Advances in Microbiology, 2025, 15(3), 137-151
https://www.scirp.org/journal/aim
ISSN Online: 2165-3410
ISSN Print: 2165-3402

Etiological Surveillance of Vaginal Discharge and Associated Risk Factors among Young Female Students Presenting to a University Clinic in Ghana

Adwoa Asante-Poku[1*], Daniel Boateng[1], Christian Bonsu[1], Mohammed Yussif[1], Gloria Ansa[2], Kenneth Mawuta Hayibor[1]

[1]Department of Bacteriology, Noguchi Memorial Institute for Medical Research, University of Ghana, Accra, Ghana
[2]University of Ghana Health Service, Accra, Ghana
Email: *aasante-poku@noguchi.ug.edu.gh

How to cite this paper: Asante-Poku, A., Boateng, D., Bonsu, C., Yussif, M., Ansa, G. and Hayibor, K.M. (2025) Etiological Surveillance of Vaginal Discharge and Associated Risk Factors among Young Female Students Presenting to a University Clinic in Ghana. *Advances in Microbiology*, **15**, 137-151.
https://doi.org/10.4236/aim.2025.153011

Received: January 15, 2025
Accepted: March 10, 2025
Published: March 13, 2025

Abstract

Background: In adolescents and young females, abnormal vaginal discharge (AVD) is of prevalent concern. The syndromic therapy of AVD is difficult due to the prevalence of mixed infection with sexually transmitted infection (STI) pathogens and non-STI causes such as bacterial infections and candidiasis. We aimed to determine the prevalence of AVD etiologies in women presenting to a university clinic in Ghana. **Methods:** Consenting female students presenting with abnormal vaginal discharge were enrolled in the study. Clinical and demographic data, signs, symptoms duration, and color of the discharge at diagnosis, were obtained from each participant. Genital discharge swabs were collected and transported to the laboratory for analysis. **Results:** A total of 153 women presenting with abnormal vagina discharge were enrolled in the study clinic. Overall, 48 (31.4%) of the participants tested positive for at least one STIs. Candida species were isolated in 71 (46.4%) of the participants. Bacteria were detected in 83 (54.2%) of the samples and the commonest isolates were *Escherichia coli, Klebsiella spp*, *Staphylococcus aureus,* and *Streptococcus agalactiae*. Overall, sensitivity across gram-positive bacterial isolates was highest to cefuroxime and gentamycin while penicillin showed the highest resistance. The most sensitive antibiotics to gram-negative bacteria isolates were gentamycin, cefuroxime, and clotrimazole while ampicillin exhibited the highest resistance. **Conclusions:** Bacterial infections are the most prevalent cause of AVD; however, STI coinfection and fungal infections are also common. Laboratory analysis of vaginal samples should be performed on patients with AVD and the drug susceptibility pattern of each bacteria isolate should be determined.

Keywords

Abnormal Vaginal Discharge, Sexually Transmitted Infections, Bacteria Isolates, Antibiotics Resistance

1. Introduction

The vagina is a complex ecosystem with a variety of microorganisms. This specific environment undergoes significant transformation from birth to puberty and menopause. Women are more susceptible to urinary and vaginal infections due to their anatomical and functional closeness to the anal canal, together with their shorter urethra [1]. The vaginal region is considered a sophisticated microbial ecosystem including a varied array of microbial species. The menstrual cycle modifies the typical physiological discharge. It is viscous and adhesive during the majority of the cycle but becomes more transparent, moist, and elastic for a short duration after ovulation. Approximately 75% of women are prone to vaginal infections at least once during their lives [2]. Abnormal vaginal discharge (AVD) is prevalent among women aged 15 to 49 years [3]. It is often characterized by alterations in amount, consistency, color, and odor, often accompanied by lower abdominal pain, pruritus, discomfort, dysuria, pelvic pain, or intermenstrual or postcoital hemorrhage [4]. These atypical vaginal discharges are frequently ascribed to several sexually transmitted infections (STIs), in addition to non-STI conditions that may be sexually transmitted, such as bacterial and candidal diseases [3]-[5]. Managing AVD is particularly problematic due to the widespread occurrence of mixed infections [6]-[9].

The predominant causes of AVD in Ghana are bacterial infections [10]. Sexually transmitted diseases frequently co-occur with bacterial infections in young adult females and vulvovaginal candidiasis. Nonetheless, several people with these diseases also exhibit STI infections, with the largest documented incidence occurring among young adults of reproductive age [11]. Treatment in Ghana typically utilizes the syndromic treatment strategy, employing cefixime and doxycycline as the first-line antibiotics, without regular culture and sensitivity testing. Antibiotic susceptibility patterns evolve. This management strategy for AVDs sometimes results in overtreatment of patients due to the challenges in appropriately categorizing infections such as STIs or non-STIs. University students are classified as a highly at-risk demographic due to their propensity for engaging in hazardous sexual behaviors and their inadequate perception of vulnerability. Due to the elevated risk of engaging in hazardous behaviors and the limited utilization of preventative measures and services among youth in underdeveloped countries, sexually transmitted infections (STIs) are prevalent sexual and reproductive health issues [11]-[13].

There is a paucity of evidence and surveillance about the genesis of AVD in young people and their antibiotic resistance. The application of diverse medication combinations in the syndromic therapy of AVD, without frequent culture and sensitivity testing, may intensify concerns over antibiotic resistance, characterized by low cure rates and high recurrence rates.

To overcome the shortcomings of existing methodologies, we have utilized a mix of several techniques, including molecular technologies, to identify and describe distinct AVDs. This pilot study report identified the causes of AVDs and the rates of coinfections among students exhibiting VDS. We also examined the antimicrobial susceptibility of isolated bacterial infections.

2. Methods

Study Design, Setting, and Ethics

This cross-sectional study was carried out at the University of Ghana Student Clinic (UGSC) between February and December 2019. Female students presenting with AVD who sought care at the UGSC were enrolled in the study after obtaining written informed consent. Those with regular menstrual cycles (21 - 35 days), as an indication of active reproductive cycle, were included in the study. Participants who were taking part in another clinical study, were pregnant, actively trying to conceive or suspected to be pregnant, in their menstrual period, those who have never had penetrative sex, had been medically diagnosed with diabetes, kidney failure, hepatitis, AIDS (HIV positive), or toxic shock syndrome, or were taking immunosuppressive medications, chemotherapy, systemic antimicrobial or antifungal medications, or antimicrobials to treat a vaginal infection at the time of the study or within the previous 30 days were excluded from the study. Before obtaining the consent, experience study nurses and doctors counseled and explained all the study procedures and protocol to the participants. The Institutional Review Board (IRB) of the Noguchi Memorial Institute for Medical Research (NMIMR), Legon-Ghana, the University of Ghana Medical Research Committee, and the Public Health Department of the University of Ghana Hospital approved the study protocol.

Sample Collection and Processing

The details of the study were explained to each participant and written informed consent was obtained before voluntary enrolment. Clinical and demographic data, signs, symptoms duration, and color of the discharge at diagnosis, were obtained from each participant. The sterile speculum was passed to each participant and 4 vaginal samples were obtained, 2 swabs each for high vaginal (HVS) and endocervical. For the endocervical samples, the first swab was stored in 1 ml of saline or transport media (STGGB) at 80˚C upon arrival at the laboratory. The second swab was plated directly at the study site, onto two different agar plates (blood agar and modified Thayer Martin agar in a CO_2 jar.) and taken back to the laboratory within 6 hours of collection. The plates were incubated for 48 hours at 37˚C in 5% CO_2 and monitored for 16 h, 24 h, and 48 h for the presence of macroscopic growth. For positive plates, the following was done.

- A score for bacterial density was given for each agar plate (low, medium, or high).

- Different morphological colonies observed on the blood agar plates were characterized by Gram staining and oxidase test and further characterized as necessary.
- *Neisseria-like* colonies observed on the modified Thayer Martin agar plates were sub cultured onto blood agar plates and incubated between 16 - 48 h at 37˚C in 5% CO_2, for further characterization as described below.

The first HVS was used to prepare a wet mount and observed under the microscope for *Trichomonas vaginalis*. This was done to observe the early stages of *Trichomonas vaginalis* and yeast cells. Samples from the endocervical canal and vagina were emulsified in sterile normal saline. A drop of each combination was deposited on separate slides using a sterile pipette and inspected under a × 40 objective lens to look for motile *Trichomonas vaginalis* and budding yeast cells. Briefly Swabs from the endocervix and posterior vaginal fornix were prepared, fixed, and examined under oil immersion at × 100 for the presence of granulocytes, clue cells (vaginal epithelial cells with a granular surface and blurred margins due to attached bacteria indicative of bacterial vaginosis), and gram-positive budding yeast cells on a well-labelled slide. A cotton swab containing the specimen was then rolled on the slide and spread uniformly to cover a 15 - 20 mm diameter. The slide was then air-dried before being fixed with two drops of 50% acetone alcohol, which were let dry for two minutes. The fixed smear was then treated with crystal violet for 30 - 60 seconds. The stain was then washed off with clean water, all of which was tipped off, and the smear was treated with Lugol's iodine for 30 - 60 seconds before being wiped off. The smear was then swiftly decolorized with acetone-alcohol, washed with clean water, then coated with a neutral red stain for 2 minutes before being wiped off and air dried. The smear sample was originally inspected using a microscope with a × 40 objective lens to check for staining and distribution, followed by an oil immersion objective lens to report the bacteria and cells. Gram-positive bacteria and yeast cells appear in dark purple, whilst gram-negative bacteria and pus cell nuclei appear in red

The same HVS was inoculated on a blood and Uri Select agar for bacterial culture The second vaginal swab was eluted in 800 µl phosphate-buffered saline and divided into four aliquots. One aliquot each was tested for *Trichomonas vaginalis* (Aptima Trichomonas vaginalis assay, HOLOGIC, Bedford, MA, USA), *Chlamydia trachomatis* and *Neisseria gonorrhea* (Aptima Combo 2, HOLOGIC, Bedford, MA, USA), and human papillomavirus (HPV) (SPF10-PCR-DEIA/LiPA25 system version 1, DDL, Voorburg, the Netherlands), and the fourth aliquot was used for VMB characterization. The endocervical swab used in the inoculation was placed in an Xpert CT/NG transport medium. Antibiotic susceptibility testing was performed for isolates obtained from the inoculated blood and Uri select agar plates.

Antibiotic Susceptibility Testing

This was done on a pure culture that demonstrated considerable growth using standard criteria as stated by the Kirby-Bauer disc diffusion method. Chocolate agar incubated with carbon dioxide served as the medium for fastidious microbes. For non-fastidious organisms, we utilized Muller Hinton Agar (MHA) cultured aerobically at 37˚C. The inoculum density required for susceptibility testing was 0.5%, according to McFarland. The antibiotic discs used were determined by the type of organism(s) being cultivated. Antimicrobial agents used included tetracycline (50 μg), ceftriaxone (30 μg), ciprofloxacin (5 μg), amoxicillin (10 μg), and erythromycin (15 μg) for gram-positive organisms and gentamycin (10 μg), amoxicillin/clavulanate, cefixime, cefuroxime, azithromycin, and doxycycline for gram-negative organism susceptibility testing. Since erythromycin is ineffective against gram-negative bacteria, susceptibility testing was limited to gram-positive bacteria. In summary, colonies of pure bacterial growth were scrapped from the culture plate containing the cultivated organism using a sterile wire loop. The colonies were then suspended in 2 milliliters of sterile peptone water to create a suspension equal to 0.5 McFarland standard. The surplus peptone water was then squeezed out by pushing the sterile cotton swab against the tube wall above the suspension level, after it had been submerged in the suspension of peptone water containing the test organism. For internal quality control, S. aureus ATCC25923 for gram-positive bacteria and E. coli ATCC25922 for gram-negative bacteria were the standard organisms in suspension. Using sterile forceps, five antibiotic discs were then positioned on the agar plate's surface, at least 2.5 cm apart. The culture plates were then incubated aerobically for 24 to 48 hours at 37˚C. Using a ruler, the widths of the growth inhibition zones surrounding each antibiotic disc were measured in millimeters, and the results were compared to the reference organism's growth inhibition zone diameter using the Clinical Laboratory Standards Institute—USA 2020

Statistical analysis

Data was entered into Microsoft Excel 2016 and analyzed using Stata v15 (College Station, TX, US). Descriptive statistics were used to summarize the demographic and clinical characteristics of the participants. The prevalence of bacterial and candida infections and other STIs was determined by the percentage of participants with the respective microorganism out of the 153 participants that were tested. Logistic regression was used to determine demographic and clinical characteristics associated with having an infection. Crude odds ratios (COR) and adjusted odds ratios (AOR) were calculated with 95% confidence interval, p value < 0.05 was considered significant.

3. Results

Patient Demographic and Clinical Characteristics

A total of 170 female students presenting to the University of Ghana Student's clinic with various complaints suspected of STIs were contacted to participate in the study, 95.8% (163/170) gave consent and were recruited during the study period. Out of the 163 recruited participants, 153 gave vaginal swabs. The mean age of the 153 participants was 20.8 years. Majority (94.8%) of the participants are Christians, 129 (84.2%) reside resident and 123 (80.4%) are dating. The most reported clinical sign and symptom was itches (105, 86.6%) and the most reported color of discharge was whitish/creamy discharge (102, 66.7%). The demographic characteristics of the participants are summarized in **Table 1**.

Table 1. Demographic and clinical characteristics of female students presenting with vaginitis in a student clinic in Ghana (n = 153).

Characteristics	Frequency (%)
Demographics	
Age (mean)	28.8
Religion	
Christian	145 (94.8)
Islam	8 (5.2)
Ethnicity	
Akan	70 (32.0)
Fante	12 (7.8)
Ga	13 (8.5)
Ewe	24 (15.7)
Others	34 (22.2)
Level	
100	27 (17.6)
200	59 (38.6)
300	33 (21.6)
400	34 (22.2)
Residential status	
Resident on campus	129 (84.3)
Resident off campus	24 (15.7)
Relationship status	
Single	29 (19.0)
Dating	123 (80.4)
Married	1 (0.6)
Number of sexual partners	
None	39 (25.7)
1	37 (24.3)
2 - 3	20 (13.2)
>3	56 (36.8)
New sexual partner in the past 3 months	
Yes	106 (69.3)
No	47 (30.7)

Continued

Contraceptive use	
Yes	132 (86.3)
No	21 (13.7)
Clinically	
Duration of discharge	
One week or less	41 (26.8)
2 - 3 weeks	34 (22.2)
>3 weeks	78 (51.0)
Sign and symptoms	
Fever	16 (10.5)
Itches	105 (86.6)
Burning sensation	53 (34.6)
Abdominal pains	20 (13.1)
Colour of discharge	
Greenish Yellow	30 (19.6)
Brownish	21 (13.7)
Whitish/creamy	102 (66.7)

Sociodemographic and Clinical Factors Associated with STIs

A total of 31% (48 of 153) participants were identified as having STIs. Table 2 presents the sociodemographic characteristics and clinical factors associated with STI infections. Female students in the 200 level and above exhibited a higher likelihood of STI infection compared to those in the 100 level; however, this difference lacked statistical significance. Students residing off-campus exhibited a higher likelihood of STI infection in comparison to their on-campus counterparts.

The prevalence of STIs differed according to the chosen reproductive history; however, none of the differences reached statistical significance. The prevalence of STIs was 43.2% among individuals without a sexual partner at the time of discharge, compared to 38.5% for those with more than three sexual partners. The prevalence among individuals with a new sexual partner in the past three months was 32.1%, compared to 31.8% among those currently using contraceptives. The prevalence of STIs is contingent upon the signs and symptoms exhibited by the participants. The prevalence of STIs is 26% among individuals reporting a burning sensation, 30.1% among those with abdominal pain, 31% among those with fever, and 29.3% among those experiencing itching. Participants exhibiting bacterial isolation demonstrated a higher prevalence of STIs at 38.6%, in contrast to 22.9% among those without bacterial isolation. The difference was statistically significant ($p = 0.039$).

Table 2. Demographic and clinical risk factors associated with STI.

Characteristics	STI		cOR (95% CI) p	aOR (95% CI) p
	Yes	No		
Demographics				
Age (mean)				
Level				
100	6 (22.2)	21 (77.8)	1	
200	22 (37.3)	37 (62.7)	2.081 (0.73 - 5.94)	0.171
300	11 (33.3)	22 (66.7)	1.750 (0.55 - 5.59)	0.950
400	9 (26.5)	25 (73.5)	1.26 (0.39 - 4.12)	0.702
Residential status				
Resident on campus	40 (31.0)	89 (69.0)	1	
Resident off campus	8 (33.3)	16(66.7)	1.113 (0.44 - 2.81)	0.822
Relationship status				
Single	39 (31.2)	86 (68.8)	1	
Dating	9 (32.1)	19 (67.9)	1.044 (0.43 - 2.52)	0.923
Number of sexual partners				
None	16 (43.2)	21 (56.8)	1	
1	4 (20.0)	16 (80.0)	0.328 (0.09 - 1.17)	0.086
2 - 3	13 (23.2)	43 (76.8)	0.397 (0.16 - 0.97)	0.044
>3	15 (38.5)	24 (61.5)	0.820 (0.33 - 2.05)	0.672
New sexual partner in the past 3 months				
Yes	34 (32.1)	72 (67.9)	1	
No	14 (29.8)	33 (70.2)	0.898 (0.43 - 1.90)	0.778
Contraceptive use				
Yes	42 (31.8)	90 (68.2)	1	
No	6 (28.6)	15 (71.4)	0.857 (0.31 - 2.37)	0.766
Duration of discharge				
One week or less	14 (34.2)	27 (65.9)	1	
2 - 3 weeks	12 (35.3)	22 (64.7)	1.052 (0.40 - 2.73)	0.917
>3 weeks	22 (28.2)	56 (71.8)	0.758 (0.34 - 1.71)	0.503
Fever				
Yes	5 (31.3)	11 (68.8)	1	
No	43 (31.4)	94(68.6)	1.006 (0.33 - 3.08)	0.991
Itches				
Yes	36 (29.3)	87 (70.7)		
No	12 (40.0)	18 (60.0	1.611 (0.70 - 3.68)	0.259

Continued

Burning sensation				
Yes	14 (26.4)	39 (73.6	1	
No	34 (34.0)	66 (66.0)	1.435 (0.69 - 3.00)	0.337
Abdominal pains				
Yes	40 (30.1)	93 (69.9)	1	
No	8 (40.0)	12 (60.0)	1.55 (0.59 - 4.08)	0.375
Bacteria isolated				
Yes	32 (38.6)	51 (61.5)	2.117 (1.04 - 4.31)	0.039
No	16 (22.9)	54 (77.1)	1	
Candida sp isolated				
Yes	19 (26.8)	52 (73.2)	0.668 (0.33 - 1.34)	0.254
No	29 (35.4)	53 (64.6)	1	

Distribution of Organisms Identified per Sample and Major STIs

Figure 1 shows the number of samples identified per sample and major STIs identified in each sample. At least one disease-causing pathogen was found in 94.61% of the samples, and up to four pathogens were identified in some of the samples. In our study, 32.7% of the participants were found to have STIs. There were 15.7% (24/153) cases of *Chlamydia Trachomatis* (CT), 2.6% (4/153) of *Neisseria gonorrhea* (NG), 3.3% (5/153) of *Trichomonas Vaginalis* (TV), and 11.1% (17/153) of HIV infections.

Bacteria and Candida Species Isolated

Bacteria were detected in 83 (54.2%) of the samples. From these samples, 88 bacterial isolates were obtained. Of these, 26 isolates (29.5%) were Gram-negative bacteria, and 62 isolates (70.5%) were Gram-positive. The most common Gram-negative bacteria were *E. coli* and *Klebsiella spp.*, while the prevalent Gram-positive bacteria were *S. aureus* and *S. agalactiae*. Additionally, 71 (46.4%) Candida species were isolated, with *Candida albicans* constituting the majority at 62 (87%) of the isolates.

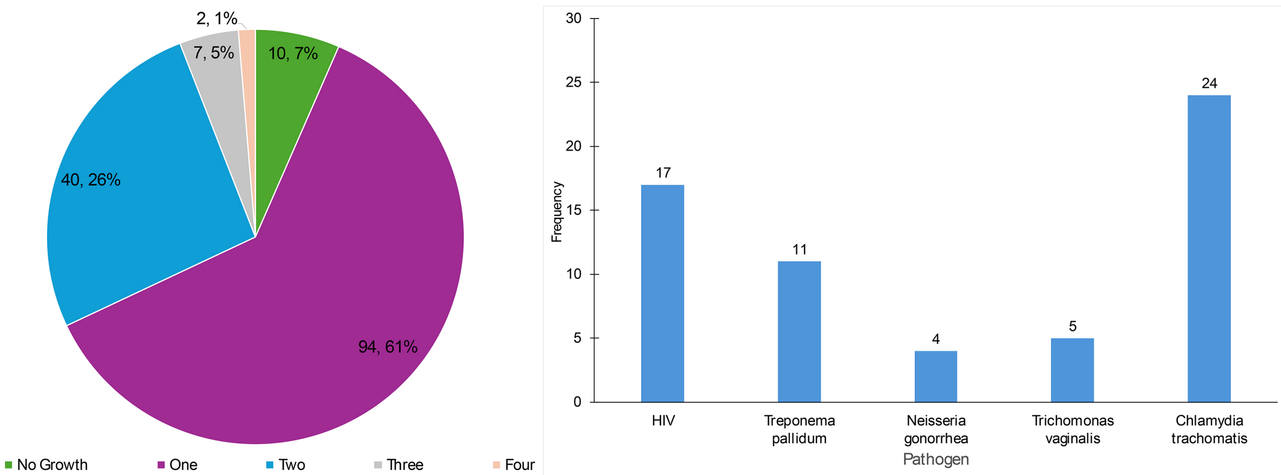

Figure 1. Distribution organisms identified per sample and major STIs.

Antibiotic Susceptibility Testing

Table 3 shows the drug susceptibility pattern of the Gram-positive bacteria to eleven antibacterial drugs tested. Among the drugs, cefuroxime had the highest sensitivity rate at 87.3%, followed by gentamycin at 65.9% and ampicillin at 64.9%. Penicillin showed the highest resistance, followed by tetracycline and clotrimazole. Enterococcus faecalis and Streptococcus agalactiae, the most frequently isolated gram-positive bacteria, were most sensitive to ampicillin (88.2%) and clotrimazole (92.3%), respectively, and most resistant to penicillin. The overall drug susceptibility pattern of Gram-negative bacteria to nine antibacterial agents is summarized in Table 4. Among gram-negative bacteria, gentamycin was the most sensitive antibiotic at 81%, followed by cefuroxime and clotrimazole at 76.9%. Ampicillin exhibited the highest resistance rate against gram-negative at 84.6%. For species-specific antimicrobial resistance rates, E. coli, the most frequently isolated gram-negative bacterium, showed 92.3% sensitivity to gentamycin. The least isolated gram-negative, *Pseudomonas oleavarans*, was sensitive to five out of the eight antibiotic drugs.

Table 3. Antibiotic susceptibility pattern of gram-negative bacteria of clinical importance isolated from the female students presenting with vaginitis in a student clinic in Ghana.

Bacteria isolate	No. of isolates	Pattern	CTX	AMP	TET	GEN	CRX	CHL	CTR	COT
Escherichia coli	13	S	84.6	7.7	23.1	92.3	84.6	38.5	92.3	0
		R	15.4	92.3	76.9	7.7	15.4	61.5	7.7	100
Klebsiella pneumonia	10	S	60.0	20.0	50.0	70.0	60.0	60.0	60.0	30.0
		R	4.0	80.0	50.0	30.0	40.0	40.0	40.0	70.0
Proteus mirabilis	2	S	100.0	50.0	50.0	100	100	50.0	100	50.0
		R	0	50.0	50.0	0	0	50.0	0	50.0
Pseudomonas oleovarans	1	S	100	0	100	0	100	100	0	100
		R	0	100	0	100	0	0	100	0
Total	26	S	76.9	15.4	38.5	80.8	76.9	50.0	76.9	19.2
		R	23.1	84.6	61.5	19.2	23.1	50.0	23.1	80.8

Table 4. Antibiotic susceptibility pattern of gram-positive bacteria of clinical importance isolated from the female students presenting with vaginitis in a student clinic in Ghana.

Bacteria isolates	No. of isolates	Pattern	FLX	ERY	TET	COT	CRX	GEN	PEN	AMP
Streptococcus agalactiae	13	S	69.2	76.9	76.9	92.3	76.9	69.2	0	53.8
		R	30.8	23.1	23.1	7.7	23.1	30.8	100	46.2

Continued

Staphylococcus aureus	6	S	100	100	83.3	100	100	100	0	0
		R	0	0	16.7	0	0	0	100	100
Staphylococcus sciuri	6	S	50.0	83.3	16.7	100	100	100	0	100
		R	50.0	16.7	83.3	0	0	0	100	0
Enterococcus faecalis	17	S	23.5	82.4	11.8	9	76.5	12	17.6	88.2
		R	76.5	17.6	88.2	4	23.5	1	82.4	11.8
Staphylococcus haemolyticus	5	S	60.0	20.0	0	0	80.0	80.0	0	40.0
		R	40.0	80.0	100	100	20.0	20.0	100	60.0
Staphylococcus saprophyticus	9	S	55.6	44.4	66.7	11.1	77.7	100	0	88.9
		R	44.4	55.6	33.3	88.9	22.3	0	100	11.1
Corynebacterium spp.	6	S	16.7	16.7	16.7	16.7	100	0	0	83.3
		R	83.3	83.3	83.3	83.3	0	100	100	16.7
Total	62	S	53.6	60.5	38.9	47.0	87.3	65.9	2.5	64.9
		R	46.4	39.5	61.1	53.0	12.7	34.1	97.5	35.1

4. Discussion

This study investigated the prevalence of major STIs, fungal and bacterial isolates among female students presenting with AVD at the University of Ghana Student's clinic. In this study we found that 80.4% of students presenting with vaginal discharge tested for at least an STI, bacteria or fungal infection. The study found that the commonest infection among the students was bacterial infection followed by fungal infection specifically *Candida albicans*. The most abundant Gram-negative bacteria were *Escherichia coli* and *Klebsiella pneumoniae*, while Gram-positive bacteria include *Staphylococcus saprophyticus and Enterococcus faecalis.* The proportion of participants testing positive for an STIs was 28% with the highest prevalence being *Chlamydia Trachomatis.*

Comparing other studies conducted in Ghana to our study, in a study among university students, overall prevalence of vaginal infections was 66%, including bacterial vaginosis 28%, *Candida* infection 22% and co-infection of bacterial and *Candida* 16% [14]-[18]. Another study among pregnant women attending antenatal clinic found a lower prevalence of at least one vaginal infection to be 56.4% [14]. Among University of Calabar female students, 70% were infected with vaginosis and vaginitis. The high rates of infection observed in our study compared to others may stem from our cohort of female students presenting with AVD, underscoring the importance of investigating to determine the etiology of the vaginal discharge.

In our study, 31% of the participants were found to have STIs. Another study among young women in Ghana reported an STI prevalence of 12% [19]. These findings are higher than those in the Gambia, where the prevalence of STIs among university students was 10% [20], and 15.74% among students at Wolaita Sodo University [21]. The higher prevalence rate in our study is not surprising, given that our cohort had AVD, and the majority were exhibiting signs and symptoms of STIs. Furthermore, since most reported STI prevalences are self-reported, accurate determination of prevalence requires surveillance with appropriately obtained and analyzed samples, as was done in this study.

In our study, the proportion of samples in which bacteria were isolated is similar to the findings of a study from Nigeria, where bacteria were isolated in 54.2% of the samples. However, this proportion was lower than that in other studies: 41.5% and 39.5% in Ethiopia [16], and 43.1% in Kenya [22]. The differences could be due to variations in participant characteristics.

The most common bacterial isolates were *Staphylococcus aureus, Staphylococcus agalactiae, Klebsiella pneumoniae*, and *Escherichia coli*. These isolates are consistent with findings from other studies conducted in Burkina Faso and Ethiopia [14] [23]. *Staphylococcus aureus*, which is commonly found on the skin including the perineum, can be transmitted to the upper vagina and cervix during sexual activity [24]. *Klebsiella pneumoniae* and *Escherichia coli*, typically residents of the gastrointestinal tract and often present in stool samples, can easily transfer to the genitourinary tract due to the close proximity of the female genital tract to the anal opening, especially during sexual intercourse [25].

The overall sensitivity across gram-positive bacterial isolates was highest to cefuroxime and gentamycin while penicillin showed the highest resistance. Our result was similar to studies conducted in Northern Ghana [10] and Ethiopia [16] [23]. Among gram-negative bacteria isolates, gentamycin, cefuroxime, and clotrimazole were the most sensitive antibiotics while ampicillin exhibited the highest resistance. This finding is similar to studies in Uganda [26] [27] and Saudi Arabia [28]. The frequent prescription of these antibiotics in health facilities, pharmacies, and over-the-counter drugstores and the widespread self-medication without prescriptions in Ghana may account for the high levels of drug resistance observed in this study [29] [30]. Additional research is necessary to understand the patterns of susceptibility and resistance. Consequently, this underscores the critical need to enhance antibiotic stewardship programs in hospitals and to educate the broader population.

5. Conclusion

The prevalence of bacterial infections in women with AVD is notably high. Concurrently, STI co-infections and fungal infections are prevalent. There is a significant resistance pattern of bacterial isolation to certain common antibiotics, necessitating improved antibiotic stewardship and education for the general public. It is essential to conduct laboratory analyses of vaginal samples from patients with

AVD, ascertain the drug susceptibility of each bacterial isolate, and administer treatment in accordance with established treatment guidelines.

Conflicts of Interest

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

References

[1] Minardi, D., d'Anzeo, G., Cantoro, D., Conti, A. and Muzzonigro, G. (2011) Urinary Tract Infections in Women: Etiology and Treatment Options. *International Journal of General Medicine*, **4**, 333-343. https://doi.org/10.2147/IJGM.S11767

[2] Jaeger, M., Plantinga, T.S., Joosten, L.A.B., Kullberg, B.J. and Netea, M.G. (2013) Genetic Basis for Recurrent Vulvo-Vaginal Candidiasis. *Current Infectious Disease Reports*, **15**, 136-142. https://doi.org/10.1007/s11908-013-0319-3

[3] World Health Organization (2021) Guidelines for the Management of Symptomatic Sexually Transmitted Infections.

[4] Singh, K. (2016) Integrated Approach to Obstetrics and Gynaecology. World Scientific Publishing Co. Pte Ltd. https://doi.org/10.1142/9995

[5] Becker, M., John, S., Stephen, M., Reynold, W., *et al.* (2010) Etiology and Determinants of Sexually Transmitted Infections in Karnataka State, South India. *Sexually Transmitted Diseases*, **37**, 159-164. https://doi.org/10.1097/OLQ.0b013e3181bd1007

[6] Prasad, D., Parween, S., Kumari, K. and Singh, N. (2021) Prevalence, Etiology, and Associated Symptoms of Vaginal Discharge During Pregnancy in Women Seen in a Tertiary Care Hospital in Bihar. *Cureus*, **13**, e12700. https://doi.org/10.7759/cureus.12700

[7] Mitchell, H. (2004) Vaginal Discharge—Causes, Diagnosis, and Treatment. *The BMJ*, **328**, 1306-1308. https://doi.org/10.1136/bmj.328.7451.1306

[8] Rao, V.L. and Mahmood, T. (2020) Vaginal Discharge. *Obstetrics, Gynaecology & Reproductive Medicine*, **30**, 11-18. https://doi.org/10.1016/j.ogrm.2019.10.004

[9] Sim, M., Logan, S. and Goh, L.H. (2020) Vaginal Discharge: Evaluation and Management in Primary care. *Singapore Medical Journal*, **61**, 297-301. https://doi.org/10.11622/smedj.2020088

[10] Gnimatin, J.P., Weyori, E.W., Agossou, S.M. and Adokiya, M.N. (2022) Bacterial Infections Epidemiology and Factors Associated with Multidrug Resistance in the Northern Region of Ghana. *Scientific Reports*, **12**, Article No. 22069. https://doi.org/10.1038/s41598-022-26547-7

[11] Konadu, D.G., Owusu-Ofori, A., Yidana, Z., Boadu, F., *et al.* (2019) Prevalence of Vulvovaginal Candidiasis, Bacterial Vaginosis and Trichomoniasis in Pregnant Women Attending Antenatal Clinic in the Middle Belt of Ghana. *BMC Pregnancy and Childbirth*, **19**, Article No. 341. https://doi.org/10.1186/s12884-019-2488-z

[12] Agyepong, N., Govinden, U., Owusu-Ofori, A. and Essack, S.Y. (2018) Multidrug-Resistant Gram-Negative Bacterial Infections in a Teaching Hospital in Ghana. *Antimicrobial Resistance & Infection Control*, **7**, Article No. 37. https://doi.org/10.1186/s13756-018-0324-2

[13] Kassie, B.A., Yenus, H., Berhe, R. and Kassahun, E.A. (2019) Prevalence of Sexually Transmitted Infections and Associated Factors among the University of Gondar Students, Northwest Ethiopia: A Cross-Sectional Study. *Reproductive Health*, **16**, Article No. 163. https://doi.org/10.1186/s12978-019-0815-5

[14] Karou, S.D., Djigma, F., Sagna, T., Nadembega, C., *et al.* (2012) Antimicrobial Resistance of Abnormal Vaginal Discharges Microorganisms in Ouagadougou, Burkina Faso. *Asian Pacific Journal of Tropical Biomedicine*, **2**, 294-297. https://doi.org/10.1016/S2221-1691(12)60025-2

[15] Fonseca, T.M.M.V. da, Cesar, J.A., Mendoza-Sassi, R.A. and Schmidt, E.B. (2013) Pathological Vaginal Discharge among Pregnant Women: Pattern of Occurrence and Association in a Population-Based Survey. *Obstetrics and Gynecology International*, **2013**, Article 590416. https://doi.org/10.1155/2013/590416

[16] Bitew, A., Abebaw, Y., Bekele, D. and Mihret, A. (2017) Prevalence of Bacterial Vaginosis and Associated Risk Factors among Women Complaining of Genital Tract Infection. *International Journal of Microbiology*, **2017**, Article 4919404. https://doi.org/10.1155/2017/4919404

[17] Aubyn, G.B. and Tagoe, D.N.A. (2013) Prevalence of Vaginal Infections and Associated Lifestyles of Students in the University of Cape Coast, Ghana. *Asian Pacific Journal of Tropical Disease*, **3**, 267-270. https://doi.org/10.1016/S2222-1808(13)60068-7

[18] Ohene, S. and Akoto, I. (2008) Factors Associated with Sexually Transmitted Infections among Young Ghanaian Women. *Ghana Medical Journal*, **42**, 96-100. https://doi.org/10.4314/gmj.v42i3.43619

[19] Lennox, J.A., Abbey, S.D., Udiba, D., Mboto, C.I., Ikpoh, I.S. and Akubuenyi, F.C. (2013) Prevalence of Vaginitis and Vaginosis among University of Calabar Female Students. *Journal of Public Health and Epidemiology*, **5**, 167-172.

[20] Kabalo, B.Y., Gelibo, T. and Tarekegn, M. (2013) Prevalence and Associated Factors of Sexually Transmitted Infections among Students of Wolaita Sodo University, Southern Ethiopia. *International Journal of Scientific & Technology Research*, **2**, 86-94.

[21] Bitew, A., Mengist, A., Belew, H., Aschale, Y. and Reta, A. (2021) The Prevalence, Antibiotic Resistance Pattern, and Associated Factors of Bacterial Vaginosis among Women of the Reproductive Age Group from Felege Hiwot Referral Hospital, Ethiopia. *Infection and Drug Resistance*, **14**, 2685-2696. https://doi.org/10.2147/IDR.S305329

[22] Nzomo, J., Waiyaki, P. and Waihenya, R. (2013) Bacterial Vaginosis and Correlates in Women of Reproductive Age in Thika, Kenya. *Advances in Microbiology*, **3**, 249-254. https://doi.org/10.4236/aim.2013.33036

[23] Mulu, W., Yimer, M., Zenebe, Y. and Abera, B. (2015) Common Causes of Vaginal Infections and Antibiotic Susceptibility of Aerobic Bacterial Isolates in Women of Reproductive Age Attending at Felegehiwot Referral Hospital, Ethiopia: A Cross Sectional Study. *BMC Women's Health*, **15**, Article No. 42. https://doi.org/10.1186/s12905-015-0197-y

[24] Chen, Y., Bruning, E., Rubino, J. and Eder, S.E. (2017) Role of Female Intimate Hygiene in Vulvovaginal Health: Global Hygiene Practices and Product Usage. *Women's Health*, **13**, Article No.58. https://doi.org/10.1177/1745505717731011

[25] Gyftopoulos, K. (2018) The Aberrant Urethral Meatus as a Possible Aetiological Factor of Recurrent Post-Coital Urinary Infections in Young Women. *Medical Hypotheses*, **113**, 6-8. https://doi.org/10.1016/j.mehy.2018.02.005

[26] Lubega, A., Joel, B. and Justina Lucy, N. (2017) Incidence and Etiology of Surgical Site Infections among Emergency Postoperative Patients in Mbarara Regional Referral Hospital, South Western Uganda. *Surgery Research and Practice*, **2017**, Article 6365172. https://doi.org/10.1155/2017/6365172

[27] Stephen, B.M., Joseph, N., Asiphas, O., Musa, K. and Taseera, K. (2021) Prevalence and Bacteriology of Culture-Positive Urinary Tract Infection among Pregnant

Women with Suspected Urinary Tract Infection at Mbarara Regional Referral Hospital, South-Western Uganda. *BMC Pregnancy and Childbirth*, **21**, Article No. 159. https://doi.org/10.1186/s12884-021-03641-8

[28] Alhumaid, S. Mutair, A.A., Alawi, Z.A., Alzahrani, A.J., *et al.* (2021) Antimicrobial Susceptibility of Gram-Positive and Gram-Negative Bacteria: A 5-Year Retrospective Analysis at a Multi-Hospital Healthcare System in Saudi Arabia. *Annals of Clinical Microbiology and Antimicrobials*, **20**, Article No. 43. https://doi.org/10.1186/s12941-021-00450-x

[29] Jimah, T., Fenny, A.P. and Ogunseitan, O.A. (2020) Antibiotics Stewardship in Ghana: A Cross-Sectional Study of Public Knowledge, Attitudes, and Practices among Communities. *One Health Outlook*, **2**, Article No. 12. https://doi.org/10.1186/s42522-020-00021-8

[30] Kretchy, J.P., Adase, S.K. and Gyansa-Lutterodt, M. (2021) The Prevalence and Risks of Antibiotic Self-Medication in Residents of a Rural Community in Accra, Ghana. *Scientific African*, **14**, e01006. https://doi.org/10.1016/j.sciaf.2021.e01006