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Predictors of knowledge, attitude, and practices of anthrax prevention among selected veterinary students in Nigeria and Ghana

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Abstract

Background Anthrax is a zoonotic disease caused by a spore-forming bacterium called *Bacillus anthracis*. Globally, between 2000 and 20,000 human cases of anthrax are reported annually; however, measures such as vaccination have been put in place in some regions for adequate control, but there are still occasional outbreaks in some African countries.

Objectives This study aimed to assess the knowledge, attitudes, and practices of veterinary medical students regarding anthrax at four West African universities.

Methods A semi-structured questionnaire was developed to collect data on veterinary students' knowledge, attitudes, and practices regarding anthrax. Data were analysed using descriptive statistics, chi-square tests, and Poisson regression with robust variance.

Results Among the 793 veterinary students selected for this study, the proportion of Nigerian veterinary students with knowledge and prevention practices of anthrax was significantly higher than that of their Ghanaian counterparts. Respondents' age and training level were significantly linked to practices for anthrax prevention among both Nigerian and Ghanaian students. The proportion of Nigerian veterinary students with a positive attitude towards anthrax was significantly higher than that of Ghanaian students. The percentage of Nigerian veterinary students with good anthrax-prevention practices increased significantly with age. Conversely, the percentage of Ghanaian veterinary students with good anthrax-prevention practices decreased significantly with age.

Conclusion The study demonstrated low knowledge and practice of anthrax among veterinary students, indicating gaps in their understanding. There is a need for curricular reforms, including earlier introduction of zoonosis topics, increased practical and field training, and community engagement to prevent recurring outbreaks in African countries.



1 Introduction

Anthrax is a zoonotic disease caused by *Bacillus anthracis*, a Gram-positive, soil-borne, and sporulating bacterium. The disease primarily affects domestic and wild herbivores, and is transmitted by ingestion of bacterial spores from vegetation and soil [1]. The spores of *B. anthracis* can survive in soil for decades and remain highly resilient to extreme temperatures, desiccation, disinfectants, ultraviolet (UV) radiation, and even gamma rays, making anthrax challenging to control [2,].

Anthrax is a listed international disease endemic in Africa and Asia, while in developed countries, it remains only as sporadic, low-incidence outbreaks [4]. Anthrax is estimated to cause between 2000 and 20,000 human cases annually worldwide [5]. The burden is highest in low-income countries, where outbreaks contribute substantially to economic hardship and human suffering [6]. However, the true incidence is likely underestimated due to widespread underreporting linked to weak surveillance systems and limited diagnostic capacity [5].

Anthrax outbreaks have been widely reported across Africa, with Ethiopia bearing the highest documented burden, recording 6602 outbreaks, while countries such as Tunisia, Malawi, and Gambia have reported only isolated cases [7]. Wang et al. [8] reported an outbreak among herbivorous livestock in the Port Loko District of Sierra Leone. In endemic African countries, anthrax outbreaks are reported almost annually, with developing nations such as Ghana experiencing more frequent episodes than developed countries [9, 10]. Reports of anthrax outbreaks in Ghana occurred in 1972, 1997, 2018, and 2019 [11]. In 2024, a major anthrax outbreak in Ghana affected 13 districts in the Upper East Region and resulted in hundreds of livestock deaths [12]. Sheep accounted for 51% of losses, followed by cattle (41%), goats (6%), and pigs (2%).

Nigeria recorded its first anthrax outbreaks in 2023, affecting Niger and Lagos States [13, 14]. Ongoing outbreaks in neighbouring countries, including Benin, Burkina Faso, Cameroon, Chad, Ghana, Niger, and Togo, have elevated anthrax to a priority concern for veterinary and public health authorities in Nigeria [14, 15].

Cross-border livestock trade between Nigeria and these countries further complicates anthrax control [16]. This trade is largely driven by the Fulani population, one of the largest nomadic pastoral groups globally.

Despite the presence of institutions promoting awareness of zoonotic diseases such as anthrax in West Africa, little is known about the knowledge, attitudes, and practices of institution-based stakeholders, particularly veterinary students, in Ghana and Nigeria.

Since these students come from different parts of these countries, they form a crucial frontline for preventing zoonoses, including anthrax, if adequately trained and informed. This study therefore assessed the knowledge, attitudes, and practices of veterinary students in Ghana and Nigeria regarding anthrax following the 2023 outbreaks, and examined the predictors associated with these outcomes.

Findings from this study will identify specific gaps in the veterinary curriculum and inform targeted educational interventions to prepare future veterinarians for anthrax control.

2 Materials and methods

2.1 Study design and setting

This cross-sectional study employed a quantitative data collection method to assess knowledge of anthrax among students at the Faculties of Veterinary Medicine in four universities: the University of Ibadan, Oyo State (UI), Nigeria; the University of Ilorin, Kwara State (Unilorin), Nigeria; the Federal University of Agriculture, Abeokuta, Ogun State (FUNAAB), Nigeria; and Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana (Fig. 1). The study was carried out between January 13th, 2025, and June 2nd, 2025. Participants were provided with written informed consent before completing the questionnaire.

2.2 Study population

Participants were undergraduate students enrolled in the Doctor of Veterinary Medicine (DVM) training programme.

2.3 Eligibility criteria

The study included undergraduate students enrolled in the DVM training programme across the pre-clinical, para-clinical, and clinical levels. Students who were on internship programmes or who declined to participate were excluded from the study.

2.4 Study variables

2.4.1 Dependent variables

The dependent variables in the study were knowledge, attitude, and practice regarding anthrax.

2.4.2 Independent variables

These included socio-demographic characteristics such as age, sex, and level of study.

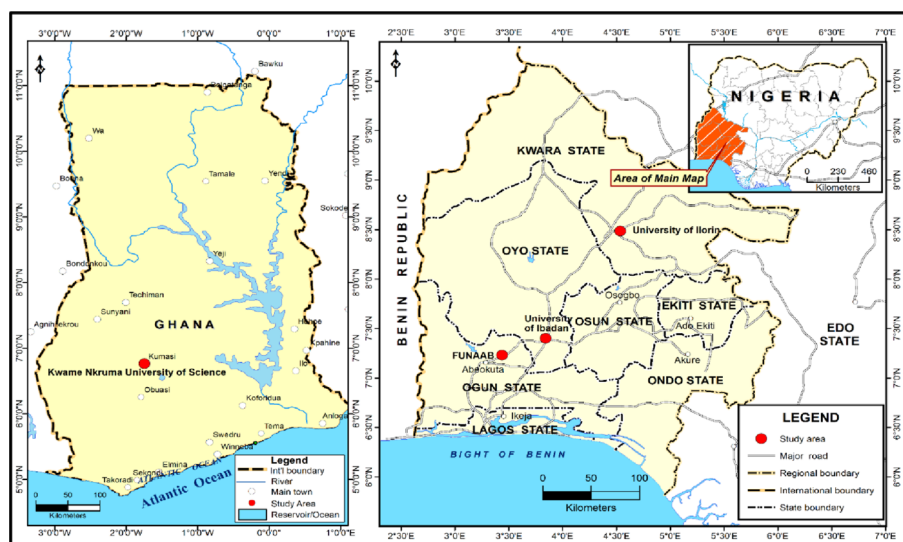


Fig. 1 Map of selected Universities in Ghana and Nigeria

2.5 Data collection

A semi-structured questionnaire was designed to collect information on veterinary students' knowledge, attitudes, and practices regarding anthrax. Four universities were purposively selected; within each, all eligible consenting DVM students available during the study period were invited to participate. The questionnaire was divided into sections: the first documented the socio-demographic profile of respondents, while the second focused on knowledge of anthrax, comprising approximately 20 questions. The third and fourth sections focus on respondents' attitudes and practices regarding anthrax, respectively. The attitude and practice sections consisted of 10 and 7 questions, respectively. The questionnaire was pretested with 25 Veterinary medical students who were not part of the study before actual collection. The reliability of the research questionnaire was ascertained using the Cronbach's alpha value test after the pretest was conducted. The reliability test results showed a Cronbach alpha (α) value of 0.83 (83%). This showed that the questionnaire items in this research effectively measured the underlying construct of veterinary students' knowledge, attitudes, and practices regarding anthrax.

2.6 Sample size determination

The Krejcie and Morgan [17] formula was used for determining the sample size.

$$n = (Z^2 \times p(1 - p)) / d^2$$

n = required sample size, Z = standard normal deviation at a 95% confidence interval.

(1.96), p = prevalence (0.5 (50%) because no similar study found), d = margin of error or degree of accuracy (0.05). After calculations, $n = 384.16$, approximated to 385 participants.

Eventually, the total number of sampled participants reached 793 (all available students); these comprised all levels of DVM training. The veterinary student populations at UI, Unilorin, FUNAAB, and KNUST were 360, 294, 450, and 230, respectively.

2.7 Data analysis

Data were entered into Microsoft Excel version 2013, cleaned and analysed with Stata 14.2 for Windows (StataCorp, College Station, TX, USA). Each knowledge question was scored: correct responses received one mark, and incorrect responses received 0, yielding a total score of 50. Percentage knowledge scores were generated for each participant by dividing the individual score by 50 before multiplying by 100. Thereafter, we categorised participants into two groups: those with a knowledge score below 75% and those with a score of 75% or higher. Attitude questions were also analysed using frequencies and percentages. Attitude questions were measured on a Likert scale ranging from "not sure" coded as "1", "strongly disagree" coded as "2", "disagree" coded as "3", "agree" coded as "4" and "strongly agree" coded as "5". Negatively worded questions were reverse-coded. There were a total of 10 attitude questions, yielding a minimum score of 10 and a maximum score of 50. A percentage attitude score was generated for each participant by dividing the individual attitude score by 50 before multiplying by 100. Thereafter, we categorised them into two groups: those with attitude scores below 75% and those with 75% or higher. To generate scores for anthrax-prevention practices, each question had a minimum score of 1 and a maximum score of 3 (1 represented "Not at all", 2 represented "Sometimes", & 3 represented "Always"); therefore, for the seven questions, the

minimum and maximum scores attainable were 7 and 21, respectively. We also generated percentage practice scores for each participant by dividing the individual practice score by 21 before multiplying by 100. Thereafter, we categorised them into two groups: those with a practice score below 75% and those with a practice score of 75% or higher. We selected a cut-off of $\geq 75\%$ a priori to represent 'good' knowledge, attitude and practice reflecting a high standard of competency expectations for Veterinary students in both countries surveyed.

Socio-demographic variables were summarised using frequencies and percentages and compared between the two countries. The associations between knowledge, attitude, and practice of anthrax and other explanatory variables, such as age, sex, religion, institution, and level, were assessed using Pearson's chi-square. Only variables that were significant at $p < 0.20$ were used for further multivariable analysis. Since the outcomes of this study (knowledge and practice of anthrax) had an overall prevalence greater than 10%, we fitted Poisson regression with robust variance separately for Nigeria and Ghana [19] rather than a binary logistic regression model to elucidate the determinants of anthrax knowledge and practice among veterinary students in Nigeria. (include attitude)

2.8 Ethical considerations

Ethical approval for this study was obtained from the College of Medicine, Institute for Advanced Medical Research and Training (IAMRAT), University of Ibadan, with approval number UI/EC/250,030. Data were anonymised to ensure confidentiality. The study adhered to the World Medical Association Declaration of Helsinki [20].

3 Results

3.1 Socio-demographic characteristics of the participants

A total of 793 veterinary students were selected for this study, out of which 563 (71.0%) were from Nigeria and 230 (29.0%) were from Ghana. Overall, 68.3% were between 20 and 24 years of age, while 16.7% were 25 years or older. There were more males (56.7%) than females (43.3%). About 77% were Christians, while 23% practised Islamic or Traditional religion. The distribution of participants by DVM training level showed that 7.2% were at 100 L, 22.7% at 200 L, 20.9% at 300 L, 16.7% at 400 L, 11.4% at 500 L, and 21.2% at 600 L. No 100-level student was selected in Nigeria because they have not been incorporated into DVM training, and no 500 L student from Ghana was chosen because they were on internship at the time of data collection (Table 1).

3.2 Knowledge level of Nigerian and Ghanaian veterinary students on anthrax

The proportion of Nigerian veterinary students with good knowledge of anthrax was significantly higher compared to their Ghanaian counterparts (44.8% vs. 20.9%, $p < 0.0001$) (Table 2). Age, sex, and DVM level were significantly associated with knowledge of anthrax among Nigerian veterinary students. When stratified by age, the proportion of veterinary students with good knowledge of anthrax was significantly highest ($p < 0.0001$) among those aged 25 years and above (63.8%) compared with those aged 20–24 years (46.5%) and 15–19 years (16.7%). The proportion of male veterinary students (49.7%) in Nigeria with good knowledge of anthrax was significantly higher ($p = 0.009$) than that of females (38.7%), and students in higher classes had significantly better knowledge of anthrax than those in lower classes ($p < 0.0001$). Sex was the only

Table 1 Socio-demographic characteristics of the selected Undergraduate Veterinary Students in Nigeria and Ghana

Variable	Total, n (%)	Nigeria, n (%)	Ghana, n (%)
<i>Age (years)*</i>			
15–19	111 (15.0)	72 (14.2)	39 (17.0)
20–24	504 (68.3)	342 (67.3)	162 (70.4)
≥ 25	123 (16.7)	94 (18.5)	29 (12.6)
<i>Sex*</i>			
Male	448 (56.7)	304 (54.3)	144 (62.6)
Female	342 (43.3)	256 (45.7)	86 (37.3)
<i>DVM Level</i>			
100	57 (7.2)	-	57 (24.8)
200	180 (22.7)	130 (23.1)	50 (21.7)
300	166 (20.9)	111 (19.7)	55 (23.9)
400	132 (16.7)	87 (15.5)	45 (19.6)
500	90 (11.4)	90 (60.0)	-
600	168 (21.2)	145 (25.8)	23 (10.0)
<i>Religion</i>			
Christianity	614 (77.4)	402 (71.4)	212 (92.2)
Islam/Traditional	179 (22.6)	161 (28.6)	18 (7.8)
<i>Institution</i>			
FUNAAB	112 (14.1)	112 (19.9)	
UNILORIN	188 (23.7)	188 (33.4)	
UI	263 (33.2)	263 (46.7)	
KNUST	230 (29.0)		230 (100.0)
Total	793 (100.0)	563 (100.0)	230 (100.0)

*Total not equal to 563 among the Nigerian students because of missing information

variable that was significantly associated with knowledge of anthrax among veterinary students in Ghana ($p=0.046$) (Table 2). The highest percentage of participants learned about anthrax through veterinary school (Ghanaian – 28.1%, Nigerian – 27.9%), though others learned about the disease through the internet and social media (Ghanaian – 17%, Nigerian – 19.8%) (Fig. 2).

3.3 Predictors of anthrax knowledge and prevention practices

The significant predictors of anthrax knowledge among Nigerian students were sex and level of study. Female veterinary students in Nigeria have significantly lower odds of possessing good knowledge of anthrax than their male counterparts. (PR = 0.82, 95% CI = 0.69–0.99, p -value = 0.035). Nigerian students in higher classes (300 L or higher) were about four times more likely to have good knowledge of anthrax compared to those in lower classes (PR = 4.43, 95% CI = 2.57–7.61, $p < 0.0001$) (Table 3).

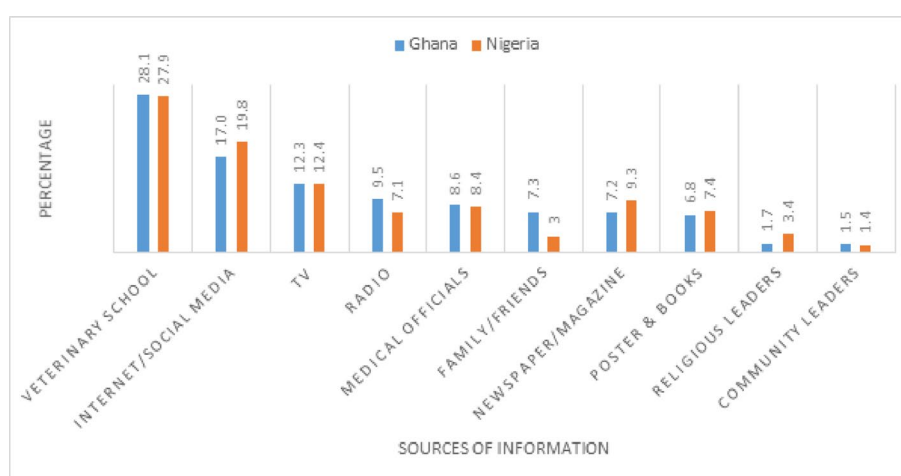
3.4 Practice level of Nigerian veterinary students on anthrax

The proportion of Nigerian veterinary students who practised good prevention practices for anthrax was significantly higher than that of Ghanaian veterinary students (69.8% vs. 31.3%, $p < 0.0001$). Age and academic level were significantly linked to anthrax prevention practices ($p < 0.05$) among Nigerian and Ghanaian students. Among Nigerian students, the percentage demonstrating good anthrax prevention increased significantly with age, from 59.7% among those aged 15–19 years to 69.0% among those aged 20–24 years, and 79.8% among those aged 25 years and older. Conversely, in Ghana, the percentage of students with good anthrax prevention practices decreased significantly with

Table 2 Factors associated with knowledge of anthrax among Undergraduate Veterinary Students in Nigeria and Ghana (N = 793)

Variables	Nigeria		Ghana	
	Total (%)	No (%) with good knowledge of Anthrax	Total (%)	No (%) with good knowledge of Anthrax
<i>Age (years)* (n = 508)</i>				
15–19	72 (14.2)	12 (16.7)	39 (17.0)	6 (15.4)
20–24	342 (67.3)	159 (46.5)	162 (70.4)	34 (21.0)
≥ 25	94 (18.5)	60 (63.8)	29 (12.6)	8 (27.6)
<i>p</i> -value		< 0.0001		0.471
<i>Sex* (n = 510)</i>				
Male	304 (54.3)	151 (49.7)	144 (62.6)	36 (25.0)
Female	256 (45.7)	99 (38.7)	86 (37.4)	12 (14.0)
<i>p</i> -value		0.009		0.046
<i>DVM Level</i>				
200 or lower	130 (23.1)	19 (14.6)	107 (46.5)	24 (22.4)
300 or higher	433 (76.9)	233 (53.8)	123 (53.5)	24 (19.5)
<i>p</i> -value		< 0.0001		0.587
<i>Religion</i>				
Christianity	402 (71.4)	180 (44.4)	212 (92.2)	45 (21.2)
Islam/Traditional	161 (28.6)	72 (45.6)	18 (7.8)	3 (16.7)
<i>p</i> -value		0.809		0.648
<i>Institution</i>				
FUNAAB	112 (14.1)	46 (41.1)		
UNILORIN	188 (23.7)	80 (42.6)		
UI	263 (33.2)	126 (47.9)		
<i>p</i> -value		0.281		

*Total varies due to missing responses

**Fig. 2** Sources of information about anthrax among Nigerian and Ghanaian Veterinary Students

age, from 56.4% in the 15–19 years group, to 27.2% in the 20–24 years group, and 20.7% among those older than 25 years. Among Nigerian students, the proportion with good anthrax prevention was significantly higher among 300-level students and above compared to 200 L and lower levels (72.9% vs. 59.2%, $p = 0.049$). In contrast, Ghanaian students in 300-level and higher classes showed significantly lower good anthrax prevention practices than those in 200 L and lower classes (9.8% vs. 56.1%, $p < 0.0001$). (Table 4).

Table 3 Predictors of Anthrax Knowledge among Veterinary Undergraduates in Nigeria

Variable	Nigeria		Ghana	
	PR (95% CI)	P-value	PR (95% CI)	P value
<i>Age (years)</i>				
15–19	Reference			
20–24	1.27 (0.76–2.14)	0.363		
≥ 25	1.31 (0.76–2.26)	0.331		
<i>Sex</i>				
Male	Reference		Reference	
Female	0.82 (0.69–0.99)	0.035	0.56 (0.31–1.02)	0.056
<i>DVM Level</i>				
200 or lower	Reference			
300 or higher	4.43 (2.57–7.61)	< 0.0001		

PR = Prevalence Ratio CI = Confidence Interval

Table 4 Factors associated with Anthrax-prevention practices among Undergraduate Veterinary Students in Nigeria and Ghana

Variable	Nigeria		Total (%)	No (%) with good Anthrax-prevention practices
	Total (%)	No (%) with good Anthrax-prevention practices		
<i>Age (years)*</i>				
15–19	72 (14.2)	43 (59.7)	39 (17.0)	22 (56.4)
20–24	342 (67.3)	236 (69.0)	162 (70.4)	44 (27.2)
≥ 25	94 (18.5)	75 (79.8)	29 (12.6)	6 (20.7)
p-value		0.018		0.001
<i>Sex*</i>				
Male	304 (54.3)	212 (69.7)	144 (62.6)	45 (31.3)
Female	256 (45.7)	180 (70.3)	86 (37.4)	27 (31.4)
p-value		0.882		0.982
<i>DVM Level</i>				
200 or lower	130 (23.1)	77 (59.2)	107 (46.5)	60 (56.1)
300 or higher	433 (76.9)	316 (72.9)	123 (53.5)	12 (9.8)
p-value		0.049		< 0.0001
<i>Religion</i>				
Christianity	402 (71.4)	280 (69.1)	212 (92.2)	66 (31.1)
Islam/Traditional	161 (28.6)	113 (71.5)	18 (7.8)	6 (33.3)
p-value		0.58		0.847
<i>Institution</i>				
FUNAAB	112 (14.1)	85 (75.9)		
UNILORIN	188 (23.7)	127 (67.6)		
UI	263 (33.2)	181 (68.8)		
p-value		0.281		

*Total not equal to 563 among the Nigerian students because of missing information

Age was the only significant predictor of anthrax-prevention practices among Nigerian and Ghanaian veterinary students. Nigerian students aged 25 years or older are about 1.36 times more likely to use effective anthrax-prevention methods than those aged 15–19 years (PR = 1.36, 95% CI = 1.09–1.70, $p = 0.006$). Ghana students older than 25 years old were about 3 times less likely to display good anthrax-prevention methods compared to those aged 15–19 years (PR = 0.36, 95% CI = 0.17–0.77, $p = 0.009$) while those between 20–24 years were about two times less likely to display good

Table 5 Predictors of Anthrax-prevention practices among Undergraduate Veterinary Students in Nigeria and Ghana

Variable	Nigeria		Ghana	
	PR (95% CI)	P-value	PR (95% CI)	P-value
<i>Age (years)</i>				
15–19	Reference		Reference	
20–24	1.17 (0.96–1.44)	0.122	0.48 (0.33–0.69)	< 0.0001
≥ 25	1.36 (1.09–1.70)	0.006	0.36 (0.17–0.77)	0.009
<i>Institution</i>				
FUNAAB	Reference			
UNILORIN	0.89 (0.76–1.04)	0.135		
UI	0.89 (0.77–1.03)	0.107		
<i>Religion</i>				
Christianity			Reference	
Islam/Traditional			1.22 (0.63–2.37)	0.547

PR = Prevalence ratio CI = Confidence interval

Table 6 Comparing knowledge and practice scores between Nigerian and Ghana Veterinary Students

Variable	No (%) with good scores		P-value
	Nigeria	Ghana	
Knowledge	252 (44.8)	48 (20.9)	< 0.0001
Practice	393 (69.8)	72 (31.3)	< 0.0001
Attitude	411 (73.0)	41 (17.8)	< 0.0001

anthrax-prevention methods compared to those aged 15–19 years (PR = 0.48, 95% CI = 0.33–0.69, $p < 0.0001$) (Table 5, 6)

The proportion of Nigerian veterinary students with a positive attitude towards anthrax was significantly higher compared to those from Ghana (73.0% vs. 17.8%, $p < 0.0001$). Age and academic level were significantly associated with positive attitude ($p < 0.05$) among Nigerian students, while academic level was the only sociodemographic variable associated with positive attitude among the students from Ghana. Among Nigerian students, the percentage that displayed a positive attitude increased significantly with age, from 52.8% among those aged 15–19 years, to 74.0% among those aged 20–24 years, and 83.0% among those over 25 years. Also, among these Nigerian students, the level of positive attitude towards anthrax increased significantly by academic levels ($p < 0.0001$) (Table 7). Among the Ghana students, the proportion of students in lower classes who displayed a positive attitude towards anthrax was higher compared to those in the lower classes (24.3% vs. 12.2%, $p = 0.017$).

DVM level was the only significant predictor of attitudes towards anthrax among the Nigerian veterinary students. Nigerian students in 300 L or higher classes were about 1.33 times more likely to show positive attitudes to anthrax-prevention compared to those in 200 L or lower classes (PR = 1.33, 95% CI = 1.09–1.61, $p = 0.004$). (Table 8). Sex was the only predictor of attitude towards Anthrax among the students from Ghana. Female Ghanaian students were about 50 times less likely to show positive attitudes to anthrax compared to their male counterparts (PR = 0.49, 95% CI = 0.26–0.93, $p = 0.0031$).

Tables 9 and 10 show the attitude of the participants (Ghanaian and Nigerian students) towards anthrax. Tables 9 and 10 show the attitude of the participants (Ghanaian and Nigerian students) towards anthrax. A higher percentage of Ghana participants (45%) strongly disagreed that sick or moribund animals could still be slaughtered to avoid loss,

Table 7 Factors associated with Attitudes among Undergraduate Veterinary Students in Nigeria and Ghana

Variable	Nigeria		Ghana	
	Total (%)	No (%) with positive attitude	Total (%)	No (%) with positive attitude
<i>Age (years)*</i>				
15–19	72 (14.2)	38 (52.8)	39 (17.0)	11 (28.2)
20–24	342 (67.3)	253 (74.0)	162 (70.4)	24 (14.8)
≥ 25	94 (18.5)	78 (83.0)	29 (12.6)	6 (20.7)
p-value		< 0.0001		0.133
<i>Sex*</i>				
Male	304 (54.3)	220 (72.4)	144 (62.6)	31 (21.5)
Female	256 (45.7)	189 (73.8)	86 (37.4)	10 (11.6)
p-value		0.698		0.058
<i>DVM Level</i>				
200 or lower	130 (23.1)	73 (56.2)	107 (46.5)	26 (24.3)
300 or higher	433 (76.9)	338 (78.1)	123 (53.5)	15 (12.2)
p-value		< 0.0001		0.017
<i>Religion</i>				
Christianity	402 (71.4)	289 (71.9)	212 (92.2)	37 (17.5)
Islam/Traditional	161 (28.6)	122 (75.8)	18 (7.8)	4 (22.2)
p-value		0.348		0.612
<i>Institution</i>				
FUNAAB	112 (14.1)	75 (67.0)		
UNILORIN	188 (23.7)	133 (70.7)		
UI	263 (33.2)	203 (77.2)		
p-value		0.087		

*Total not equal to 563 among the Nigerian students because of missing information

Table 8 Predictors of attitudes towards Anthrax among Undergraduate Veterinary Students in Nigeria and Ghana

Variable	Nigeria		Ghana	
	PR (95% CI)	P-value	PR (95% CI)	P-value
<i>Age (years)</i>				
15–19	Reference		Reference	
20–24	1.16 (0.90–1.51)	0.262	0.58 (0.31–1.22)	0.107
≥ 25	1.26 (0.96–1.66)	0.101	0.79 (0.32–1.99)	0.621
<i>Sex</i>				
Male			Reference	
Female			0.49 (0.26–0.93)	0.031
<i>DVM Level</i>				
200 L or Lower	Reference		Reference	
300 L or Higher	1.33 (1.09–1.61)	0.004	0.55 (0.29–1.02)	0.058
<i>Institution</i>				
FUNAAB	Reference			
UNILORIN	1.06 (0.90–1.25)	0.493		
UI	1.14 (0.99–1.33)	0.078		

as against 38% Nigerian participants. A higher percentage (54%) of Ghana and Nigeria participants, respectively, consider their job as a risk of exposure to anthrax. A greater percentage (63.9%) of Nigerian students disagreed that animals condemned for anthrax could still be slaughtered and consumed if cooked well, as against a low percentage (26%) of Ghanaian students. Also, 65% and 46% Nigerian students and Ghanaian counterparts,

Table 9 Attitude of Nigerian Veterinary students towards Anthrax

S/N	Item	SA (%)	A (%)	D (%)	SD (%)	Not Sure (%)
1	Sick or moribund animals can be slaughtered to avoid loss	118 (21.0)	77 (13.7)	80 (14.2)	219 (38.9)	69 (12.3)
2	The source of the vaccine against anthrax does not really matter	25 (4.4)	35 (6.2)	143 (25.4)	273 (48.5)	87 (15.5)
3	Annual vaccination of animals against anthrax is important for prevention	309 (54.9)	145 (25.8)	28 (5.0)	20 (3.6)	61 (10.8)
4	I do not consider my job a risk of exposure to anthrax	35 (6.2)	46 (8.2)	120 (21.3)	300 (53.3)	62 (11.0)
5	I do not consider anthrax a fatal disease	24 (4.3)	15 (2.7)	78 (13.9)	391 (69.4)	55 (9.8)
6	Animals condemned for anthrax can still be slaughtered and consumed if cooked well	62 (11.0)	26 (4.6)	60 (10.7)	360 (63.9)	55 (9.8)
7	Any case of anthrax should be reported	346 (61.5)	68 (12.1)	28 (5.0)	77 (13.7)	44 (7.8)
8	Wearing PPE is not so important in anthrax prevention	62 (11.0)	27 (4.8)	71 (12.6)	325 (57.7)	78 (13.9)
9	To cordon off an anthrax-infected area is too harsh a measure	42 (7.5)	50 (8.9)	107 (19.0)	281 (49.9)	83 (14.7)
10	Because there is no compensation, if animals are infected and condemned, butchers should still go ahead to slaughter and sell them for consumption	36 (6.4)	39 (6.9)	65 (11.5)	366 (65.0)	57 (10.1)

Table 10 Attitude of Ghanaian Veterinary students towards Anthrax

S/N	Item	SA (%)	A (%)	D (%)	SD (%)	Not Sure (%)
1	Sick or moribund animals can be slaughtered to avoid loss	15 (6.5)	28 (12.2)	27 (11.7)	104 (45.2)	56 (24.4)
2	The source of the vaccine against anthrax does not really matter	79 (34.4)	4 (1.7)	12 (5.2)	106 (46.1)	29 (12.6)
3	Annual vaccination of animals against anthrax is important for prevention	0 (0.0)	0 (0.0)	105 (45.7)	42 (18.3)	83 (36.1)
4	I do not consider my job a risk of exposure to anthrax	0 (0.0)	0 (0.0)	18 (7.8)	54 (23.4)	158 (68.7)
5	I do not consider anthrax a fatal disease	0 (0.0)	0 (0.0)	119 (51.7)	29 (12.6)	82 (35.7)
6	Animals condemned for anthrax can still be slaughtered and consumed if cooked well	0 (0.0)	0 (0.0)	158 (68.7)	60 (26.1)	12 (5.2)
7	Any case of anthrax should be reported	0 (0.0)	0 (0.0)	103 (44.7)	59 (25.6)	68 (29.6)
8	Wearing PPE is not so important in anthrax prevention	0 (0.0)	0 (0.0)	120 (52.2)	48 (20.9)	62 (27.0)
9	To cordon off an anthrax-infected area is too harsh a measure	0 (0.0)	0 (0.0)	170 (73.9)	51 (22.2)	9 (3.9)
10	Because there is no compensation, if animals are infected and condemned, butchers should still go ahead to slaughter and sell them for consumption	79 (34.4)	4 (1.7)	12 (5.2)	106 (46.1)	29 (12.6)

respectively, strongly disagreed that, because there was no compensation, infected and condemned animals could still be slaughtered and sold for human consumption.

Also, 48(20%) Ghanaian and 325(57%) Nigerian students disagreed that wearing PPE is not so important in anthrax prevention (Tables 9 and 10).

4 Discussion

4.1 Knowledge of anthrax among veterinary students

This study revealed that the proportion of veterinary students in Nigeria with greater knowledge of anthrax was higher than that of Ghanaian students. This finding suggests important differences in training exposure and educational emphasis between the two countries.

Although Ghana has experienced more frequent anthrax outbreaks than Nigeria, this did not translate into higher knowledge levels among Ghanaian students, indicating a gap between outbreak exposure and structured academic learning.

While Ghanaian students are reportedly introduced to anthrax training earlier in their programme than Nigerian students, overall knowledge levels remained low in both countries, indicating significant gaps in their understanding. This suggests that early exposure alone may be insufficient without adequate depth, reinforcement, and practical application of zoonosis-related content.

The proportion of students with good knowledge in this study was lower than that reported among livestock owners in Meta Welkite District, Oromia Region, Ethiopia [21], in which all respondents (100%) had a good knowledge of anthrax. These differences may be attributed to the greater direct exposure of livestock owners to disease outbreaks and their consequences, compared with students whose knowledge is largely theoretical. This finding underscores a paradox in which livestock owners may possess more experiential knowledge of anthrax than veterinary students, who are expected to serve as custodians of animal and public health knowledge.

These results strongly support the need for curriculum review and strengthening of zoonosis-focused training, particularly for high-priority diseases such as anthrax.

The study also found that a higher percentage of students reported veterinary school as their primary source of information on anthrax, rather than informal sources, such as the internet, television, and radio, reinforcing the central role of university education as an effective way of shaping knowledge of zoonotic diseases.

In contrast, the least common source of information cited was the community leaders, suggesting limited community-level engagement in zoonosis education. According to Henley et al. [22], a one-health approach to zoonosis is only successful with bottom-up community engagement, education, and international collaboration. Mogaji et al. [14]. and Okunlade et al. [23] also emphasised that assessing community knowledge and practices is crucial for effective control and prevention of anthrax.

4.2 Attitudes and risk perceptions related to anthrax

A concerning finding was that 58% of Ghanaian veterinary students believed that sick or moribund animals could still be slaughtered to avoid financial loss, compared with a much lower proportion in Nigeria. Such attitudes reflect a tolerance for risky practices that are known to contribute to recurrent human anthrax infections.

Meanwhile, the slaughter of generally sick animals or the butchering of dead animals for salvage purposes, as well as the consumption or handling of meat from infected animals, contribute to recurrent cases of anthrax in humans [14]. Furthermore, 35% of veterinary students in Ghana strongly agreed that infected or condemned animals could still be slaughtered and sold for consumption due to the absence of compensation mechanisms, compared with only 6.4% of Nigerian students.

This finding aligns with reports of suspected human anthrax cases, including one fatality, in the Binduri District of Ghana in 2023, which were linked to the consumption of dead cattle [24]. Some farmers in northern Ghana reportedly believe that local concoctions can render meat from infected animals safe for consumption; however, such practices are ineffective and dangerous.

These beliefs highlight the intersection between economic pressure, cultural practices, and disease transmission risk.

4.3 Preventive practices and use of protective measures

A positive finding of this study was that most students in both countries strongly disagreed with the notion that personal protective equipment (PPE) is unimportant for anthrax prevention. This reflects a general awareness of the role of PPE in reducing occupational exposure, not only for anthrax but for zoonotic diseases more broadly. However, a significantly higher proportion of Nigerian veterinary students demonstrated good anthrax-prevention practices compared with Ghanaian counterparts, indicating the need for targeted awareness and practical training among Ghanaian students.

4.4 Predictors of knowledge and practices

Regression analysis revealed that sex and level of study are significant predictors of anthrax knowledge among Nigerian students, with males and students in higher academic levels demonstrating better knowledge. This suggests that cumulative academic exposure plays an important role in knowledge acquisition, particularly in Nigeria.

On the other hand, among Ghanaian students, age emerged as a significant predictor of anthrax-prevention practices, with older students less likely to demonstrate adequate preventive behaviours. This finding may reflect differences in curriculum structure and timing of zoonosis training across cohorts. The veterinary education model at Kwame Nkrumah University of Science and Technology, located within the College of Health Sciences, may promote earlier exposure to One Health concepts [25].

4.5 Attitudes toward vaccination and control measures

Overall, students in both countries demonstrated generally positive attitudes towards anthrax prevention, although Nigerian veterinary students exhibited significantly more positive attitudes towards anthrax than their Ghanaian counterparts. These findings regarding attitudes towards anthrax are consistent with those reported by Salli et al. [26], who assessed knowledge, attitudes and practices towards anthrax among community members and professionals in the Dugda district of West Guji zones, Southern Ethiopia.

A higher proportion of students strongly agreed that annual vaccination of animals against infection is essential for prevention. Once an outbreak occurs, control measures such as ring vaccination, proper carcass disposal, and quarantine of new or affected animals are critical for limiting the spread of disease [27]. Studies have also demonstrated that vaccination with the Sterne live anthrax spore vaccine (a non-pathogenic, non-encapsulated strain of *Bacillus anthracis*) or non-living vaccine prototypes is immunogenic and effective [28]. In addition, public education on recognising anthrax symptoms in livestock is essential to improve detection and prevent people from handling, processing, or consuming infected animals [7].

5 Implications and conclusions

Anthrax is a fatal, virulent, and highly contagious disease with significant public health implications as a zoonosis. This study identified significant gaps in knowledge, attitudes, and practices among veterinary students, particularly in Ghana. Curricular reforms are urgently needed, including earlier introduction of zoonosis topics, enhanced practical and field training, and specific emphasis on the economic drivers of risky practices like slaughtering infected animals.

The absence of compensation policies for farmers whose livestock are affected by anthrax contributes to unsafe practices, including the sale and consumption of infected meat. Government-led compensation schemes could reduce these behaviours and improve outbreak control.

Educating and empowering future veterinarians, while strengthening their engagement with communities, is essential to preventing recurrent anthrax outbreaks in Ghana, Nigeria, and other African countries.

5.1 Recommendation

Findings from this research indicate a great need to revise the Doctor of Veterinary Medicine Curriculum to introduce zoonosis education earlier. Targeted communication should be developed for students in Ghana to address the specific attitudinal misconceptions (e.g., about slaughtering sick animals and compensation). More community engagements and practical field trainings should be incorporated into the DVM program to bridge the theory-practice gap.

5.2 Limitations

This study is limited in that sampling may be biased as one university in Ghana was enlisted, while three were enlisted in Nigeria. Also, some of the students in both schools were unwilling to participate in the study, while some were excluded (100-level students, especially in Nigeria) because they had not been exposed to Veterinary Medicine courses, though they are Veterinary students. Also, 500-level students in Ghana were on an internship.

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Author contributions

A. O. O and F.O.J wrote the main manuscript text. P.I.A, A.O.O and D.A.A prepared the figures. All the authors reviewed and edited the manuscript.

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Data availability

All the data used and analysed during this study are available on request from the corresponding author.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Ethical approval was obtained for this study from the College of Medicine, Institute for Advanced Medical Research and Training (IAMRAT), University of Ibadan, with the approval number UI/EC/250030. Written informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

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