis were Ghanaians. None of the symptoms experienced either after the first or the second dosage of vaccines was significantly associated with the history of COVID-19 diagnosis. Number of symptoms after both first and second dosage of vaccines did not also show significant association with history of COVID-19 diagnosis (Table 2).

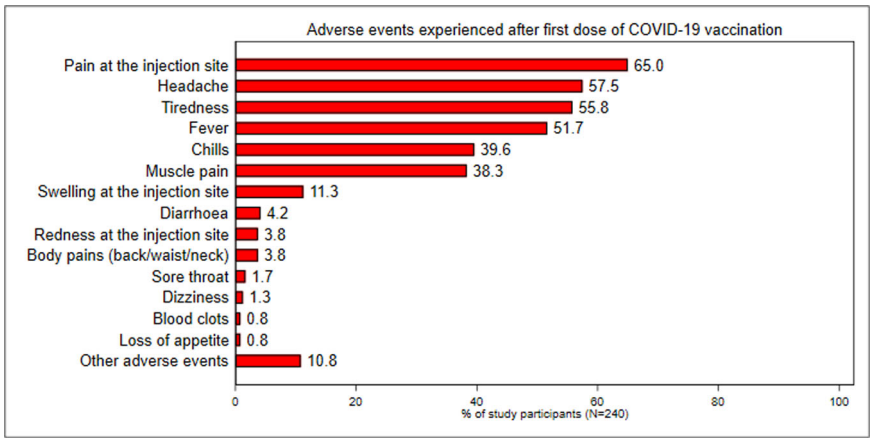

FIGURE 1 Adverse events experienced after first dose of coronavirus disease 2019 (COVID-19) vaccines. Note that the responses are based on multiple response items.

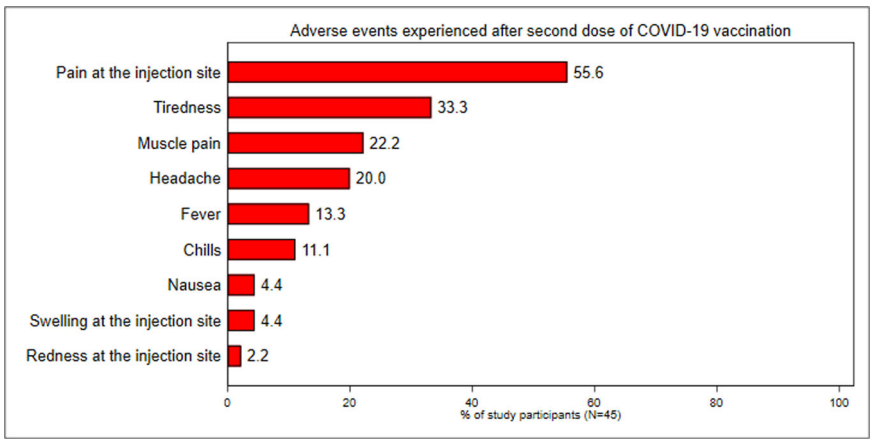

FIGURE 2 Adverse events experienced after second dose of coronavirus disease 2019 (COVID-19) vaccines. Note that the responses are based on multiple response items.

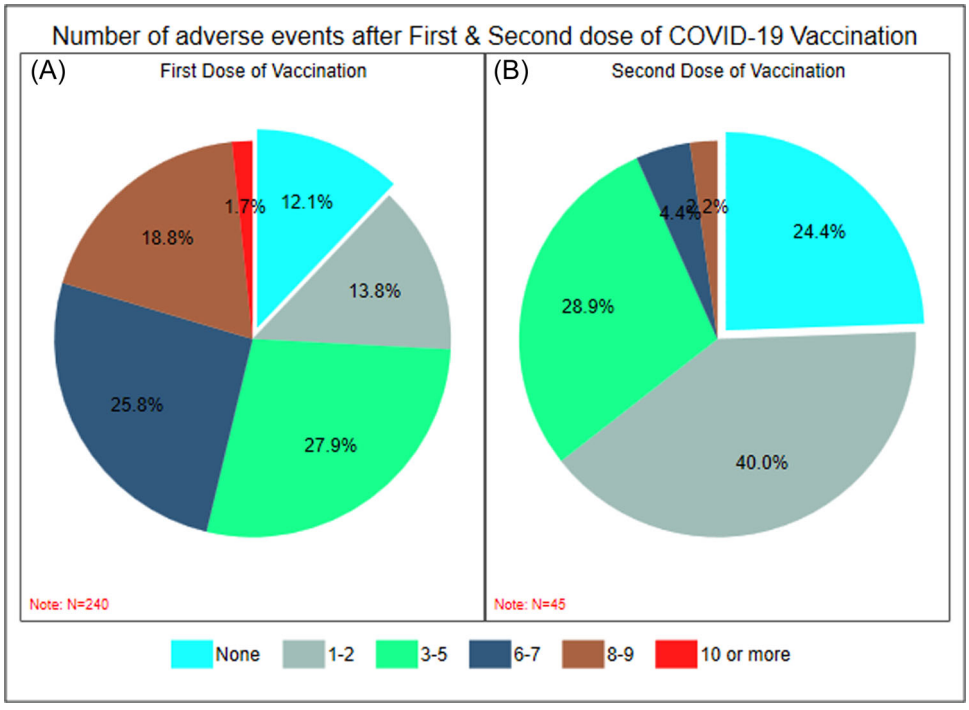

FIGURE 3 Number of adverse events experienced after first and second doses of coronavirus disease 2019 (COVID-19) vaccines

TABLE 2 Association between history of COVID-19 diagnosis and characteristics of study participants

Factor	History of COVID-19 diagnosis		Chi-square	*p*-value
	No (%)	Yes (%)		
N	210 (100.0)	30 (100.0)		
Age group			ε	0.122
10–19	3 (1.4)	1 (3.3)		
20–29	163 (77.6)	18 (60.0)		
30–39	30 (14.3)	7 (23.3)		
40–49	8 (3.8)	3 (10.0)		
>49	6 (2.9)	1 (3.3)		
Sex			3.26	0.071
Female	107 (51.0)	10 (33.3)		
Male	103 (49.0)	20 (66.7)		
Highest level of education			ε	0.475
Senior high/lower	6 (2.9)	0 (0.0)		
Tertiary/University/college	192 (91.4)	30 (100.0)		
Nonresponse	12 (5.7)	0 (0.0)		
Category of employment			2.78	0.249
Health science	116 (55.2)	18 (60.0)		
Others	55 (26.2)	10 (33.3)		
Unemployed	39 (18.6)	2 (6.7)		
Type of COVID-19 vaccines			ε	0.583
AstraZeneca (Oxford)	164 (78.1)	25 (83.3)		
AstraZeneca (India)	8 (3.8)	0 (0.0)		
I don't know what vaccine I received	11 (5.2)	2 (6.7)		
Moderna	13 (6.2)	0 (0.0)		
Pfizer-BioNTech	12 (5.7)	3 (10.0)		
Sputnik-V	2 (1.0)	0 (0.0)		
Number of COVID-19 vaccination dose			0.66	0.416
1	169 (80.5)	26 (86.7)		
2	41 (19.5)	4 (13.3)		
Country of vaccination			ε	0.900
Ghana	175 (83.3)	29 (96.7)		
United States of America (USA)	19 (9.0)	1 (3.3)		
Canada	4 (1.9)	0 (0.0)		
Nigeria	4 (1.9)	0 (0.0)		
United Kingdom (Britain inclusive)	2 (1.0)	0 (0.0)		
Saudi Arabia	1 (0.5)	0 (0.0)		
Nonresponse	5 (2.4)	0 (0.0)		
Nationality			ε	0.900
Ghana	187 (89.0)	30 (100.0)		
Nigeria	9 (4.3)	0 (0.0)		

(Continues)

TABLE 2 (Continued)

Factor	History of COVID-19 diagnosis		Chi-square	*p*-value
	No (%)	Yes (%)		
United States of America (USA)	4 (1.9)	0 (0.0)		
Cameroon	2 (1.0)	0 (0.0)		
Belgium	1 (0.5)	0 (0.0)		
Ethiopia	1 (0.5)	0 (0.0)		
The Gambia	1 (0.5)	0 (0.0)		
Nonresponse	5 (2.4)	0 (0.0)		
Experienced any symptoms			1.55	0.214
No	22 (10.5)	1 (3.3)		
Yes	188 (89.5)	29 (96.7)		
Adverse event experienced after first dose of COVID-19 vaccines				
Pain at the injection site	138 (65.7)	20 (66.7)	0.01	0.918
Headache	119 (56.7)	19 (63.3)	0.48	0.490
Tiredness	122 (58.1)	12 (40.0)	3.49	0.062
Fever	110 (52.4)	14 (46.7)	0.34	0.566
Chills	85 (40.5)	10 (33.3)	0.56	0.454
Muscle pain	79 (37.6)	13 (43.3)	0.36	0.547
Swelling at the injection site	24 (11.4)	3 (10.0)	0.05	0.817
Diarrhea	8 (3.8)	2 (6.7)	$\mathcal{E}$	0.362
Redness at the injection site	8 (3.8)	1 (3.3)	$\mathcal{E}$	1.000
Body pains (back, waist, neck, joint)	8 (3.8)	1 (3.3)	$\mathcal{E}$	1.000
Sore throat	4 (1.9)	0 (0.0)	$\mathcal{E}$	1.000
Dizziness	3 (1.4)	0 (0.0)	$\mathcal{E}$	1.000
Blood clots	2 (1.0)	0 (0.0)	$\mathcal{E}$	1.000
Loss of appetite	2 (1.0)	0 (0.0)	$\mathcal{E}$	1.000
Other symptoms	23 (11.0)	3 (10.0)	$\mathcal{E}$	1.000
Number of adverse events after first dose			$\mathcal{E}$	0.789
None	21 (10.0)	2 (6.7)		
1–2	32 (15.2)	5 (16.7)		
3–5	58 (27.6)	9 (30.0)		
6–7	52 (24.8)	10 (33.3)		
8–9	43 (20.5)	4 (13.3)		
10 or more	4 (1.9)	0 (0.0)		
Adverse event experienced after second dose of COVID-19 vaccines				
Pain at the injection site	21 (51.2)	4 (100.0)	$\mathcal{E}$	0.085
Tiredness	14 (34.1)	1 (25.0)	$\mathcal{E}$	1.000
Muscle pain	9 (22.0)	1 (25.0)	$\mathcal{E}$	1.000
Headache	8 (19.5)	1 (25.0)	$\mathcal{E}$	1.000
Fever	6 (14.6)	0 (0.0)	$\mathcal{E}$	1.000
Chills	5 (12.2)	0 (0.0)	$\mathcal{E}$	1.000

TABLE 2 (Continued)

Factor	History of COVID-19 diagnosis No (%)	Yes (%)	Chi-square	*p*-value
Nausea	2 (4.9)	0 (0.0)	$\mathcal{E}$	1.000
Swelling at the injection site	1 (2.4)	1 (25.0)	$\mathcal{E}$	0.172
Redness at the injection site	1 (2.4)	0 (0.0)	$\mathcal{E}$	1.000
Number of adverse events after second dose			$\mathcal{E}$	0.227
None	22 (53.7)	2 (50.0)		
1–2	4 (9.8)	2 (50.0)		
3–5	12 (29.3)	0 (0.0)		
6–7	2 (4.9)	0 (0.0)		
8–9	1 (2.4)	0 (0.0)		

Abbreviation: COVID-19, coronavirus disease 2019.

$\mathcal{E}$: Fischer's exact test.

3.6 | Number of adverse events after first and second dose of vaccination by characteristics of study participants

Table 3 shows the association between number of adverse events after both first and second vaccinations and the characteristics of the study participants. The age group ($p = 0.04$) was significantly associated with number of adverse events after first dose of COVID-19. Most of those aged 30–39 years had either 1–2 (29.7%) or 6–7 (27.0%) adverse events. Also, most of those aged 20–29 years had either 3–5 (27.6%) or 6–7 (27.6%) adverse events. Sex ($p = 0.03$) was also associated with number of adverse events with most of the females having either 3–5 (23.9%), 6–7 (31.6%), and 8–9 (23.9%) adverse events. Type of vaccine received ($p = 0.04$) and country of vaccination ($p < 0.001$) were also significantly associated with the number of adverse events after the first dosage of COVID-19 vaccine. Also, among the 45 who had received their second dose of vaccine, the type of vaccine ($p = 0.004$) and nationality ($p = 0.02$) were significantly associated with the number of adverse events after second dose of COVID-19 vaccination (Table 3).

The number of adverse events of the first dose was significantly associated with the number of adverse events of the second dose among those who had received their second dose of vaccines. All five participants who had no symptoms after the first diagnosis and had received their second dose did not experience adverse events after the second dose. Among the two participants who had received the second dose after experiencing 10 or more adverse events after the first dose, one experienced 1–2 adverse events and the other experienced 6–7 adverse events after the second dosage. Among the eight who experienced 6–7 adverse events after the first dosage and had received their second dose, 12.5% experienced 8–9 adverse events. All those who experienced 8–9 adverse events after the second dosage experienced 6–7 adverse events after the first dosage (Table 3).

3.7 | Goodness of fit and multicollinearity

We examined the goodness of fit and multicollinearity of our final models. We did not observe lack of fit and presence of multicollinearity in our models.

3.8 | Penalized binary logistic regression model of predictors of experience of any form of adverse event following COVID-19 vaccination

Table 4 shows the penalized binary logistic regression model, quantifying the association between characteristic of study participants and the experienced of any form of adverse event after COVID-19 vaccination. In both the crude and adjusted model, history of COVID-19 diagnosis did not have significant association with experience of any form of adverse event after COVID-19 vaccination.

Compared with those below 30 years, the adjusted odd of experiencing any form of adverse event was 86% significantly lower among those in the age group 40–49 years (AOR: 0.14, 95% CI: 0.03–0.58). Experience of any form of adverse event after COVID-19 vaccination was 94% significantly lower among those who received AstraZeneca (India) (AOR: 0.06, 95% CI: 0.01–0.37). The experience of any form of adverse event after COVD-19 diagnosis was over 16 times higher among Ghanaians compared to non-Ghanaian (AOR: 16.20, 95% CI: 1.98–132.56) (Table 4).

3.9 | Penalized binary logistic regression model of predictors of experience of 8 or more adverse events following COVID-19 vaccination

Table 4 also shows the penalized binary logistic regression model, quantifying the association between characteristic of study participants

TABLE 3 Number of adverse events after first and second dose of vaccination by characteristics of study participants

	Number of adverse events after first dose of COVID-19 vaccine								Number of adverse events after second dose of COVID-19 vaccine						
Variables	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	10 or more %	Fisher's *p*-value	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	Fisher's *p*-value
Overall	240	12.1	13.8	27.9	25.8	18.8	1.7		45	24.4	40.0	28.9	4.4	2.2	
Age group								**0.042**							0.108
10–19	4	0.0	25.0	75.0	0.0	0.0	0.0		0	-	-	-	-	-	-
20–29	181	12.2	11.0	27.6	27.6	19.9	1.7		33	21.2	45.5	30.3	0.0	3.0	
30–39	37	2.7	29.7	18.9	27.0	18.9	2.7		7	14.3	42.9	14.3	28.6	0.0	
40–49	11	36.4	0.0	45.5	9.1	9.1	0.0		3	66.7	0.0	33.3	0.0	0.0	
>49	7	28.6	14.3	28.6	14.3	14.3	0.0		2	50.0	0.0	50.0	0.0	0.0	
Sex								**0.029**							0.944
Female	117	9.4	9.4	23.9	31.6	23.9	1.7		23	21.7	43.5	26.1	4.3	4.3	
Male	123	14.6	17.9	31.7	20.3	13.8	1.6		22	27.3	36.4	31.8	4.5	0.0	
Highest level of education								0.812							0.600
Senior high/lower	6	16.7	16.7	33.3	0.0	33.3	0.0		1	0.0	0.0	100.0	0.0	0.0	
Tertiary/university/college	222	12.2	13.5	27.9	25.7	18.9	1.8		44	25.0	40.9	27.3	4.5	2.3	
Nonresponse	12	8.3	16.7	25.0	41.7	8.3	0.0								
Category of employment								0.573							0.249
Health science	134	10.4	14.2	28.4	26.9	18.7	1.5		24	25.0	37.5	33.3	0.0	4.2	
Others	65	16.9	16.9	29.2	18.5	15.4	3.1		19	15.8	47.4	26.3	10.5	0.0	
Unemployed	41	9.8	7.3	24.4	34.1	24.4	0.0		2	100.0	0.0	0.0	0.0	0.0	
History of COVID-19 diagnosis								0.789							0.227
No	210	12.9	13.3	27.6	24.8	19.5	1.9		41	26.8	34.1	31.7	4.9	2.4	
Yes	30	6.7	16.7	30.0	33.3	13.3	0.0		4	0.0	100.0	0.0	0.0	0.0	
Number of times diagnosed of COVID if ever diagnosed								**0.030**							-
1	28	7.1	14.3	32.1	39.3	7.1	0.0		3	0.0	100.0	0.0	0.0	0.0	
2	2	0.0	0.0	0.0	0.0	100.0	0.0		0	-	-	-	-	-	

TABLE 3 (Continued)

Variables	Number of adverse events after first dose of COVID-19 vaccine								Number of adverse events after second dose of COVID-19 vaccine						
	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	10 or more %	Fisher's *p*-value	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	Fisher's *p*-value
Year of diagnosis if ever diagnosed								0.337							-
2020	15	13.3	20.0	20.0	40.0	6.7	0.0		2	0.0	100.0	0.0	0.0	0.0	
2021	15	0.0	6.7	40.0	33.3	20.0	0.0		1	0.0	100.0	0.0	0.0	0.0	
Type of vaccines								**0.040**							**0.004**
AstraZeneca (Oxford)	189	7.9	13.8	28.6	27.5	20.6	1.6		34	23.5	44.1	29.4	0.0	2.9	
AstraZeneca (India)	8	50.0	12.5	0.0	25.0	12.5	0.0		0	-	-	-	-	-	
Don't know	13	30.8	7.7	23.1	23.1	15.4	0.0		0	-	-	-	-	-	
Moderna	13	30.8	15.4	15.4	30.8	0.0	7.7		4	25.0	0.0	25.0	50.0	0.0	
Pfizer-BioNTech	15	13.3	20.0	40.0	6.7	20.0	0.0		7	28.6	42.9	28.6	0.0	0.0	
Sputnik-V	2	0.0	0.0	100.0	0.0	0.0	0.0		0	-	-	-	-	-	
Number of doses received								0.290							-
1	195	12.3	13.3	28.7	27.7	16.9	1.0		0	-	-	-	-	-	
2	45	11.1	15.6	24.4	17.8	26.7	4.4		45	24.4	40.0	28.9	4.4	2.2	
Country of vaccination								**<0.001**							0.180
Ghana	204	8.8	12.7	28.9	28.4	19.6	1.5		34	23.5	47.1	26.5	0.0	2.9	
United States of America (USA)	20	30.0	20.0	25.0	5.0	15.0	5.0		10	30.0	20.0	30.0	20.0	0.0	
Canada	4	0.0	50.0	25.0	25.0	0.0	0.0		0	-	-	-	-	-	
Nigeria	4	0.0	0.0	0.0	50.0	50.0	0.0		1	0.0	0.0	100.0	0.0	0.0	
United Kingdom (Britain incl.)	2	0.0	50.0	50.0	0.0	0.0	0.0		0	-	-	-	-	-	
Saudi Arabia	1	0.0	0.0	100.0	0.0	0.0	0.0		0	-	-	-	-	-	
Nonresponse	5	100.0	0.0	0.0	0.0	0.0	0.0		0	-	-	-	-	-	
Nationality								0.058							**0.024**
Ghana	217	9.7	12.9	29.5	26.7	19.4	1.8		41	24.4	41.5	29.3	2.4	2.4	
Nigeria	9	22.2	22.2	11.1	22.2	22.2	0.0		1	0.0	0.0	100.0	0.0	0.0	
United States of America (USA)	4	50.0	0.0	25.0	25.0	0.0	0.0		1	100.0	0.0	0.0	0.0	0.0	
Cameroon	2	0.0	50.0	0.0	0.0	50.0	0.0		1	0.0	100.0	0.0	0.0	0.0	

(Continues)

TABLE 3 (Continued)

Variables	Number of adverse events after first dose of COVID-19 vaccine								Number of adverse events after second dose of COVID-19 vaccine						
	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	10 or more %	Fisher's *p*-value	Total *N*	None %	1–2 %	3–5 %	6–7 %	8–9 %	Fisher's *p*-value
Belgium	1	0.0	0.0	100.0	0.0	0.0	0.0		0	-	-	-	-	-	
Ethiopia	1	0.0	0.0	0.0	100.0	0.0	0.0		0	-	-	-	-	-	
The Gambia	1	0.0	100.0	0.0	0.0	0.0	0.0		0	-	-	-	-	-	
Nonresponse	5	80.0	20.0	0.0	0.0	0.0	0.0		1	0.0	0.0	0.0	100.0	0.0	
Number of adverse events after first dose of vaccination								-							**0.003**
None	29	100.0	-	-	-	-	-		5	100.0	0.0	0.0	0.0	0.0	
1–2	33	-	100.0	-	-	-	-		7	14.3	71.4	0.0	14.3	0.0	
3–5	67	-	-	100.0	-	-	-		11	18.2	36.4	45.5	0.0	0.0	
6–7	62	-	-	-	100.0	-	-		8	25.0	25.0	37.5	0.0	12.5	
8–9	45	-	-	-	-	100.0	-		12	8.3	50.0	41.7	0.0	0.0	
10 or more	4	-	-	-	-	-	100.0		2	0.0	50.0	0.0	50.0	0.0	
Number of adverse events after second dose of vaccination								**0.003**							-
None	11	45.5	9.1	18.2	18.2	9.1	0.0		11	100.0	-	-	-	-	
1–2	18	0.0	27.8	22.2	11.1	33.3	5.6		18	-	100.0	-	-	-	
3–5	13	0.0	0.0	38.5	23.1	38.5	0.0		13	-	-	100.0	-	-	
6–7	2	0.0	50.0	0.0	0.0	0.0	50.0		2	-	-	-	100.0	-	
8–9	1	0.0	0.0	0.0	100.0	0.0	0.0		1	-	-	-	-	100.0	

Abbreviation: COVID-19, coronavirus disease 2019.

%: Row percentage

TABLE 4 Penalized binary logistic regression model of predictors of experience of any form of adverse event and 8 or more adverse events after uptake of COVID-19 vaccines

		Experience of any form of adverse events					Experience of 8 or more adverse events after first dose of vaccination				
		Any adverse event	Unadjusted penalized binary logistic regression model		Adjusted penalized binary logistic regression model		8 or more adverse events	Unadjusted penalized binary logistic regression model		Adjusted penalized binary logistic regression model	
Variables	*N*	*n* (%)	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value	*n* (%)	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Overall	240	217 (90.4)					49 (20.4)				
Ever been diagnosed with COVID-19											
No	210	188 (89.5)	1.00 (reference)		1.00 (reference)		45 (21.4)	1.00 (reference)		1.00 (reference)	
Yes	30	29 (96.7)	2.35 [0.43–12.82]	0.325	2.90 [0.37–22.52]	0.310	4 (13.3)	0.62 [0.22–1.77]	0.369	0.66 [0.22–1.91]	0.440
Age group											
<30	185	169 (91.4)	1.00 [reference]		1.00 [reference]		39 (21.5)	1.00 [reference]		1.00 [reference]	
30–39	37	36 (97.3)	2.37 [0.43–13.09]	0.323	4.11 [0.62–27.33]	0.143	8 (21.6)	1.07 [0.46–2.48]	0.877	1.07 [0.45–2.58]	0.872
40–49	11	7 (63.6)	0.16 [0.05–0.58]	**0.005**	0.14 [0.03–0.58]	**0.007**	1 (9.1)	0.53 [0.09–3.04]	0.476	0.61 [0.10–3.58]	0.581
>49	7	5 (71.4)	0.21 [0.04–1.04]	0.056	0.23 [0.03–1.56]	0.133	1 (14.3)	0.86 [0.14–5.23]	0.866	0.80 [0.12–5.26]	0.814
Sex											
Female	117	108 (92.3)	1.00 [reference]		1.00 [reference]		30 (25.6)	1.00 [reference]		1.00 [reference]	
Male	123	109 (88.6)	0.66 [0.28–1.56]	0.346	0.61 [0.21–1.76]	0.365	19 (15.4)	0.54 [0.28–1.01]	0.054	0.56 [0.29–1.08]	0.083
Highest education											
SHS/Lower	6	5 (83.3)	1.00 [reference]		1.00 [reference]		2 (33.3)	1.00 [reference]		1.00 [reference]	
Tertiary	222	200 (90.1)	2.43 [0.38–15.57]	0.349	0.58 [0.06–5.43]	0.636	46 (20.7)	0.47 [0.10–2.30]	0.355	0.63 [0.12–3.41]	0.589
Nonresponse	12	12 (100.0)	6.82 [0.24–195.13]	0.262	2.80 [0.07–107.79]	0.581	1 (8.3)	0.23 [0.02–2.34]	0.217	0.27 [0.03–2.97]	0.288
Category of employments											
Health science	134	124 (92.5)	1.00 [reference]		1.00 [reference]		27 (20.1)	1.00 [reference]		1.00 [reference]	
Others	65	55 (84.6)	0.45 [0.18–1.11]	0.083	0.85 [0.26–2.79]	0.785	12 (18.5)	0.91 [0.43–1.92]	0.811	1.12 [0.50–2.52]	0.783
Unemployed	41	38 (92.7)	0.93 [0.26–3.28]	0.907	1.56 [0.33–7.50]	0.576	10 (24.4)	1.30 [0.58–2.94]	0.524	1.41 [0.59–3.34]	0.441
Type of vaccine received											
AstraZeneca (Oxford)	189	178 (94.2)	1.00 [reference]		1.00 [reference]		42 (22.2)	1.00 [reference]		1.00 [reference]	
AstraZeneca (India)	8	5 (62.5)	0.10 [0.02–0.44]	**0.002**	0.06 [0.01–0.37]	**0.002**	1 (12.5)	0.69 [0.12–4.14]	0.689	0.66 [0.11–4.08]	0.653
Moderna	13	10 (76.9)	0.19 [0.05–0.74]	**0.017**	1.36 [0.20–9.39]	0.754	1 (7.7)	0.42 [0.07–2.34]	0.320	0.36 [0.04–2.94]	0.337
Pfizer-BioNTech	15	13 (86.7)	0.35 [0.08–1.52]	0.161	7.59 [0.65–88.90]	0.107	3 (20.0)	0.97 [0.28–3.34]	0.964	0.87 [0.13–5.71]	0.884

(Continues)

TABLE 4 (Continued)

Variables	N	Experience of any form of adverse events					Experience of 8 or more adverse events after first dose of vaccination				
		Any adverse event n (%)	Unadjusted penalized binary logistic regression model		Adjusted penalized binary logistic regression model		8 or more adverse events n (%)	Unadjusted penalized binary logistic regression model		Adjusted penalized binary logistic regression model	
			COR (95% CI)	p-value	AOR (95% CI)	p-value		COR (95% CI)	p-value	AOR (95% CI)	p-value
Sputnik-V	2	2 (100.0)	0.32 [0.01–7.11]	0.473	0.33 [0.01–7.61]	0.486	0 (0.0)	0.69 [0.03–14.74]	0.815	0.63 [0.03–13.99]	0.771
Don't know	13	9 (69.2)	0.14 [0.04–0.48]	**0.002**	0.15 [0.03–0.73]	**0.019**	2 (15.4)	0.75 [0.18–3.09]	0.695	0.63 [0.14–2.83]	0.547
Nationality											
Non-Ghanaian	23	18 (78.3)	1.00 [reference]		1.00 [reference]		3 (13.0)	1.00 [reference]		1.00 [reference]	
Ghanaian	217	199 (91.7)	3.21 [1.11–9.29]	**0.032**	0.47 [0.08–2.83]	0.407	46 (21.2)	1.59 [0.49–5.16]	0.442	1.88 [0.36–9.89]	0.459
Country of vaccination											
Outside Ghana	36	27 (75.0)	1.00 [reference]		1.00 [reference]		6 (16.7)	1.00 [reference]		1.00 [reference]	
Ghana	204	190 (93.1)	4.54 [1.83–11.28]	**0.001**	16.20 [1.98–132.56]	**0.009**	43 (21.1)	1.26 [0.51–3.14]	0.614	0.62 [0.10–3.76]	0.601

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; COVID-19, coronavirus disease 2019.

and the experienced of number of adverse events following COVID-19 vaccination. In both the crude and adjusted model, history of COVID-19 diagnosis did not have significant association with experience of number of adverse events after COVID-19 vaccination. Also, none of the observed characteristics showed significant association with the experience of number of adverse events after COVID-19 vaccination (Table 4).

3.10 | Predictive ability of the fitted models

For the adjusted model for the experience of any form of adverse event among study participants, the area under the receiver operating curve (AUROCC) was 83.69% (95% CI: 73.95%–93.44%) and that of the model for the experience of 8 or more adverse events was 64.57% (95% CI: 55.83%–73.32%) (Figure 4). Thus, the model for predicting experience of any form of adverse event provided a better predictive accuracy compared to the model for predicting experience of 8 or more adverse events.

4 | DISCUSSION

4.1 | Principal findings

To the best of our knowledge, there have not been any studies available during the time of writing this paper with regard to adverse events of COVID-19 vaccination in Ghana and associated factors. The present study sought to identify common adverse event experienced among persons vaccinated with the COVID-19 vaccines and the number of these adverse events and to identify factors that are associated with the experience of any adverse event and the number of the adverse events. In the current study, all participants had received at least one dose of the COVID-19 vaccine and nearly one of every five received two doses of the vaccines. The most common vaccine received was AstraZeneca (Oxford). A plausible explanation could be the government's policy to vaccinate health workers first because they are at the frontline fighting the COVID-19 pandemic and at the time, AstraZeneca was the first vaccine to be used in Ghana because it was approved for use in Ghana, and subsequently we got donations which introduced Ghana to the newer vaccines such as Moderna, Pfizer-BioNTech and others, and majority of the participants in this study were health workers. Also, as of March 2021, AstraZeneca was not approved for use in the United States because clinical trials were on going. One of every eight of them had ever been diagnosed of COVID-19 at the time of the study which was almost similar to about 13% reported from a study in Saudi Arabia.[37]

4.2 | Interpretation

The study showed that nine in every 10 of people who had taken the first dose experienced some form of adverse event, a finding similar

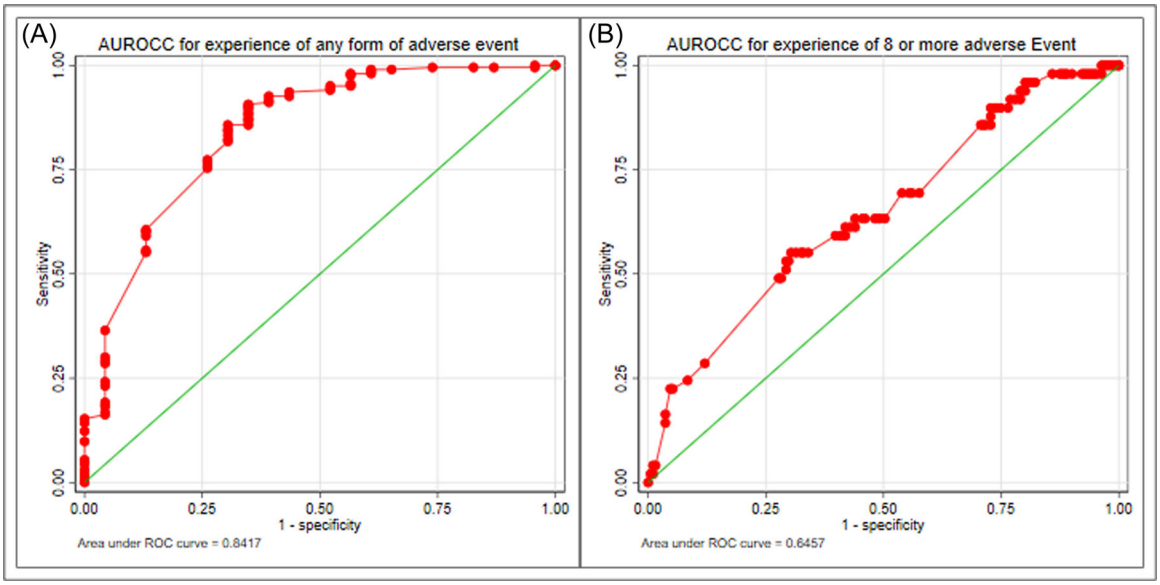

FIGURE 4 **Area under receiver operating characteristics curve (AUROCC) of penalized multivariable binary logistic regression model for predicting experience of any form of adverse events and 8 or more adverse events following receipt of** coronavirus disease 2019 (**COVID-19) vaccination.**

to a previous study.[41] The findings from this study showed that the most common adverse event experienced among the majority after the first dose of vaccines included pain at injection sites, headaches, tiredness, chills, muscle pains, and fever. About a quarter of the participants who received the second round of doses did not experience any form of adverse event whilst 2.2% experienced 8 or more adverse events. The adverse event experienced were no different from that experienced across the world.[36,37,45–48] A prevalence study on healthcare workers vaccinated against COVID-19 in Ethiopia by Jarso et al.[42] found that 84.3% of participants receiving the AstraZeneca vaccine reported symptoms after the first dose. Compared to our study which was also done in Africa (Ghana) where 87.9% participants reported adverse event after the first dose, the percentages are not far off from the Ethiopian study leaving room for further study as to why many Africans are developing adverse event after the first dose and whether there could be a genetic component as well. Also, in this same Ethiopian study, the most prevalent symptoms experienced in descending order include - pain at the injection site (64.1%), fatigue (35.7%), headache (28.9%), joint pain (26.5%), and muscle pain (21.5%) being the least common symptom.[42] In our study, the prevalence of pain at the injection site also hovered around a similar figure of 65.8% which was also the most common symptom experienced post-COVID-19 vaccination. However, the second most common symptom in our case was headache (57.5%), followed by the following—tiredness (55.8%), fever (51.7%), chills (39.6%), muscle pains (38.3%), and swelling at the injection site (11.3%). It is also clear in our case that muscle pain was a less common symptom (16.8%) in comparison to the Ethiopian study. It is also important to note that 78.8% of our study participants received the AstraZeneca vaccine and it is a fair comparison to this Ethiopian study whose participants also received the AstraZeneca vaccine. Another Ethiopian study among healthcare workers vaccinated against COVID-19 by Desalegn et al.[41] had a COVID-19 vaccine side-effect prevalence of 91.3% among respondents after the first dose and that of the second dose was 67%. With regard to our study, there was a slight reduction in prevalence of adverse event as we recorded 87.9% after the first dose but a higher prevalence of 75.6% after the second dose as compared to the Ethiopian study.

Concerning the side-effects of the first versus the second dose in the Ethiopian study, the following were reported respectively—pain at the injection site (63.8% vs. 50.4%), headache (48.8% vs. 33.5%), fever (38.8% vs. 20.9%), muscle pain (38.8% vs. 21.7%), fatigue (26% vs. 28.7%, tenderness at the site (27.6% vs. 21.7%), and joint pain (27.6% vs. 20.9%) being the least reported symptom.[41] In our study, pain at the injection site after both the first (65.8%) and the second (55.6%) dose was around the same prevalence for the Ethiopian study and was the most common post-first-dose-vaccination symptom. For headache (57.5% vs. 20.0%), for fever (51.7% vs 13.3%) which is slightly higher here for the first dose and lower for the second dose compared to the aforementioned study. For, muscle pain (38.3% vs. 22.2%) which was slightly lower here in the first dose but higher in the second dose as compared with the other study. For tiredness or fatigue (55.8% vs 33.3%) was seen in our study which was significantly higher than that of the Ethiopian study. Even though the two studies in this literature review were in Ethiopia, there are some slight differences in side-effects experienced among the people. Another study conducted among residents of the United Arab Emirates with 50.1% receiving Sinopharm vaccine, 47.4% receiving Pfizer-BioNTech vaccine and AstraZeneca being the least at 0.6% of participants recorded pain at the injection site once again, as the most common side-effect (47%), with fatigue and drowsiness coming in second at 28.2%, followed by joint/muscle pain (23.1%),

then lastly headache (17.7%) and fever (14.4%).[49] But it is difficult to compare this study to ours due to the fact that AstraZeneca was not the predominant vaccine received. However, the running theme seems to be that pain at the injection site was the most common adverse event or side-effect in all studies mentioned.

Possible risk factors for experiencing an adverse reaction to the vaccine may include a history of an underlying health condition (e.g., immunocompromised), pre-medication with an antipyretic before vaccination, and extremes of age (older individuals and younger individual—due to low immunity or lack of a well-established immune system respectively). However, a study among healthcare workers in Ghana with a mean age of 32.24 ± 4.30 years showed that 80.7% of the respondents experienced an adverse reaction despite majority having no known chronic condition and almost half of the respondents pre-medicating with paracetamol before vaccination. In this same study aforementioned, adverse reactions were said to last longer in the older age group (40–44 years). Hence, age and medication were found to be significant associated risk factors with adverse reaction from COVID-19 vaccination.[35]

In this paper, majority of participants were aged 20–29; the dissemination method of the questionnaire (via social media) may have contributed to this group being majority because the aged are less actively involved on such platforms. Therefore, it is no surprise that only about 18.8% and 2% of the participants experienced 8 or more adverse events for the first and second dose respectively while only 1.7% experienced 10 or more adverse events for the first dose and no one had experienced 10 or more adverse event after receiving the second dose.

None of the observed characteristics was however significantly associated with history of COVID-19 diagnosis among the participants. This means that the diagnosis of COVID was random among those receiving the vaccine at least based on the observed factors. The study showed that the experienced of adverse event after vaccination was not significantly associated with history of diagnosis. Individually, none of the various observed adverse events were also associated with history of diagnosis. This was confirmed with a nonsignificant adjusted odds ratio of experience of any form of adverse event among the diagnosed compared to non-diagnosed. Similarly, the history of COVID-19 infection was not significantly associated with number of adverse events following COVID-19 vaccination. Hence, the occurrence of adverse events after vaccination cannot be associated with history of COVID-19 infection. Furthermore, history of COVID-19 diagnosis was also not associated with the number of the adverse events after COVID-19 vaccinations.

The findings from this study also showed that experience of any form of adverse events was low among participants aged 40–49 years compared with those below 30 years. In a study in Jordan, a bivariate analysis showed similar findings where systemic adverse events among younger persons (<45 years) was higher compared to older persons after the first dose.[47] Also, compared to those who took AstraZeneca (oxford), experienced of adverse events was lower among those taking AstraZeneca (India) and among those who did not know the specific vaccine they took. Similar study showed that the type of vaccine was associated with number of adverse events from a bivariate analysis.[47] Experience of adverse events was about 16 times higher among those who took their vaccines within Ghana compared to those who took their vaccines outside the country.

4.3 | Strengths of the study

The data were self-reported, and the data were collected near the time the participants were vaccinated which reduced recall bias and this is expected to strengthen its objectivity and validity. To the best of our knowledge, our study is the first study conducted to assess the adverse events following COVID-19 vaccination, number of adverse events, and its associated factors in a resource limited setting like Ghana. Our modeling approach, the penalized binary regression model accounted for the low prevalence of 8 or more adverse events observed, thereby improving the accuracy of our parameter estimates.

4.4 | Limitation of the data

We encountered some limitations for designing and implementing the study because our study is one of the first studies conducted in Ghana to assess the adverse events of the administered COVID-19 vaccines and their associated factors. Per the study design, there were no control groups to examine rare, very serious, and long-term reactions of the vaccines.

Furthermore, the findings might not apply to those without access to internet and social media platforms because the survey was conducted online using social media platforms via google forms. Although this paper did not assess for any pre-existing medical conditions or whether participants were pre-medicated before receiving the vaccination, the importance of these two factors cannot be ruled out since they may contribute significantly to how one's immune system responds to the vaccine. This creates an avenue for further research into this area to determine if this is, indeed, the case.

5 | CONCLUSION

Our findings have key policy implications for COVID-19 vaccination and management with regard to education about these adverse events of mainly the AstraZeneca vaccine which was the vaccine available in Ghana at the time. Our study could serve as a basis for possible further studies into the other vaccines which may achieve the immunity effect but also with less adverse event so that they could be made available in the country. Thus, this study provides evidence to better understand COVID-19 vaccination safety and adverse events of vaccination to support evidence-based public health decision making processes like public education to reduce vaccine hesitancy to control the pandemic while providing a baseline

data on which further research can be grounded. Though the experience of adverse events after COVID-19 vaccination is very common, it was higher among those who had the first dose of the vaccines. The most common adverse events include pain at injection site, headache, tiredness, chills, fever, and muscle pains. Majority of the participants did not experience 8 or more adverse events after taken the first and/or the second dose. The experience of eight or more adverse events was much lower for the second dose compared to the first dose. Factors associated with the experience of adverse events of COVID-19 vaccination were highlighted. To support more evidence-based decision making and to understand vaccination safety and adverse events of vaccination better, further studies are warranted to assess rare, severe, and long-term adverse events of vaccines and their associated factors.

AUTHOR CONTRIBUTIONS

Naa Adzoa Adzeley Boi-Dsane: Conceptualization; data curation; investigation; project administration; writing—review & editing. **Bartholomew Dzudzor**: Conceptualization; data curation; investigation; writing—review & editing. **Yakubu Alhassan**: Data curation; formal analysis; investigation; visualization; writing—original draft; writing—review & editing. **Justice Moses K Aheto**: Data curation; formal analysis; investigation; methodology; software; validation; visualization; writing—original draft; writing—review & editing.

ACKNOWLEDGMENTS

We thank the participants for taking part in the study and making it a success. The authors declare that this study received no outside funding.

CONFLICT OF INTEREST

Justice Moses K. Aheto is an Editorial Board member of Health Science Reports and coauthor of this article. He was excluded from editorial decision-making related to the acceptance of this article for publication in the journal. All other authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data sets used and/or analyzed during the current study are available at https://figshare.com/articles/dataset/COVID_19_Data_dta/20326611.

TRANSPARENCY STATEMENT

The corresponding author Justice Moses K. Aheto affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Naa A. A. Boi-Dsane https://orcid.org/0000-0002-1685-5287
Justice M. K. Aheto http://orcid.org/0000-0003-1384-2461

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How to cite this article: Boi-Dsane NAA, Dzudzor B, Alhassan Y, Aheto JMK. Prevalence of common adverse events experienced following COVID-19 vaccination and its associated factors in Ghana: cross-sectional study design. *Health Sci Rep*. 2022;e1012. doi:10.1002/hsr2.1012