RESEARCH ARTICLE

Bacterial vaginosis, vulvovaginal candidiasis and trichomonal vaginitis among reproductive-aged women seeking primary healthcare in Sana’a city, Yemen

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Abstract

Background: In Yemen, the underlying causes of infectious vaginitis have been neglected. Therefore, this study aimed to determine the prevalence and risk factors associated with bacterial vaginosis (BV), vulvovaginal candidiasis (VVC) and trichomonal vaginitis (TV) among non-pregnant reproductive-aged women.

Methods: A cross-sectional study was conducted among 347 non-pregnant reproductive-aged women seeking primary healthcare in Sana’a city, Yemen. Data about sociodemographic characteristics, lifestyle-related behaviors, routine hygienic practices, menstrual care and history and type of contraceptive intake were collected using a structured questionnaire. Vaginal discharge samples were collected and examined for discharge characteristics and pH by a gynecologist. Then, samples were examined for BV, VVC and TV. Data were analyzed using suitable statistical tests.

Results: Vaginal infections were prevalent among 37.6% of reproductive-aged women, where BV was the most prevalent (27.2%). VVC was significantly higher among symptomatic women and significantly associated with itching (P = 0.005). Using bivariate analysis, the age of < 25 years (odds ratio [OR] = 1.9, 95% confidence interval [CI]: 1.16–3.10; P = 0.010) and using intrauterine contraceptive devices (IUCDs) (OR = 1.8, 95% CI: 1.09–2.89; P = 0.020) were significantly associated with BV, while history of miscarriage was significantly associated with a lower risk of BV (OR = 0.5, 95% CI: 0.31–0.85, P = 0.009). However, polygyny was significantly associated with VVC (OR = 3.4, 95% CI: 1.33–8.66; P = 0.007). Multivariable analysis confirmed that age of < 25 years and using IUCD were the independent predictors of BV, while history of miscarriage was an independent protective factor against BV. On the other hand, marriage to a polygamous husband was the independent predictor of VVC.

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Background
Inflammation of the vagina, or vaginitis, is caused by various infectious and non-infectious factors [1]. The most common infectious causes of vaginitis are bacterial vaginosis (BV), vulvovaginal candidiasis (VVC) and trichomonal vaginitis (TV) [2]. The healthy vaginal tract of reproductive-aged women is colonized by normal microbiota dominated by lactobacilli, which protect against pathogenic bacterial species when present in sufficient numbers [3]. Therefore, depletion of lactobacilli distorts the balance of the vaginal microbiota and leads to an increase in anaerobic organisms, contributing to BV [4, 5]. Although BV is most commonly asymptomatic, it can be characterized by the discharge of homogeneous grayish-white smelly secretions, fishy smell after intercourse or during menstruation and an elevation of vaginal pH to above 4.5 [6–9]. The prevalence of BV ranges from 8 to 51%, depending on geographical location, socioeconomic status and ethnicity [10].

VVC is caused by the overgrowth of yeasts, mainly Candida albicans, which are essentially part of the vaginal flora [11]. Symptoms of VVC include vaginal discharge, itching, pain, and swelling. In addition, vulvar erythema and edema with excoriations are common findings. The typical vaginal discharge in VVC is described as cottage cheese-like in character [9]. It has been suggested that 75.0% of women may experience VVC during their lifetimes [12].

Trichomonas vaginalis is a flagellate protozoan parasite that causes trichomoniasis, which is mainly characterized by severe vaginitis among symptomatic females. The global incidence of trichomoniasis cases was estimated at 140.8 million [95% Uncertainty interval (UI): 121.2–163.2 million] in 2015, with a percentage change of 15.4 (14.5 to 16.5) between 2005 and 2015 [13]. Its transmission is usually sexual, and frequent recurrences often occur if the male partner is not simultaneously treated. Women with TV may complain of yellowish-green, foul-smelling, frothy vaginal discharge. Additionally, dysuria, dyspareunia, vulvar itching and pain may be found. The vulva may be erythematous, edematous and excoriated, and subepithelial hemorrhages or “strawberry spots” may be observed on the vagina and cervix [9].

Vaginitis has been associated with serious sequelae. BV during pregnancy increases the risk of preterm birth and miscarriage [14, 15]. TV can increase the transmission of human immunodeficiency virus [16], while VVC during pregnancy may lead to preterm birth [17]. Over the past 10 years, several risk factors of vaginitis have been identified. Douching, multiple partners and intrauterine contraceptive devices (IUCDs) are risk factors of BV [18–21], while low socioeconomic status, low educational level, douching and poverty are related to TV [22], and immunodeficiency, diabetes and recent antibiotic use are risk factors of VVC [23–25].

In Yemen, vaginitis is one of the most common conditions behind seeking medical care (Personal communication, M. Alhaj, 2019). Recently, BV has been reported among 39.2% of pregnant women in Hadhramout governorate, east of Yemen [26], while TV has been reported among 11.1% of pregnant women seeking primary healthcare (PHC) in Sana’a city [27]. Yet, the prevalence and risk factors associated with the infectious causes of vaginitis among reproductive-aged women are still unclear. Therefore, the present study aimed to determine the prevalence and risk factors associated with the most common infectious causes of vaginitis among Yemeni women.

Methods
Study design, area and population
A cross-sectional study was conducted among reproductive-aged women seeking healthcare in PHC centers in Sana’a city, the capital of Yemen, in the period from February to December 2017. Women were excluded from participation if they were menstruating, pregnant, or if they had received antibiotic or antifungal therapies in the preceding week or vaginal douching within the previous 24 h.

Sample size and sampling strategy
Cluster sampling was adopted, where all PHC centers in Sana’a were listed and four centers were randomly selected. Then, all reproductive-aged women attending each center were invited to voluntarily participate until obtaining the sample size required. The minimum sample size calculated was 294 women at a 95% confidence interval (CI), a precision of 7.0%, an expected prevalence rate of 50.0% and a...
design effect of 1.5. Yet, 347 women were included in the study.

Data collection
Data about sociodemographic characteristics, lifestyle-related behaviors, routine hygienic practices, menstrual care and history of contraceptive intake were collected using a structured questionnaire through face-to-face interview.

Vaginal examination
The vagina of each woman was examined by a gynecologist for the characteristics of vaginal discharge (color, consistency and odor) using a dry sterile speculum. Then, vaginal pH was measured by applying a pH paper to its lateral wall.

Laboratory investigations
Clinical samples were collected from vaginal walls with two cotton-tipped swabs. The vaginal swabs were then inoculated into a tube containing approximately 2 ml of saline and transported to the Microbiology Laboratory of the University of Science and Technology Hospital. Gram-stained smears were prepared, examined and interpreted for the diagnosis of BV according to the Nugent scoring system [28]. A score of $\geq 7$ was interpreted as positive for BV [29]. Ten percent potassium hydroxide (KOH) wet mounts were examined for C. albicans yeasts or pseudohyphae followed by colony identification after cultivation on Sabouraud dextrose agar for the diagnosis of VVC [30]. Saline wet mounts were examined for motile trophozoites of T. vaginalis followed by their morphological identification on Giemsa-stained smears for the diagnosis of TV [31].

Statistical analysis
Data were analyzed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Frequencies and proportions were used to summarize and present the data. The association between independent and dependent variables was tested using Pearson’s chi-square or Fisher’s exact test, whichever suitable, and the odds ratio (OR) and its corresponding 95% CI were reported. A Multivariable logistic regression model was developed for all variables included in the bivariate analysis, and the adjusted OR and its corresponding 95% CI were reported. $P$-values $< 0.05$ were considered statistically significant.

Results
Characteristics of the study population
The age of reproductive-aged women in the present study ranged from 15 to 50 years, with a median age of 28.0 years (interquartile range: 10). Of 347 women, the majority of women were aged between 26 and 35 years (46.5%), of secondary level of education (38.6%), married (98.3%), urban residents (89.3%) and unemployed (90.5%). Approximately half of the women were living in rented houses (Table 1).

Prevalence and association of vaginal infections with symptomatic presentation
Table 2 shows an overall prevalence of 37.6% for any type of vaginal infections among reproductive-aged women. BV was the most frequent single infection (27.2%) followed by VVC among 6.6% of women. In contrast, TV was the least frequent vaginal infection, where only three (0.9%) women were found to be positive. Mixed infection with BV and VVC was observed among 2.6% of women, while mixed infection with TV and VVC was observed among 0.3% of women. Table 3 shows that BV was not significantly associated with the symptomatic presentation, characteristics of vaginal discharge or vulvovaginal itching. In contrast, VVC was significantly higher among symptomatic women ($P = 0.006$) and significantly associated with vulvovaginal itching ($P = 0.005$).

| Characteristic | n (%)     |
|---------------|-----------|
| Age (years)   |           |
| < 26          | 123 (35.5) |
| 26–35         | 161 (46.5) |
| > 35          | 62 (17.9)  |
| Education level|           |
| Illiterate    | 70 (20.2)  |
| University or above | 64 (18.4) |
| Secondary     | 134 (38.6) |
| Primary       | 79 (22.8)  |
| Marital status|           |
| Married       | 341 (98.30)|
| Divorced or widow | 6 (1.7)  |
| Residence     |           |
| Urban         | 310 (89.3) |
| Rural         | 37 (10.7)  |
| Employment status|       |
| Employed      | 33 (9.50)  |
| Unemployed    | 314 (90.5) |
| Ownership of a house |   |
| Yes           | 168 (48.4) |
| No            | 179 (51.6) |

*$The total women included in the study were 347$
Association of certain sociodemographic factors, women’s practices and history of poor obstetric outcomes with vaginal infections among reproductive-aged women.

Bivariate analysis showed that women aged < 25 years (OR = 1.9, 95% CI: 1.16–3.10; P = 0.010) were at about two times higher risk of BV. In contrast, education, residence, employment status, husband’s employment status, polygyny and being married for the first time were not significantly associated with BV. On the other hand, polygyny was the only sociodemographic factor significantly associated with VVC, where those married to polygamous husbands were at about three and half times higher risk of being infected with VVC than those married to monogamous husbands (OR = 3.4, 95% CI: 1.33–8.66; P = 0.007). Although women married for more than once were 2.8 times more likely to be infected with VVC (OR = 2.8, 95% CI: 0.96–7.97; P = 0.051), the significance of the association was on the borderline (Table 4).

Table 5 shows that using IUCD was the only practice significantly associated with BV among reproductive-aged women, where users were about two times more likely to be infected compared with their counterparts (OR = 1.8, 95% CI: 1.04–3.08; P = 0.036) as the independent predictors of BV. However, history of miscarriage was identified as an independent protective factor (AOR = 0.5, 95% CI: 0.26–0.81; P = 0.006) against BV among reproductive-aged women seeking PHC in Sana’a. On the other hand, marriage to a polygamous husband was identified as an independent predictor of VVC, where women with polygamous husbands were four times more likely to get infected (AOR = 3.9, 95% CI: 1.15–13.29; P = 0.029) (Table 6).

### Table 2

Prevalence of vaginal infections among reproductive-age women attending PHC centers in Sana’a city, Yemen (2017)

| Type of vaginal infection | Prevalence                                                                 |
|--------------------------|-----------------------------------------------------------------------------|
|                         | n (%)  | 95% CI                            |
| Overall prevalence (any type) | 130   | (37.6) (32.5–42.7)               |
| Single infections        |        |                                  |
| BV                       | 94     | (27.2) (22.7–32.0)               |
| TV                       | 23     | (6.6) (4.5–9.7)                  |
| Mixed infection          |        |                                  |
| BV and WC                | 9      | (2.6) (1.4–4.9)                  |
| TV and WC                | 1      | (0.3) (0.1–1.6)                  |

### Table 3

Association of vaginal infections with certain clinical features among reproductive-aged women attending PHC centers in Sana’a, Yemen (2017)

| Feature              | N  | BV       | P-value | WC       | P-value |
|----------------------|----|----------|---------|----------|---------|
|                      |    | n (%)    |         | n (%)    |         |
| Symptomatic presentation |    |         |         |         |         |
| No                   | 86 | 23 (26.7)| 0.479   | 2 (2.3)  | 0.006*  |
| Yes                  | 260| 80 (30.8)| 0.170   | 31 (11.9)|         |
| Color of discharge   |    |         |         |         |         |
| Clear to white       | 279| 81 (29.0)| 0.541   | 26 (9.3) | 0.778   |
| Grey-yellow, milky or brown | 67 | 22 (32.8)| 0.037   | 7 (10.4) |         |
| Consistency of discharge |    |         |         |         |         |
| Watery and scanty    | 141| 37 (26.2)| 0.234   | 9 (6.4)  | 0.980   |
| Thick and profuse    | 205| 66 (32.2)| 0.693   | 24 (11.7)|         |
| Odor of discharge    |    |         |         |         |         |
| Non-offensive        | 245| 67 (27.3)| 0.125   | 23 (9.4) | 0.883   |
| Unpleasant           | 101| 36 (35.6)| 0.018   | 10 (9.9) |         |
| Vulvovaginal itching |    |         |         |         |         |
| Yes                  | 96 | 31 (32.3)| 0.525   | 16 (16.7)| 0.005   |
| No                   | 250| 72 (28.8)| 0.156   | 17 (6.8) |         |

*The total women included in the study were 347; n, number of infected women; CI, confidence interval; BV, bacterial vaginosis; VVC, vulvovaginal candidiasis, TV, trichomonal vaginitis

### Table 2 Notes

* The number of women examined, n number of women positive for BV or VVC, BV, bacterial vaginosis, VVC, vulvovaginal candidiasis

* Fisher’s exact test was used
The present study revealed that 37.6% of Yemeni reproductive-aged women seeking PHC in Sana’a city have single or mixed vaginal infections with BV, VVC or TV. Such prevalence is almost comparable to those reported among women seeking medical care from Pakistan and Nepal, being 33.5 and 39.0%, respectively [32, 33]. On the contrary, it is lower than the prevalence (89.0%) reported among non-pregnant reproductive-aged women from Rajasthan in India but higher than the prevalence (15.4%) reported among Ethiopian reproductive-aged women seeking medical care [34, 35].

BV was the most common cause of vaginitis among Yemeni women seeking PHC in Sana’a, being more predominant than VVC. However, TV was the least frequent cause of vaginitis, being detected among less than 1.0% of women. The predominance of BV over the other two causes of vaginitis is consistent with the findings among reproductive-aged women from distantly separated countries worldwide, including Indonesia, southwestern Nigeria, Nepal, Iran, Turkey and Grenada [18, 25, 33, 36–38]. In contrast, VVC was the most prevalent cause of vaginitis among sexually active adolescents from Brazil [21] and reproductive-aged women seeking medical care in Ethiopia and northeastern/northwestern Nigeria [35, 39, 40].

Based on the Nugent scoring system as the “gold standard” for BV diagnosis [41], BV was found to be prevalent among 27.2% of Yemeni reproductive-aged women in the present study which is lower than that (39.2%) reported among pregnant women from Hadhramout, an eastern Yemeni governorate [26]. Compared to the finding of the present study, a similar prevalence of 27.0% was reported for BV among women from socio-economically deprived communities in Peru [42]. However, lower BV prevalence of 15.2 and 19.5% were reported among reproductive-aged women attending hospitals in Ethiopia [35, 38], and non-pregnant women attending PHC centers in Iran (16.2%) [36]. Besides, higher prevalence of 48.6% was reported for BV among women with vaginitis attending hospital in Kochi, India [43]. It is noteworthy that the comparison between studies is difficult due to differences in study designs and populations, diagnostic

### Table 4

| Variable                     | N  | BV n (%) | OR (95% CI) | P-value | VVC n (%) | OR (95% CI) | P-value |
|------------------------------|----|----------|-------------|---------|-----------|-------------|---------|
| **Age (years)**              |    |          |             |         |           |             |         |
| ≥ 25                         | 245| 63 (25.7) | Reference   | 0.010   | 23 (9.4)  | Reference   | 0.883   |
| < 25                         | 101| 40 (39.6) | 1.9 (1.16–3.10) |         | 10 (9.9)  | 1.1 (0.49–2.32) |         |
| **Education**                |    |          |             |         |           |             |         |
| University                   | 64 | 15 (23.4) | Reference   | 0.366   | 5 (7.8)   | Reference   | 0.616   |
| Pre-university               | 212| 62 (29.2) | 1.4 (0.71–2.59) |         | 21 (9.9)  | 1.3 (0.47–3.59) |         |
| Not educated                 | 70 | 26 (37.1) | 1.9 (0.91–0.91) | 0.088   | 7 (10.0)  | 1.3 (0.39–4.36) | 0.659   |
| **Residence**                |    |          |             |         |           |             |         |
| Urban                        | 309| 91 (29.4) | Reference   |         | 30 (9.7)  | Reference   | 0.754   |
| Rural                        | 37 | 12 (32.4) | 1.2 (0.55–2.39) | 0.708   | 3 (8.1)   | 0.8 (0.24–2.83) |         |
| **Employment status**        |    |          |             |         |           |             |         |
| Employed                     | 33 | 8 (24.2)  | Reference   | 0.927   | 3 (9.1)   | Reference   |         |
| Housewife                    | 313| 95 (30.4) | 1.4 (0.59–3.13) | 0.465   | 30 (9.6)  | 1.1 (0.31–3.68) |         |
| **Husband’s employment status**| |          |             |         |           |             |         |
| Employed                     | 284| 85 (29.9) | Reference   | 0.604   | 26 (9.2)  | Reference   |         |
| Unemployed                   | 62 | 18 (29.0) | 1.0 (0.52–1.75) | 0.889   | 7 (11.3)  | 1.3 (0.52–3.06) |         |
| **Polygyny**                 |    |          |             |         |           |             |         |
| No                           | 316| 93 (29.4) | Reference   | 0.007   | 26 (8.2)  | Reference   |         |
| Yes                          | 30 | 10 (33.3) | 1.2 (0.54–2.66) | 0.655   | 7 (23.3)  | 3.4 (1.33–8.66) |         |
| **First marriage**           |    |          |             |         |           |             |         |
| Yes                          | 322| 95 (29.5) | Reference   | 0.051   | 28 (8.7)  | Reference   |         |
| No                           | 24 | 8 (33.3)  | 1.2 (0.49–2.89) | 0.692   | 5 (20.8)  | 2.8 (0.96–7.97) |         |

N number of examined women, n number of infected women, BV bacterial vaginosis, VVC vulvovaginal candidiasis, OR odds ratio, CI confidence interval, IUCD intrauterine contraceptive device

**Discussion**

The present study revealed that 37.6% of Yemeni reproductive-aged women seeking PHC in Sana’a city have single or mixed vaginal infections with BV, VVC or TV. Such prevalence is almost comparable to those reported among women seeking medical care from Pakistan and Nepal, being 33.5 and 39.0%, respectively [32, 33]. On the contrary, it is lower than the prevalence (89.0%) reported among non-pregnant reproductive-aged women from Rajasthan in India but higher than the prevalence (15.4%) reported among Ethiopian reproductive-aged women seeking medical care [34, 35]. BV was the most common cause of vaginitis among Yemeni women seeking PHC in Sana’a, being more predominant than VVC. However, TV was the least frequent cause of vaginitis, being detected among less than 1.0% of women. The predominance of BV over the other two causes of vaginitis is consistent with the findings among reproductive-aged women from distantly separated countries worldwide, including Indonesia, southwestern Nigeria, Nepal, Iran, Turkey and Grenada [18, 25, 33, 36–38]. In contrast, VVC was the most prevalent cause of vaginitis among sexually active adolescents from Brazil [21] and reproductive-aged women seeking medical care in Ethiopia and northeastern/northwestern Nigeria [35, 39, 40].

Based on the Nugent scoring system as the “gold standard” for BV diagnosis [41], BV was found to be prevalent among 27.2% of Yemeni reproductive-aged women in the present study which is lower than that (39.2%) reported among pregnant women from Hadhramout, an eastern Yemeni governorate [26]. Compared to the finding of the present study, a similar prevalence of 27.0% was reported for BV among women from socio-economically deprived communities in Peru [42]. However, lower BV prevalence of 15.2 and 19.5% were reported among reproductive-aged women attending hospitals in Ethiopia [35, 38], and non-pregnant women attending PHC centers in Iran (16.2%) [36]. Besides, higher prevalence of 48.6% was reported for BV among women with vaginitis attending hospital in Kochi, India [43]. It is noteworthy that the comparison between studies is difficult due to differences in study designs and populations, diagnostic
Table 5: Bivariate analysis of the association of the practices and history of poor obstetric outcomes with BV and VVC among women attending the PHC centers in Sana’a city, Yemen (2017)

| Variable                        | N  | BV number (%) | OR (95% CI)     | P-value | VVC number (%) | OR (95% CI)     | P-value |
|---------------------------------|----|---------------|-----------------|---------|----------------|-----------------|---------|
| Using IUCD                      |    |               |                 |         |                |                 |         |
| No                              | 242| 63 (26.0)     | Reference       | 0.020   | 21 (8.7)       | Reference       | 0.406   |
| Yes                             | 104| 40 (38.5)     | 1.8 (1.09–2.89) | 0.020   | 12 (11.5)      | 1.4 (0.65–2.91) | 0.020   |
| Using local antibiotics         |    |               |                 |         |                |                 |         |
| No                              | 148| 48 (32.4)     | Reference       | 0.349   | 14 (9.5)       | Reference       | 0.966   |
| Yes                             | 198| 55 (27.8)     | 0.8 (0.50–1.27) | 0.406   | 19 (9.6)       | 1.0 (0.49–2.09) | 0.020   |
| Using systemic antibiotics      |    |               |                 |         |                |                 |         |
| No                              | 181| 57 (31.5)     | Reference       | 0.463   | 13 (7.2)       | Reference       | 0.118   |
| Yes                             | 165| 46 (27.9)     | 0.8 (0.53–1.34) | 0.309   | 20 (12.1)      | 1.8 (0.86–3.71) | 0.049   |
| Smoking                         |    |               |                 |         |                |                 |         |
| No                              | 276| 76 (27.5)     | Reference       | 0.071   | 26 (9.4)       | Reference       | 0.883   |
| Yes                             | 70 | 27 (38.6)     | 1.7 (0.95–2.86) | 0.128   | 7 (10.0)       | 1.1 (0.44–2.57) | 0.758   |
| History of miscarriage          |    |               |                 |         |                |                 |         |
| No                              | 216| 75 (34.7)     | Reference       | 0.009   | 23 (10.6)      | Reference       | 0.365   |
| Yes                             | 130| 28 (21.5)     | 0.5 (0.31–0.85) | 0.423   | 10 (7.7)       | 0.7 (0.32–1.52) | 0.049   |
| History of preterm labor        |    |               |                 |         |                |                 |         |
| No                              | 311| 89 (28.6)     | Reference       | 0.163   | 28 (9.0)       | Reference       | 0.313   |
| Yes                             | 35 | 14 (40.0)     | 1.7 (0.81–3.42) | 0.049   | 5 (14.3)       | 1.7 (0.61–4.69) | 0.049   |
| Using sanitary napkins          |    |               |                 |         |                |                 |         |
| Yes                             | 301| 90 (29.9)     | Reference       | 0.890   | 29 (9.6)       | Reference       | 0.874   |
| No                              | 45 | 13 (28.9)     | 1.0 (0.48–1.89) | 0.128   | 4 (8.9)        | 0.9 (0.31–2.74) | 0.049   |
| Regular vaginal douching        |    |               |                 |         |                |                 |         |
| Yes                             | 111| 27 (24.3)     | Reference       | 0.128   | 9 (8.1)        | Reference       | 0.534   |
| No                              | 235| 76 (32.3)     | 1.5 (0.89–2.48) | 0.128   | 24 (10.2)      | 1.3 (0.58–2.87) | 0.049   |
| Drying genital area             |    |               |                 |         |                |                 |         |
| Yes                             | 130| 32 (24.6)     | Reference       | 0.104   | 9 (6.9)        | Reference       | 0.199   |
| No                              | 216| 71 (32.9)     | 1.5 (0.92–2.45) | 0.049   | 24 (11.1)      | 1.7 (0.76–3.74) | 0.049   |
| Privacy of toilet               |    |               |                 |         |                |                 |         |
| Personal                        | 96 | 33 (34.4)     | Reference       | 0.246   | 9 (9.4)        | Reference       | 0.949   |
| Shared                          | 250| 70 (28.0)     | 0.7 (0.45–1.23) | 0.128   | 24 (9.6)       | 1.0 (0.46–2.29) | 0.049   |
| Toilet type                     |    |               |                 |         |                |                 |         |
| Arabic                          | 331| 96 (29.0)     | Reference       | 0.143   | 23 (10.1)      | Reference       | 0.699   |
| European                        | 15 | 7 (46.7)      | 2.1 (0.76–6.07) | 0.128   | 10 (8.4)       | 0.8 (0.37–1.77) | 0.049   |
| Preferred clothing              |    |               |                 |         |                |                 |         |
| Wide clothes                    | 279| 84 (30.1)     | Reference       | 0.779   | 28 (10.0)      | Reference       | 0.520   |
| Tight clothes                   | 67 | 19 (28.4)     | 0.9 (0.51–1.66) | 0.128   | 5 (7.5)        | 0.7 (0.27–1.95) | 0.049   |
| Method of genital area cleaning |    |               |                 |         |                |                 |         |
| Forward                         | 212| 60 (28.3)     | Reference       | 0.453   | 23 (10.8)      | Reference       | 0.296   |
| Backward                        | 134| 60 (32.1)     | 1.2 (0.75–1.92) | 0.049   | 10 (7.5)       | 0.7 (0.31–1.44) | 0.049   |

N: number of examined women, n: number of infected women, BV: bacterial vaginosis, VVC: vulvovaginal candidiasis, OR: odds ratio, CI: confidence interval, IUCD: intrauterine contraceptive device
Frequent sexual intercourse can hence, sustains an ideal environment for the growth of anaerobic bacteria [52]. Frequent sexual intercourse prevents the restoration of the vaginal ecosystem after a coital act and, present study. Frequent sexual intercourse prevents the vaginal environment in a way that increases the likelihood of transferring perianal and perivulvar bacteria to the vagina, leading to BV [53].

The significant association between BV and young age is consistent with previous studies elsewhere [49, 50]. The significant association of VVC with vaginal itching among reproductive-aged women for BV should be undertaken to avoid its negative health impacts, particularly for women complaining of and seeking treatment for infertility.

The significant association of VVC with vaginal itching among reproductive-aged women in the present study is consistent with a review evaluating vaginal complaints, which suggests more likelihood of vaginal itching among patients with candidiasis [46]. Furthermore, the lack of a significant difference between BV among asymptomatic and symptomatic women is a common observation [47]. It is noteworthy that even asymptomatic BV can contribute to a range of adverse outcomes [10, 48]. This, in turn, supports the need for screening reproductive-aged women irrespective of the symptomatic nature of vaginitis.

The significant association between BV and young age is consistent with previous studies elsewhere [49, 50]. The risk of BV in younger women might be explained by the higher frequency of unprotected sexual intercourse among newly married adolescent and young ladies that can affect the vaginal environment in a way that increases the likelihood of BV [51]. This could be supported by the few women reporting the use of condoms (1.2%) in the present study. Frequent sexual intercourse prevents the restoration of the vaginal ecosystem after a coital act and, hence, sustains an ideal environment for the growth of anaerobic bacteria [52]. Frequent sexual intercourse can also increase the likelihood of transferring perianal and perivulvar bacteria to the vagina, leading to BV [53].

The identification of using IUCD as an independent predictor of BV among reproductive-aged women is in line with previous findings from Indonesia and Turkey [18, 54], which reported a significant association between long-term use of IUCD and BV. The significant association of IUCD with BV in the present study also agrees with the findings of earlier studies in Belgium and Sweden [55, 56]. In contrast, an earlier review on the association of IUCD and pelvic inflammatory diseases found no association between IUCD use and BV due to the lack of strong evidence [57]. According to the review, the lack of adequate adjustment for sexual behaviors and the use of inappropriate control groups were among the factors making the evidence of association not convincing [57]. The association between IUCD use and BV in the present study could be attributed to increased menstrual flow and irregular vaginal bleeding, where these can change the vaginal microbiome and decrease the ratio lactobacilli [18, 58]. In this study, vaginal bleeding was observed in 15.4% (16/104) of women using IUCD. Moreover, the IUCD may facilitate the ascent of cervicovaginal microorganisms into the uterus [59]. It has been suggested that about a half of IUCD users can have at least one episode of BV during the first 24 months [55]. Therefore, there is a need for continual monitoring of BV among women using IUCDs, with replacement if needed.

Although miscarriage has been suggested as a poor obstetric outcome of BV [15], history of miscarriage was a protective factor against BV among women in the present study. This finding could be partially explained by the higher awareness among aborted women of the risk of BV, which was translated into correct practices against BV. It is to be noted that a half of women in the present study were aware of vaginitis as a cause of miscarriage. BV has been suggested as a cause of preterm delivery irrespective of treatment [60]. Although the odds of preterm births were 1.7-fold higher among women with BV in the present study, the association did not attain statistical significance. Moreover, specific bacterial species in BV can be associated with preterm births [61], such an association can be influenced by the predominance of certain bacterial species.

In line with the low prevalence of VVC (6.6%) among reproductive-aged women in the present study, Yemen was identified as a country with the least frequent VVC infections on a global scale by a recent systematic review [62]. The present study, being married to a polygamous husband was an independent predictor of infection with VVC, suggesting that husbands may mechanically circulate this fungal infection among their multiple wives. Although the role of sexual transmission of Candida is still controversial, penile colonization with Candida has been reported [63–65]. This, in turn, highlights the importance of health education of polygamous husbands about sexually transmitted diseases (STDs). The prevalence of TV (0.9%) among reproductive-aged women in the present study is lower than the prevalence (11%) found among pregnant women attending PHC centers in Sana’a city [27]. The very low prevalence in the present study could be attributed to the low sensitivity

### Table 6 Independent predictors of BV and VVC among women attending the PHC centers in Sana’a city, Yemen as revealed by multivariable analysis (2017)

| Variable                                      | AOR (95% CI) | P-value  |
|-----------------------------------------------|--------------|----------|
| Independent predictors associated with BV     |              |          |
| Age younger than 25 years                     | 2.0 (1.10–3.62) | 0.023    |
| Using IUCD                                    | 1.8 (1.04–3.08) | 0.036    |
| History of miscarriage                        | 0.5 (0.26–0.81) | 0.006    |
| Independent predictor associated with VVC     |              |          |
| Polygyny                                      | 3.9 (1.15–13.29) | 0.029    |

BV: bacterial vaginosis, VVC: vulvovaginal candidiasis, AOR: adjusted odds ratio, CI: confidence interval, IUCD: intrauterine contraceptive device.
of microscopic examination of wet mount preparations and Giemsa-stained smears in detecting all infections with TV [66–68].

The low prevalence of mixed vaginal infections (2.9%) among women in the present study entails the discontinuation of vaginitis management as a mixed infection, considering that this practice is thought to be common among physicians in Yemen (personal communication, Alhaj, M. 2019). Nevertheless, focusing on the management of BV as the most common cause of vaginitis by prescribing antibiotics may lead to the spread of VVC [25]. Therefore, routine examination of vaginal swabs is key to the proper clinical management of vaginitis among women in Yemen.

Despite the suitability of the present cross-sectional design to determine the prevalence of vaginal infections, its value identifying the associated risk factors is limited. Therefore, case-control studies are recommended for a comprehensive analysis of the risk factors associated with vaginal infections among reproductive-aged women in Yemen. On the other hand, relying on microscopic examination for the diagnosis of TV could underestimate the prevalence of the infection, and the use of more sensitive techniques is recommended.

Conclusions

More than a third of non-pregnant reproductive-aged women seeking PHC in Sana’a city have single or mixed infections with BV, VVC or TV, with BV is the most frequent cause of vaginitis among 27.2% of women. BV is significantly associated with the age of < 25 years and using IUCDs. Second to BV as a cause of vaginitis, VVC is significantly higher among women with polygamous husbands. Health education interventions are recommended to raise women’s awareness of vaginitis and its prevention. In addition, regular monitoring of BV among women using IUCD, educating polygamous husbands and their wives about the transmission and prevention of STDs and screening women for the causes of vaginitis before treatment are recommended.

Abbreviations

AOR: Adjusted odds ratio; BV: Bacterial vaginosis; CI: Confidence interval; IUCD: Intrauterine contraceptive device; OR: Odds ratio; PHC: Primary healthcare; SPSS: Statistical Packages for Social Sciences; STD: Sexually transmitted disease; TV: Trichomonal vaginitis; VVC: Vulvovaginal candidiasis

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Authors’ contributions

MAKM designed the study. NAA, LKAA, SAA, FAMA, NJMA, WB, and SJHA conducted the fieldwork and performed the laboratory investigations. MAKM analyzed the data. MAA drafted the manuscript. MAKM, RA, MA and AVAA revised the manuscript. All authors approved the final draft for submission.

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Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Ethics Committee of the Faculty of Medicine, University of Science and Technology, Sana’a, Yemen. Informed written consent was obtained from each participant after a clear explanation of the study objectives. Drugs were prescribed for women positive for vaginal infections by the gynecologist in each PHC center.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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References

1. Donders GG. Definition and classification of abnormal vaginal flora. Best Pract Res Clin Obstet Gynaecol. 2007;21(3):355–73.
2. Workowski KA, Bolan GA. Centers for Disease Control and Prevention (CDC). Sexually transmitted diseases treatment guidelines, 2015. MMWR Recomm Rep. 2015;64(RR–03):1–137.
3. Kumar N, Behera B, Sagiri SS, Pal K, Ray SS, Roy S. Bacterial vaginosis: etiology and modalities of treatment—a brief note. J Pharm Bioallied Sci. 2011;3(4):496–503.
4. Ventolin G. Progresses in vaginal microflora physiology and implications for bacterial vaginosis and candidiasis. Womens Health (Lond). 2016;12(3):283–91.
5. Borges S, Silva J, Teixeira P. The role of lactobacilli and probiotics in maintaining vaginal health. Arch Gynecol Obstet. 2014;289(4):479–89.
6. Amsel R, Tottem PA, Spiegel CA, Chen XC, Eschenbach D, Holmes KK. Nonspecific vaginitis: diagnostic criteria and microbial and epidemiologic associations. Am J Med. 1983;74(1):14–22.
7. Verstraelen H, Verhelst R. Bacterial vaginosis an update on diagnosis and treatment. Expert Rev Anti-infect Ther. 2009;7(9):1109–24.
8. Haner BL, Gibson MV. Vaginitis. Am Fam Physician. 2011;83(7):807–15.
9. Paladine HL, Desai UA. Vaginitis: diagnosis and treatment. Am Fam Physician. 2018;97(5):321–9.
10. Kenyon C, Colebunders R, Crucitti T. The global epidemiology of bacterial vaginosis: a systematic review. Am J Obstet Gynecol. 2013;209(6):505–23.
11. van Schalkwyk J, Yudin MH, Infectious Disease Committee. Vaginovaginitis: screening for and management of trichomoniavias, vulvovaginal candidiasis, and bacterial vaginosis. J Obstet Gynaecol Can. 2015;37(3):266–74.
12. Achkar JM, Fries BC. Candida infections of the genitalia of women. Clin Microbiol Rev. 2010;23(2):253–73.
13. GBD 2017 Diseases and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 2004–17.” The Lancet. 2018;392(10159):174–208.
bacterial vaginosis and other cervicovaginal infections. Contraception. 2003; 68(2):105–9.

60. Shimaoka M, Yo Y, Doi K, Kotani Y, Suzuki A, Tsuji I, Mandai M, Matsumura N. Association between preterm delivery and bacterial vaginosis with or without treatment. Sci Rep. 2019;9(1):509.

61. Mannis-James L. Bacterial vaginosis and preterm birth. J Midwifery Womens Health. 2011;56(6):575–83.

62. Denning DW, Kneale M, Sobel JD, Rautemaa-Richardson R. Global burden of recurrent vulvovaginal candidiasis: a systematic review. Lancet Infect Dis. 2018;18(11):e339–47.

63. David LM, Walzman M, Rajamanoharan S. Genital colonisation and infection with candida in heterosexual and homosexual males. Genitourin Med. 1997; 73(5):394–6.

64. Reed BD, Zazove P, Pierson CL, Gorenflo DW, Horrocks J. Candida transmission and sexual behaviors as risks for a repeat episode of Candida vulvovaginitis. J Womens Health (Larchmt). 2003;12(10):979–89.

65. Horowitz BJ, Edelstein SW, Lippman L. Sexual transmission of Candida. Obstet Gynecol. 1987;69(6):883–6.

66. Mahmoud A, Sherif NA, Abdella R, El-Genedy AR, El Kateb AY, Askalani AN. Prevalence of Trichomonas vaginalis infection among Egyptian women using culture and latex agglutination: cross-sectional study. BMC Womens Health. 2015;15:7.

67. Perazzi BE, Menghi CJ, Coppolillo EF, Gatta C, Eliseth MC, de Torres RA, et al. Prevalence and comparison of diagnostic methods for Trichomonas vaginalis infection in pregnant women in Argentina. Korean J Parasitol. 2010;48(1):61–5.

68. Adjie C, Boateng R, Dompreh A, Okyere B, Owredu EW. Prevalence and the evaluation of culture, wet mount, and ELISA methods for the diagnosis of Trichomonas vaginalis infection among Ghanaian women using urine and vaginal specimens. Trop Med Health. 2019;47:33.

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