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Systematic Review

Vulvovaginal Infections in Saudi Arabia: Prevalence in Clinically Sampled and Screened Populations, Aetiology and Antimicrobial Resistance: A Systematic Review and Meta-Analysis

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Abstract

Background. Vulvovaginal infections are among the commonest reasons women seek gynaecological care, but Saudi estimates come from scattered single-centre studies that differ in population, diagnostic criteria and laboratory method. We set out to synthesise what those studies report about prevalence, causative organisms and antimicrobial susceptibility. Methods. PubMed/MEDLINE and the Saudi Digital Library were searched using nine numbered Boolean lines combining vulvovaginal condition terms, organism names and Saudi geographic terms, with no date or language restriction. The search was supplemented by hand-searching and citation searching of Saudi and regional journals. The review was registered in PROSPERO (CRD420261569339). Eligible studies reported original data from Saudi Arabia on female genital tract specimens with an extractable denominator. Two outcome streams were kept separate throughout: diagnosed infection and organism colonisation or detection. Study quality was appraised with the nine-item JBI checklist for prevalence studies. Proportions were pooled under a random-effects model after Freeman–Tukey double-arcsine transformation, but only where populations, outcome definitions and denominators were comparable. Results. Of 288 unique records, 35 were assessed in full text and 21 studies met the eligibility criteria; hand-searching identified two further eligible studies, giving 23 included studies and 147 extracted outcome rows. Group B Streptococcus colonisation in screened pregnant women was 19.0% (95% CI 8.2–32.9; 8 studies, 8793 women), and Candida culture positivity among symptomatic women attending clinical services was 27.4% (95% CI 17.8–38.1; 5 studies, 5353 women). Heterogeneity was extreme in both (I-squared 99.4% and 97.2%), and the prediction intervals span almost the whole plausible range, so neither value should be read as a national figure. Both estimates refer to the clinical or screening population sampled, not to women in Saudi Arabia generally. Repeating the two primary analyses on the logit scale and with a binomial–normal generalised linear mixed model changed little (17.4% and 17.3% for colonisation; 27.1% and 27.0% for Candida). Trichomoniasis was not pooled as a primary outcome because estimates ranged from 0.7% to 15.0%; restricting the analysis to the three studies that state a detection method removed the heterogeneity entirely and gave 13.8% (95% CI 12.3–15.4; I-squared 0%); that restricted figure rests on three studies with different detection methods and recruitment criteria and remains exploratory. *Candida albicans* predominated in every study reporting species, but accounted for 42.1% to 70.7% of isolates, with *C. glabrata* consistently second. Reported fluconazole resistance in *Candida* ranged from 0% to 85% across five studies using three different testing methods. Group B *Streptococcus* remained fully susceptible to penicillin G, ampicillin and vancomycin in both studies that tested them,

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238 isolates in total, while erythromycin resistance was 15.7% and 16.7%. Conclusions. The Saudi evidence base is dominated by Group B *Streptococcus* screening in pregnancy and by vulvovaginal candidiasis. Bacterial vaginosis has one study with an extractable denominator and aerobic vaginitis none, which is the clearest gap identified. Pooled values carry wide prediction intervals and heterogeneity that subgroup analysis by region, period, sampling site, sampling frequency and population did not resolve. The resistance evidence is too fragmented to guide empiric therapy, chiefly because breakpoint standards go unreported in more than half of the susceptibility results.

Keywords: vulvovaginal candidiasis; bacterial vaginosis; trichomoniasis; Group B *Streptococcus*; antimicrobial resistance; Saudi Arabia; systematic review; meta-analysis

1. Introduction

1.1. Background

Vulvovaginal infection describes inflammation or microbial overgrowth confined to the vulva and vagina and is distinct in anatomy and management from urinary tract infection, which involves the bladder and upper urinary tract, and from sexually transmitted infection, a category defined by route of transmission rather than by site [1,2]. The distinction matters in practice because the three categories are investigated with different specimens and treated differently, yet they present with overlapping lower genital tract symptoms.

A healthy vagina is dominated by *Lactobacillus* species, which ferment glycogen-derived substrates to lactic acid and maintain the pH near 4.0 to 4.5 [3]. Lactic acid, together with bacteriocins and hydrogen peroxide, limits the expansion of anaerobes and facultative organisms that are present at low abundance, a property described as colonisation resistance [4]. Loss of lactobacillary dominance raises vaginal pH and permits polymicrobial overgrowth, the state recognised clinically as bacterial vaginosis [5,6].

Four conditions account for most symptomatic presentations. Bacterial vaginosis is a dysbiosis rather than infection by a single pathogen, diagnosed by the Amsel clinical criteria or by Nugent scoring of a Gram-stained smear [6,7]. Vulvovaginal candidiasis follows overgrowth of *Candida* species, most often *C. albicans*, and is defined by symptoms together with microscopic or cultural evidence of yeast [8,9]. Trichomoniasis is caused by the flagellate protozoan *Trichomonas vaginalis* and is sexually transmitted, which places it in both categories at once [10]. Aerobic vaginitis involves displacement of lactobacilli by aerobic enteric organisms such as *Escherichia coli*, *Streptococcus agalactiae* and *Enterococcus faecalis*, accompanied by epithelial atrophy and a marked inflammatory infiltrate [11,12]. Mixed infections occur, and diagnostic pathways that stop at the first positive result miss them [13,14].

Symptoms discriminate poorly between these conditions. Discharge, pruritus, odour and dysuria occur across all of them, and clinical impression alone misclassifies a substantial proportion of cases [1,7]. A further complication is that recovering an organism does not establish disease. *Candida* species are carried asymptomatically by a large minority of healthy women, and *Streptococcus agalactiae* colonises the vagina and rectum without causing maternal symptoms, its clinical importance lying in vertical transmission at delivery [9,15]. Prevalence figures therefore depend on whether a study counted colonisation or diagnosed infections, and the two cannot be combined.

1.2. Clinical and Public-Health Importance

Symptomatic vulvovaginal infection causes discharge, irritation and quality-of-life impairment [16], and recurrence is common: up to 10% of cases of vulvovaginal candidiasis are recurrent, defined as four or more episodes in a year [17]. Bacterial vaginosis recurs in roughly half of treated women within twelve months [6] and has been associated with preterm birth and with increased susceptibility to sexually transmitted infection [5]. The cumulative effect on quality of life and on healthcare use is substantial, and the global cost of bacterial vaginosis alone has been estimated in the billions of dollars annually [18].

Accurate aetiological diagnosis is necessary to guide management. Bacterial vaginosis responds to nitroimidazoles or clindamycin, candidiasis to azoles or polyenes, and trichomoniasis requires systemic nitroimidazole treatment of the patient and her sexual partners [1,7]. Treating based on symptoms alone therefore risks both failure and unnecessary antimicrobial exposure, and empiric antifungal use in particular selects for non-albicans species that are intrinsically less azole-susceptible [19,20].

Resistance has become a practical constraint rather than a theoretical one. Fluconazole-resistant vulvovaginal candidosis is now recognised as a distinct management problem with limited oral alternatives [19,21]. Among Group B *Streptococcus* isolates, beta-lactams retain near-universal activity, but macrolide and lincosamide resistance has risen worldwide and directly affects prophylaxis in women with penicillin allergy [15,22]. Both patterns can only be tracked where susceptibility testing is performed and reported against a stated breakpoint standard.

1.3. The Saudi Evidence Gap

Reported Group B *Streptococcus* colonisation in pregnancy has ranged from under 4% to over 30% within Saudi Arabia [23], and comparable spread is seen for candidiasis and trichomoniasis. Several factors plausibly contribute: the region and city sampled, whether participants were pregnant, symptomatic or screened routinely, whether recruitment occurred in an antenatal clinic, a gynaecology outpatient department or a hospital laboratory, and which diagnostic criteria and identification methods were applied. Culture on selective media, chromogenic agar, automated biochemical identification and nucleic acid amplification do not detect the same cases, and studies using microscopy alone are not measuring the same quantity as studies using PCR.

Saudi reports are dominated by single-centre series that differ in population, diagnostic criteria and laboratory method [24]. Existing Saudi syntheses have covered Group B Streptococcus colonisation [23], but none has brought these studies together for all three conditions while keeping infection separate from colonisation and preserving each study's denominator. Nor has the Saudi resistance evidence been assembled in a form that shows which organism-agent combinations are actually supported by data and which rest on a single small series.

1.4. Aim and Research Questions

This review cum meta-analysis addresses four questions. First, what percentage of women tested has each specified vulvovaginal condition in the clinical and screening populations that Saudi studies have sampled, reported separately by condition and by denominator type (the total number of individuals or specimens in the group being studied)? No included study sampled a general population, so none of the figures reported here is a prevalence among women in Saudi Arabia as a whole. Second, which organisms and species have been identified, and in what relative distribution? Third, what antimicrobial and antifungal susceptibility patterns have been reported, and against which testing methods and interpretive

criteria? Fourth, do estimates vary systematically by region, population, clinical setting, study period or diagnostic method?

2. Methods

2.1. Protocol and Reporting

Reporting follows the structure and content of the PRISMA 2020 statement [25]. The question was framed using the CoCoPop structure recommended for prevalence reviews [26]. The condition comprised vulvovaginal infections and the organisms responsible for them; the context was Saudi Arabia; the population was women from whom female genital tract specimens were obtained. The review protocol was registered prospectively in PROSPERO (registration number CRD420261569339). The scope decisions fixed in advance are listed in Section 2.2. The subgroup analyses by sampling site, sampling frequency and timing of sampling, and the alternative-transformation sensitivity analyses, were not prespecified and are identified as post hoc wherever they are reported.

2.2. Eligibility Criteria

Studies were included when they reported primary data collected in Saudi Arabia from female genital tract specimens, including vaginal, high vaginal, vagino-rectal and cervicovaginal samples, or reported a clearly defined maternal vaginal or rectovaginal colonisation denominator, and when at least one countable frequency could be extracted. A countable frequency meant the number positive out of the number tested for a named condition or organism, species counts among positive specimens or isolates, or susceptibility results for genital tract isolates.

Studies were excluded when they were not original research, when specimens were not collected in Saudi Arabia, when no female genital tract outcome was reported, when only urinary isolates were reported without separate vaginal findings, when the only outcomes were *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, human papillomavirus or syphilis, when specimens came from neonates without a maternal vaginal denominator, or when no usable denominator appeared anywhere in the available text. Duplicate reports of one dataset were to be reduced to the most complete report; no such duplicates were identified. Four scope decisions were fixed in advance. Both symptomatic and asymptomatic participants were eligible. Pregnant and non-pregnant women were eligible. Hospital, clinic, antenatal and community populations were eligible. *Trichomonas vaginalis* was treated as an eligible vulvovaginal pathogen, whereas other sexually transmitted pathogens were not eligible as standalone outcomes. Candida and Group B Streptococcus colonisation were retained as outcomes in their own right, recorded separately from diagnosed infection. Studies that reported organism recovery without separating colonisation from diagnosed infection were not excluded for that reason. Their outcomes were classified as colonisation or detection and were never pooled with infection outcomes, so the distinction was handled at classification rather than at selection.

2.3. Study Selection

Records were retrieved from PubMed/MEDLINE and the Saudi Digital Library and de-duplicated by PubMed identifier. The database search was supplemented by hand-searching of Saudi and regional obstetric, gynaecological and microbiological journals that are not indexed in MEDLINE, and by citation searching of the included reports. Five additional records were retrieved and assessed in full text against the same eligibility criteria; two met them and were added to the review, and three were excluded because no female genital tract outcome was reported, because only urinary isolates were reported, and because no prevalence denominator was available. We screened manuscript abstracts against

the eligibility criteria using a structured decision form that recorded a decision, a reason code and any conditions or organisms mentioned. We re-examined records classified as unclear, together with every exclusion assigned to a borderline reason code; the categories were neonatal-only, urinary-only, symptoms-only, insufficient-abstract and no-denominator. These codes map onto the criteria in the preceding paragraph as follows: neonatal-only denotes specimens from neonates without a maternal vaginal denominator; urinary-only denotes urinary isolates reported without separate vaginal findings; symptoms-only denotes a clinical syndrome reported without laboratory confirmation, so that no countable frequency for a named condition or organism could be extracted; insufficient-abstract denotes records whose available text was too sparse for any criterion to be judged, which were carried forward to full-text assessment rather than excluded at this stage; and no-denominator denotes records with no usable denominator anywhere in the available text. Records that remained unclear after adjudication were carried forward to full-text assessment rather than excluded. We sought full texts for all records passing title and abstract screening. We then assessed eligibility against the same criteria and recorded a specific exclusion reason for every rejected report. Two inclusion decisions were required and are described in the results. The detailed selection process is shown in Figure 1. Eligibility assessment was not confined to the review authors. The selection process, comprising the inclusion and exclusion decisions at both the title-and-abstract and the full-text stage, was examined independently by three colleagues who took no part in drafting the review, working alongside the authors, and their assessments were reconciled with those of the authors before the final set of included studies was fixed. These colleagues are named in the Acknowledgements.

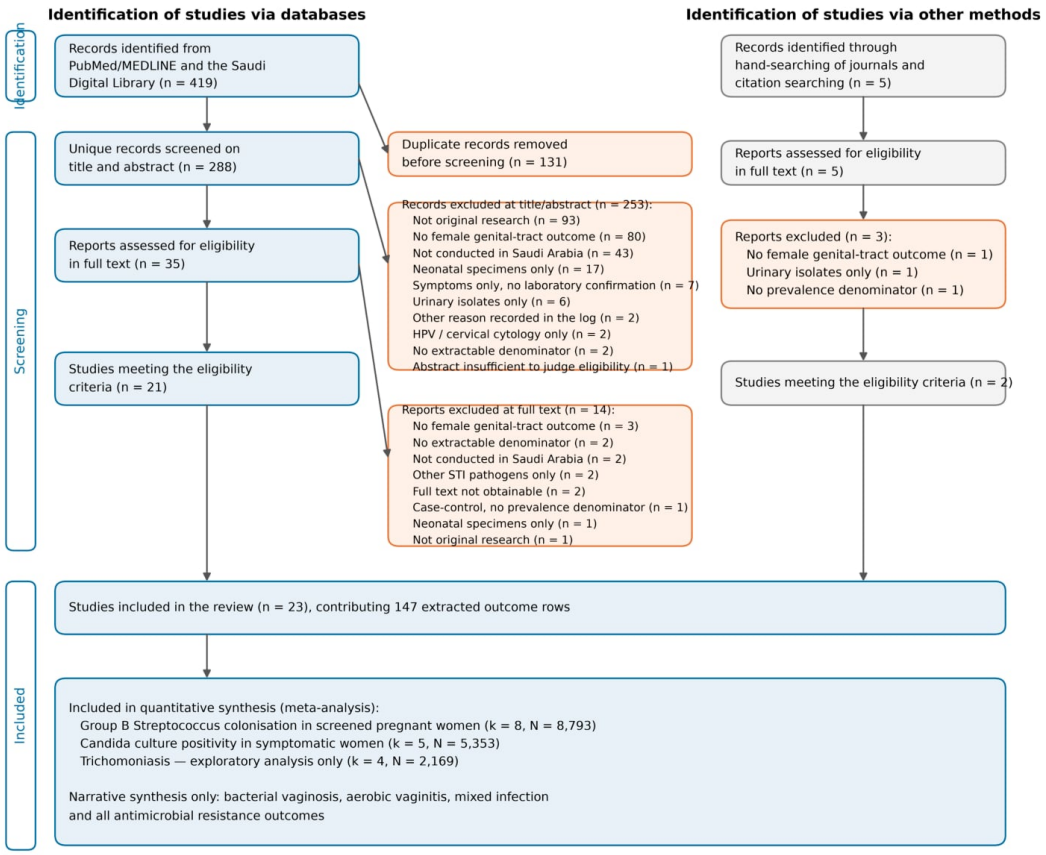


Figure 1. PRISMA 2020 flow of study selection, with the number of records excluded and the reason at each stage.

2.4. Data Extraction

Data were extracted into a standardised form with one row per outcome. Study-level fields comprised author, year, study period, city or region, design, setting, population, pregnancy status, symptom status, number recruited or tested, age range, specimen type, diagnostic and laboratory methods, whether organisms were identified to species level, funding and declared conflicts of interest. Outcome-level fields comprised outcome class, condition or organism, antimicrobial agent, number tested, number positive, numbers susceptible, intermediate and resistant, the percentage as reported, denominator type, test method, breakpoint standard and free-text notes.

Any field not stated in the available text was recorded as not reported. Numerators were not back-calculated from percentages during extraction. Where a source gave only a percentage against a stated denominator, the numerator was left missing and the percentage retained; two exceptions were made at the analysis stage and are identified explicitly in Section 2.7. Every extracted percentage was recomputed from its numerator and denominator and checked against the percentage printed in the source.

2.5. Outcomes and Definitions

Primary outcomes were the prevalence of each specified condition and the prevalence of each organism, each reported against an explicitly stated denominator. Secondary outcomes were species distribution including non-albicans *Candida*, the frequency of mixed infection, susceptibility and resistance proportions, and variation by study characteristics.

Four denominator types were distinguished and never merged: all women tested, symptomatic women tested, confirmed cases, and positive specimens or isolates. Outcomes were classified into four mutually exclusive classes. Infection prevalence covered a diagnosed condition among a tested population. Colonisation prevalence covered organism carriage or detection without a clinical diagnosis of infection. Species distribution covered counts among positive specimens or isolates. Resistance covered susceptibility testing results.

Group B *Streptococcus* screening in pregnancy was classified as colonisation throughout and was never combined with any infection outcome. *Candida* from symptomatic women presenting with suspected candidiasis was classified as infection; *Candida* from unselected or asymptomatic women was classified as colonisation.

2.6. Risk-of-Bias Assessment

Each included study was appraised against the nine-item JBI critical appraisal checklist for studies reporting prevalence data [26], covering the sampling frame, sampling method, sample size, description of subjects and setting, coverage of the identified sample, validity of condition measurement, consistency of measurement across participants, statistical analysis and response rate. Each item was rated as yes, no, unclear or not applicable, with a written rationale recorded for every study. An overall rating was assigned based on the proportion of applicable items met: low risk at 75% or above, moderate risk at 50% to 74%, and high risk below 50%. These thresholds are not part of the JBI tool, which is built for domain-level judgement rather than for scoring, and they were applied only to attach a single summary label to each study. The domain-level ratings on which the labels rest are reported in full in Figure S1 and Table S3 and should be read in preference to the summary label. Because an item rated as unclear counts against a study in the same way as an item rated as no, a summary label of high risk often reflects reporting that is too sparse to judge rather than a demonstrated methodological failure. Studies in that category are therefore described throughout as high risk of bias or insufficient information, and the two situations are distinguished in the text.

2.7. Statistical Analysis

Prevalence was calculated as the number positive divided by the number tested within a single stated denominator type. Confidence intervals for individual study estimates were calculated by the Wilson score method.

Pooling was restricted to outcomes measured in comparable populations with comparable outcome definitions and matching denominator types. Proportions were stabilised with the Freeman–Tukey double-arcsine transformation [27] and combined under a random-effects model with the DerSimonian–Laird estimator of between-study variance [28], an approach adopted for prevalence synthesis because raw proportions near the bounds have unstable variances [29,30]. Pooled estimates were returned to the proportion scale by the Miller inverse transformation evaluated at the harmonic mean sample size [31]. The back-transformation was verified by round-trip: every individual study proportion was transformed and inverted, with a maximum absolute error of 1.7×10^{-16}.

Heterogeneity was quantified by Cochran Q, the between-study variance tau-squared, and I-squared. A 95% prediction interval was calculated on the transformed scale and back-transformed; where an interval bound fell outside the valid domain of the transformation, it is reported at the corresponding boundary value and flagged. Negative I-squared values arising when Q falls below its degrees of freedom were truncated to zero.

Subgroup analyses were specified for region, setting, symptom status, pregnancy status, diagnostic method and study period. Subgroups were pooled only when at least three studies contributed; smaller subgroups are reported as individual study estimates with their range. Three further groupings were examined for Group B Streptococcus colonisation: sampling site (vaginal only against vagino-rectal), sampling frequency (a single swab set against repeated sampling during pregnancy) and timing of sampling (antenatal screening against sampling in labour). These groupings were not prespecified. Sensitivity analyses comprised leave-one-out iteration, exclusion of studies rated high risk of bias, exclusion of studies whose numerator was derived from a reported percentage, and re-estimation with the Paule–Mandel variance estimator. Two numerators were derived from a reported percentage and its stated denominator in order to admit those studies to the pooled analyses: 103 of 326 from a reported 31.6% for Group B Streptococcus colonisation, and 71 of 208 from a reported 34.1% for Candida culture positivity. Both are flagged in the extraction table and each was removed in a dedicated sensitivity analysis. No other derivation was required; the remaining studies report their counts directly [32,33]. Two further sensitivity analyses were performed. Each primary pool was re-estimated on the logit scale by restricted maximum likelihood and with a binomial–normal generalised linear mixed model, that is, a random-intercept logistic regression fitted by maximum likelihood with adaptive Gauss-Hermite quadrature, so that the pooled value depends neither on the Freeman–Tukey transformation nor on back-transformation at the harmonic mean sample size. Prediction intervals were obtained with a t quantile on k minus 2 degrees of freedom. For pools of four studies, that quantile is large and the interval is correspondingly wide; the intervals are reported on that basis, as a statement of how weakly the pooled value constrains a future study, and not as a second estimate. The primary analyses were performed in Python 3 using statsmodels 0.15.0, SciPy and pandas, and the additional analyses in R 4.5.3 using metafor 5.0.1 and lme4 2.0.6.

3. Results

3.1. Study Selection

The nine searches returned 419 records in total, reducing to 288 unique records after 131 duplicates arising from overlap between lines were removed. Title and abstract screening excluded 253 records, most commonly because the report was not original research (93),

reported no female genital tract outcome (80) or was not conducted in Saudi Arabia (43). A second adjudication pass over 56 borderline records recovered three studies of maternal Group B *Streptococcus* or *Candida* colonisation that the first pass had misclassified as neonatal-only and carried three records with no abstract forward to full-text assessment. Twenty-one studies met the criteria from the database search. Hand-searching and citation searching retrieved five further records, of which two met the eligibility criteria: a retrospective study of 1201 women in labour in Jeddah and a retrospective laboratory series of 4055 high vaginal swabs from symptomatic non-pregnant women in Riyadh. Twenty-three studies were therefore included, yielding 147 extracted outcome rows. Figure 1 presents the selection process. No included study sampled a general population: every denominator is a clinical or screening population, and the estimates in Section 3.4 should be read on that basis.

Two inclusion decisions rested on documented reviewer judgement. One 1985 report of *Gardnerella vaginalis* isolation states neither country nor city in its title or abstract and carries no affiliation field in PubMed; it was included on the basis of the NLM-assigned MeSH geographic heading for Saudi Arabia, verified by confirming that the record is retrieved by that heading, and was excluded from the regional subgroup analysis [34]. One in vitro biofilm study on 157 stored vaginal isolates was included for its species distribution, but its susceptibility results follow deliberate experimental exposure to EDTA, cycloheximide and a heparin-benzyl alcohol preservative and were therefore excluded from the resistance synthesis [35].

3.2. Study Characteristics

The included studies span 1985 to 2026 and together enrolled or tested 20,759 women and 157 stored isolates. Twelve studies were cross-sectional, six prospective, two retrospective record-based studies, one a non-randomised case-control study, one a comparative observational laboratory study and one an in vitro study on stored isolates. Settings were antenatal clinics, labour and delivery units, gynaecology outpatient departments and hospital microbiology laboratories; no community-based or population-sampled study was identified.

Geographic coverage is uneven. Riyadh contributed five studies, Jeddah four, Taif three, and Makkah, the Eastern Province and Hail two each; Tabuk contributed one and the central region one without a named city, and three studies report no city at all. No study of vulvovaginal infection meeting the eligibility criteria represents the Northern Borders, Jazan, Najran and Asir regions, although a questionnaire-based series of 456 pregnant women with bacterial vaginosis has been reported from Najran without a prevalence denominator.

Populations differ in ways that bear directly on comparability. Eight studies screened pregnant women, two of them at or beyond 35 weeks of gestation in line with an antenatal screening protocol. Nine recruited symptomatic women presenting with discharge or suspected candidiasis, and pregnancy status was not reported at all in eight. Whether screening was universal cannot be established for most settings. The only study that reports both figures screened 4604 of 5292 women who delivered during the study period, so screening there was near-universal but not complete, and the remaining Group B Streptococcus studies describe recruitment of consecutive or convenience samples of pregnant women without stating a universal screening policy. One study states explicitly that Group B Streptococcus screening is not routinely performed in the kingdom. The colonisation estimates in this review are therefore prevalences among screened pregnant women. One restricted recruitment to postmenopausal women with diabetes aged 45 to 55 [36], and one included only culture-confirmed *C. albicans* isolates after excluding non-albicans species, mixed infection and pregnancy [37]. Funding was declared by one study and conflicts of interest by none. Table 1 gives the study characteristics in full.

Table 1. Characteristics of the 23 included studies. The final column lists the organisms or conditions each study tested for.

Study	City/Region	Study Period	Design	Setting	Population	N Recruited/ Tested	Age	Pregnancy	Symptoms	Organisms or Conditions Tested
Uduman [38]	Al-Khobar, Saudi Arabia	NR	cross-sectional	King Fahd Hospital of the University, Obstetr…	Saudi women admitted for delivery (in labour)	260	NR	pregnant	NR	Group B Streptococcus
Chowdhury [34]	NR	NR	cross-sectional	NR (clinic-based, unselected women with vagin…	Women with vaginal discharge (and a compariso…	2715	NR (80% of G. vaginalis isolates were from wo…	NR	mixed	Gardnerella vaginalis, Candida albicans, Trichomonas vaginalis
Farrag [39]	Saudi Arabia (city NR)	NR	cross-sectional screening study	gynaecology clinic	gynaecological patients (IUCD users and non-u…	218	NR	NR	mixed	Group B Streptococcus
Al-Hedaithy [40]	Not stated	NR	Prospective	Not stated	Patients with clinical signs of vaginitis yie…	500	NR	NR	symptomatic	Candida and other yeasts
El-Kersh [41]	Riyadh	NR	Prospective with follow-up testing	King Khalid University Hospital	Saudi pregnant women >28 weeks gestation	217 women (867 swabs)	NR	pregnant	asymptomatic	Group B Streptococcus
Iftikhar [42]	Jeddah, Saudi Arabia	January 2001 to January 2002	Prospective study	Private hospital clinic	Women of reproductive age attending clinic wi…	100	reproductive age group (specific range NR)	NR	symptomatic	Bacterial vaginosis, Candida, Trichomonas vaginalis
Alzanbagi [43]	Jeddah	2003	cross-sectional	Six cardinal hospitals in Jeddah	Women with vaginal discharge	1767	15–50 years	NR	symptomatic	Trichomonas vaginalis
Zamzami [32]	Jeddah, Saudi Arabia	NR	Prospective cohort	Delivery room, King Abdul-Aziz University Hos…	Low-risk labouring women (parturient women)	326	NR	pregnant	NR	Group B Streptococcus
Al-Akeel [35]	Riyadh (author affiliation; collection site n…	NR	In vitro laboratory study on stored clinical …	University laboratory	157 vaginal yeast isolates (126 C. albicans, …	157 isolates	NR	mixed	NR	Candida species

Table 1. *Cont.*

Study	City/Region	Study Period	Design	Setting	Population	N Recruited/ Tested	Age	Pregnancy	Symptoms	Organisms or Conditions Tested
Khan [44]	Makkah	September 2013–December 2014	Prospective descriptive	Antenatal clinic, Maternity and Children Hosp...	Pregnant women >35 weeks gestation	1328	17–47 years	pregnant	asymptomatic	Group B Streptococcus
Musleh [45]	Al-Khobar, Eastern Province	October 2011–September 2016	Prospective observational cross-sectional	King Fahd Hospital of the University, labour...	Saudi women admitted in labour, gestational a...	457 women (1371 specimens)	NR	pregnant	asymptomatic	Group B Streptococcus
Venugopal [33]	Central region, Saudi Arabia	NR	cross-sectional	hospital	Women with signs and symptoms of VVC attendin...	208	15–64 years	mixed	symptomatic	Candida species
Mohamed [46]	Makkah	One year (2018)	cross-sectional	Maternity and Children Hospital, Makkah/Umm...	Pregnant women ≥35 weeks gestation	400	NR	pregnant	asymptomatic	Group B Streptococcus
Yassin [47]	Riyadh	June 2016–June 2018	cross-sectional (laboratory-based)	Regional Laboratory, King Saud Medical City	Women with vaginitis: 138 pregnant, 256 non-p...	394	NR	mixed	symptomatic	Bacterial vaginosis, Trichomonas vaginalis, Candida species
Al Halteet [36]	Taif, Mecca Province	September 2017–April 2018	cross-sectional	King Faisal Specialist Hospitals, Taif	Postmenopausal women with diabetes, symptoms ...	550	45–55 years	nonpregnant	symptomatic	Candida species
Hawash [48]	Taif, Western Province	June 2020–December 2020	Single-visit prospective study	Public hospital gynaecology clinic	Saudi women aged 18–35 attending a gynaecolog...	174 enrolled (147 with valid result)	18–35 years	NR	mixed	Trichomonas vaginalis
Hawash [49]	Taif, Western Province	June 2018–May 2019	Non-randomized case-control	King Faisal Medical Complex gynaecology clinic	Women aged ≥18 seeking medical care: 79 with...	155	≥18 years	NR	mixed	Trichomonas vaginalis

Table 1. *Cont.*

Study	City/Region	Study Period	Design	Setting	Population	N Recruited/ Tested	Age	Pregnancy	Symptoms	Organisms or Conditions Tested
Saleem [50]	Hail, Saudi Arabia	January 2019 to December 2023	retrospective cross-sectional study	multiple hospital departments (gynaecology eme…	Pelvic inflammatory disease (PID) patients	370	mean age 34.52 ± 9.73 years; highest prevalen…	NR	symptomatic	Candida species
Zubair [37]	Tabuk City	February 2025–July 2025	Comparative observational (laboratory-based)	Three government facilities: Maternity and Ch…	Reproductive-age women with clinical signs of…	163 confirmed-positive isolates	Reproductive age (NR precisely)	nonpregnant	symptomatic	Candida albicans
Saleem [51]	Hail, Saudi Arabia	March 2022 to February 2023	cross-sectional	tertiary hospital	pregnant women with vulvovaginitis and vagina…	440	18–55	pregnant	symptomatic	Candida species
Alayed [52]	Riyadh	July 2021–December 2022	Retrospective cohort	King Saud University Medical City, labour and…	Saudi pregnant women screened for GBS at 35–4…	4604 screened (5292 deliveries)	NR	pregnant	asymptomatic	Group B Streptococcus
Almaghrabi [53]	Jeddah, Western Province	January 2019–December 2020	retrospective record-based study	Obstetric unit, King Abdulaziz University Hospital	Saudi women with singleton pregnancy at ≥28 weeks admitted in labour	1201	18–43 years (mean 28.4)	pregnant	asymptomatic (screened in labour)	Group B Streptococcus and other genital tract organisms
Najam [54]	Riyadh	September 2023–September 2024	retrospective cross-sectional study	Dr Sulaiman Al Habib Hospital, Al Suwaidi, Riyadh (tertiary care)	Symptomatic non-pregnant premenopausal women with high vaginal swabs taken in routine care	4055 specimens	18 to over 48 years	nonpregnant	symptomatic	Candida species and other vaginal organisms

3.3. Diagnostic Criteria and Laboratory Methods

Diagnostic approaches vary substantially and are set out study by study in Table S1. Group B *Streptococcus* studies used selective enrichment broth followed by subculture, with identification by latex agglutination, CAMP testing, automated biochemical panels or MALDI-TOF mass spectrometry; one study added capsular gene-based multiplex PCR for serotyping [46]. Candida studies used Sabouraud dextrose agar culture, in most cases followed by chromogenic agar and either automated identification or ITS sequencing; the largest series reports routine laboratory culture and identification of high vaginal swabs without specifying the identification platform and classifies non-albicans isolates as a single group. Two studies investigated trichomoniasis using wet mount microscopy, a point-of-care antigen test and nested PCR [48,49], while the largest trichomoniasis study reports no detection method anywhere in the available record [43].

Bacterial vaginosis was diagnosed by Amsel's criteria in one study [42] and by Gram stain in another [47]; no included study applied Nugent scoring. The 1985 *Gardnerella* study predates both Amsel and Nugent and uses the historical category of non-specific vaginitis, confirmed by hippurate hydrolysis and starch fermentation of all 269 isolates [34]. These definitions are not interchangeable. Species-level identification was attempted in all studies reporting organisms, but the methods used differ in discriminating power, and chromogenic agar alone does not reliably separate *C. glabrata* from other non-albicans species. One study explicitly reports ten isolates showing a brown colony colour consistent with *C. tropicalis* that were not confirmed by automated identification and were excluded from its species denominator [36].

3.4. Prevalence by Condition

Prevalence estimates by condition are given in Table 2, and the pooled analyses in Figure 2. Group B Streptococcus colonisation in pregnancy. Eight studies screened a combined 8793 pregnant women and detected colonisation in 1226, giving a pooled prevalence of 19.0% (95% CI 8.2 to 32.9) [32,38,41,44–46,52]. Individual estimates ranged from 3.9% to 44.5%, the lowest from a retrospective audit of routine screening records [52] and the second highest from a study that sampled twice during pregnancy [32]. The highest estimate, 44.5%, comes from a retrospective series of 1201 women in Jeddah swabbed at both vaginal and rectal sites on admission in labour [53]. Musleh [47] is included for its vaginal–rectal colonisation outcome; the same study also cultured urine, and that result is listed separately in Table 2 for completeness. The exclusion criterion in Section 2.2 applies only to studies in which urinary isolates were the sole genital tract-related finding, which is not the case here; a separate Saudi series of 6471 pregnant women screened for asymptomatic bacteriuria, in which Group B Streptococcus was the second most common urinary isolate after *Escherichia coli*, illustrates why urinary and vaginal denominators are kept apart [55]. A further study screened 218 gynaecological outpatients, including intrauterine contraceptive device users, and reported an overall colonisation rate of 17% across vaginal, cervical, urethral and rectal sites [39]. It was not added to the pool because the population is not pregnant and the sampled sites are not comparable, and because the numerator is not recoverable from the available record. Heterogeneity was extreme (I-squared 99.4%, tau-squared 0.210, $Q = 1256.4$ on 7 degrees of freedom, $p < 0.001$), and the 95% prediction interval extends from 0% to 75.0%. A prediction interval of that width means the pooled value does not usefully predict what a new Saudi study would find. Candida culture positivity in symptomatic women. Five studies of Candida culture positivity among symptomatic women attending gynaecology, antenatal or laboratory services tested 5353 women and identified 1825 cases, with a pooled prevalence of 27.4% (95% CI 17.8 to 38.1) and individual estimates ranging from 15.6% to 37.7% (I-squared 97.2%, tau-squared 0.064, $Q = 143.5$ on 4 degrees of freedom,

$p < 0.001$). The 95% prediction interval runs from 1.0% to 70.4%. The largest contributor is a laboratory series in which *Candida* was recovered from 1529 of 4055 high vaginal swabs (37.7%) taken from symptomatic non-pregnant women in Riyadh [54]. All five studies defined a case as a positive Candida culture in a woman presenting with vulvovaginal symptoms. None of the available records describes a composite case definition requiring compatible clinical findings together with microbiological confirmation, and for the studies assessed from abstracts alone, this may reflect limited reporting rather than the absence of such criteria. Because Candida can be carried asymptomatically and symptoms are not specific, this pooled figure is best read as Candida culture positivity among symptomatic women rather than as confirmed vulvovaginal candidiasis; some of the 1825 women will have had symptoms attributable to another cause. Trichomoniasis. The four trichomoniasis studies all recruited women attending clinical services: two enrolled women presenting with vaginal discharge, one enrolled gynaecology clinic attendees irrespective of symptoms, and one enrolled women seeking care and reported symptomatic and asymptomatic arms separately. None sampled a community population. Four studies tested 2169 women and detected 68 infections, but estimates ranged from 0.7% to 15.0% and heterogeneity reached I-squared 97.5%. Pooling across that range was judged inappropriate, and the pooled value of 9.0% (95% CI 0.8 to 23.9) is reported for completeness only and marked as exploratory in Figure 2. The heterogeneity is attributable to a single study: the 0.7% estimate comes from the one study that reports no detection method [43], and excluding it leaves three studies using wet mount microscopy, a point-of-care antigen test and PCR that are statistically homogeneous, pooling to 13.8% (95% CI 12.3 to 15.4) with I-squared 0.0%, tau-squared 0 and Q = 0.57 on 2 degrees of freedom ($p = 0.75$). Statistical homogeneity among three studies is not evidence of clinical equivalence. The three differ in detection method, in recruitment criteria and in the symptom status of the women tested, and with k = 3, the prediction interval remains wide (Table S6). The restricted estimate is reported as an exploratory analysis and not as a national figure. One study reported symptomatic and asymptomatic arms separately, at 16 of 79 and 7 of 76, respectively [49].

Bacterial vaginosis. Only one study reports bacterial vaginosis in 35 of 100 symptomatic women by Amsel's criteria, using a denominator of all symptomatic women tested ($n = 100$) [42]. A second study reports 87 of 205 confirmed vaginitis cases, using a denominator of confirmed cases rather than of women tested [47], and a third reports *Gardnerella vaginalis* in 269 of 2043 women with non-specific vaginitis using pre-Amsel criteria [34]. These three denominators are not comparable and were not pooled. No pooled Saudi estimate of bacterial vaginosis prevalence can be derived from the available evidence. Aerobic vaginitis. No included study reported aerobic vaginitis as a diagnosed condition using any recognised criteria. The Group B *Streptococcus* studies report an organism associated with aerobic vaginitis but assess colonisation in pregnancy rather than the clinical syndrome. Mixed infections. Two studies quantified mixed infection. In the 1985 series, 35 of 269 *Gardnerella* isolates were recovered with *C. albicans*, eight with *T. vaginalis*, six with *Bacteroides* species and three each with Group B *Streptococcus* and *Staphylococcus aureus* [34]. One study of 100 symptomatic women reported bacterial vaginosis in 35, candidiasis in 25 and trichomoniasis in 15, with no pathogen identified in the remaining 25 [42].

Table 2. Proportions positive by condition and organism, with the denominator each study used. Every row refers to the clinical or screening population stated in the denominator column; no row represents a prevalence in the general female population.

Study	Outcome Class	Condition/Organism	Positive	Tested	Prevalence (%)	Denominator	Method
Musleh [45]	Colonization/detection	*Bacteriuria* (GBS, ≥10^5 CFU/mL) among tested women	40	457	8.8	all tested	Urine culture
Alayed [52]	Colonization/detection	GBS (Group B *Streptococcus*) colonization	180	4604	3.9	pregnant women screened	Vaginal/rectal swab culture on selective blood agar (Granada medium);...
Musleh [45]	Colonization/detection	GBS colonization, history of previous abortion	NR	NR	14.3	NR	Culture, latex agglutination, CAMP test, or automated identification
Chowdhury [34]	Colonization/detection	Gardnerella vaginalis	NR	160	5	all tested	NR
Khan [44]	Colonization/detection	Group B *Streptococcus*(GBS) vaginal colonization	178	1328	13.4	pregnant women screened	Vaginal swab culture (Todd-Hewitt broth enrichment, subculture on she...
Musleh [45]	Colonization/detection	Group B *Streptococcus* (GBS) vaginal–rectal colonization	87	457	19.0	pregnant women screened	Culture (blood agar/colistin-nalidixic acid agar, latex agglutination...
Mohamed [46]	Colonization/detection	Group B *Streptococcus* (GBS) vagino-rectal colonization	60	400	15.0	pregnant women screened	Culture (Todd-Hewitt broth enrichment, sheep blood agar) + Microscan ...
El-Kersh [41]	Colonization/detection	Group B *Streptococcus*(vagino-rectal colonization)	60	217	27.6	pregnant women screened	Vaginal and rectal swab culture (Islam/Edwards blood agar and Lim bro...
Zamzami [32]	Colonization/detection	Group B *Streptococcus* (vagino-rectal colonization)	NR	326	31.6	pregnant women screened	Rectal and vaginal swabs, culture (method not specified in abstract)
Uduman [38]	Colonization/detection	Group B *Streptococcus* vaginal colonization	24	260	9.2	pregnant women screened	high vaginal swab culture
Farrag [39]	Colonization/detection	Group B beta-haemolytic streptococcus (GBS)	NR	218	17	all tested	culture (vaginal, cervical, urethral, rectal swabs)
Farrag [39]	Colonization/detection	Group B beta-haemolytic streptococcus (GBS)	NR	NR	31	IUCD users tested	culture (vaginal, cervical, urethral, rectal swabs)

Table 2. *Cont.*

Study	Outcome Class	Condition/Organism	Positive	Tested	Prevalence (%)	Denominator	Method
Farrag [39]	Colonization/detection	Group B beta-haemolytic streptococcus (GBS)	NR	NR	14.5	non-IUCD users tested	culture (vaginal, cervical, urethral, rectal swabs)
Farrag [39]	Colonization/detection	Group B beta-haemolytic streptococcus (GBS)–all four sites colonized	NR	NR	8.1	non-IUCD users tested	culture (vaginal, cervical, urethral, rectal swabs)
Farrag [39]	Colonization/detection	Group B beta-haemolytic streptococcus (GBS)—urethral site	NR	NR	83.8	colonized women (both groups)	culture (urethral swab)
Iftikhar [42]	Diagnosed infection	Bacterial vaginosis	35	100	35.0	symptomatic women tested	Amsel's criteria
Yassin [47]	Diagnosed infection	Bacterial vaginosis	87	205	42.4	confirmed cases	Gram staining
Iftikhar [42]	Diagnosed infection	*Candida albicans* (vulvovaginal candidiasis)	25	100	25.0	symptomatic women tested	NR
Saleem [50]	Diagnosed infection	*Candida* species (PID patients)	NR	370	NR	all tested	culture (high vaginal swab)
Chowdhury [34]	Diagnosed infection	Gardnerella vaginalis (non-specific vaginitis)	269	2043	13.2	symptomatic women tested	NR
Iftikhar [42]	Diagnosed infection	No pathogen identified	25	100	25.0	symptomatic women tested	NR
Hawash [49]	Diagnosed infection	Trichomonas vaginalis	16	79	20.3	symptomatic women tested	nested PCR
Hawash [49]	Diagnosed infection	Trichomonas vaginalis	7	76	9.2	asymptomatic women tested	nested PCR
Alzanbagi [43]	Diagnosed infection	Trichomonas vaginalis (trichomoniasis)	12	1767	0.7	all tested	NR
Hawash [48]	Diagnosed infection	Trichomonas vaginalis infection	18	147	12.2	all tested	composite reference (wet mount microscopy, clinician OSOM, PCR for di…
Iftikhar [42]	Diagnosed infection	Trichomoniasis	15	100	15.0	symptomatic women tested	NR

Table 2. *Cont.*

Study	Outcome Class	Condition/Organism	Positive	Tested	Prevalence (%)	Denominator	Method
Yassin [47]	Diagnosed infection	Trichomoniasis	NR	205	0.5	confirmed cases	wet mount examination
Yassin [47]	Diagnosed infection	Vaginitis (overall, any cause)	205	394	52.0	all tested	wet mount, Gram stain, culture
Yassin [47]	Diagnosed infection	Vaginitis—non-pregnant women	NR	256	44.5	all tested	wet mount, Gram stain, culture
Yassin [47]	Diagnosed infection	Vaginitis—pregnant women	NR	138	65.9	all tested	wet mount, Gram stain, culture
Venugopal [33]	Diagnosed infection	Vulvovaginal candidiasis (culture positive for *Candida* spp.)	NR	208	34.1	symptomatic women tested	culture on Sabouraud agar, morphology, wet mount, germ tube test, Vit…
Saleem [51]	Diagnosed infection	Vulvovaginal candidiasis (*Candida* species)	114	440	25.9	symptomatic women tested	culture
Yassin [47]	Diagnosed infection	Vulvovaginal candidiasis (*Candida*)	NR	205	58.5	confirmed cases	culture (SDA), germ tube test, CHROM agar, API20C AUX
Al Halteet [36]	Diagnosed infection	Vulvovaginal candidiasis (VVC, *Candida* spp. confirmed by CHROM agar/V…	86	550	15.6	symptomatic women tested	CHROM agar colony morphology and VITEK 2 compact system (YST ID cards)
Al Halteet [36]	Diagnosed infection	Vulvovaginal candidiasis (VVC, culture-positive *Candida* spp.)	96	550	17.5	all tested	culture on Sabouraud dextrose agar (SDA)
Yassin [47]	Diagnosed infection	Vulvovaginal candidiasis—non-pregnant women	NR	NR	53.5	NR	culture
Yassin [47]	Diagnosed infection	Vulvovaginal candidiasis—pregnant women	NR	NR	64.8	NR	culture
Al Halteet [36]	Diagnosed infection	Yeast cells on direct microscopy (KOH)	70	550	12.7	all tested	Direct microscopy with 10% KOH
Almaghrabi [53]	Colonization/detection	Group B Streptococcus (vagino-rectal colonization)	534	1201	44.5	pregnant women screened	Culture with enrichment, MicroScan WalkAway identification, latex agglutination
Almaghrabi [53]	Colonization/detection	*Candida albicans*	412	1201	34.3	all tested	Culture
Najam [54]	Diagnosed infection	Vulvovaginitis (any organism cultured)	1690	4055	41.7	symptomatic women tested	Culture of high vaginal swab
Najam [54]	Diagnosed infection	*Candida* species (culture positive)	1529	4055	37.7	symptomatic women tested	Culture of high vaginal swab

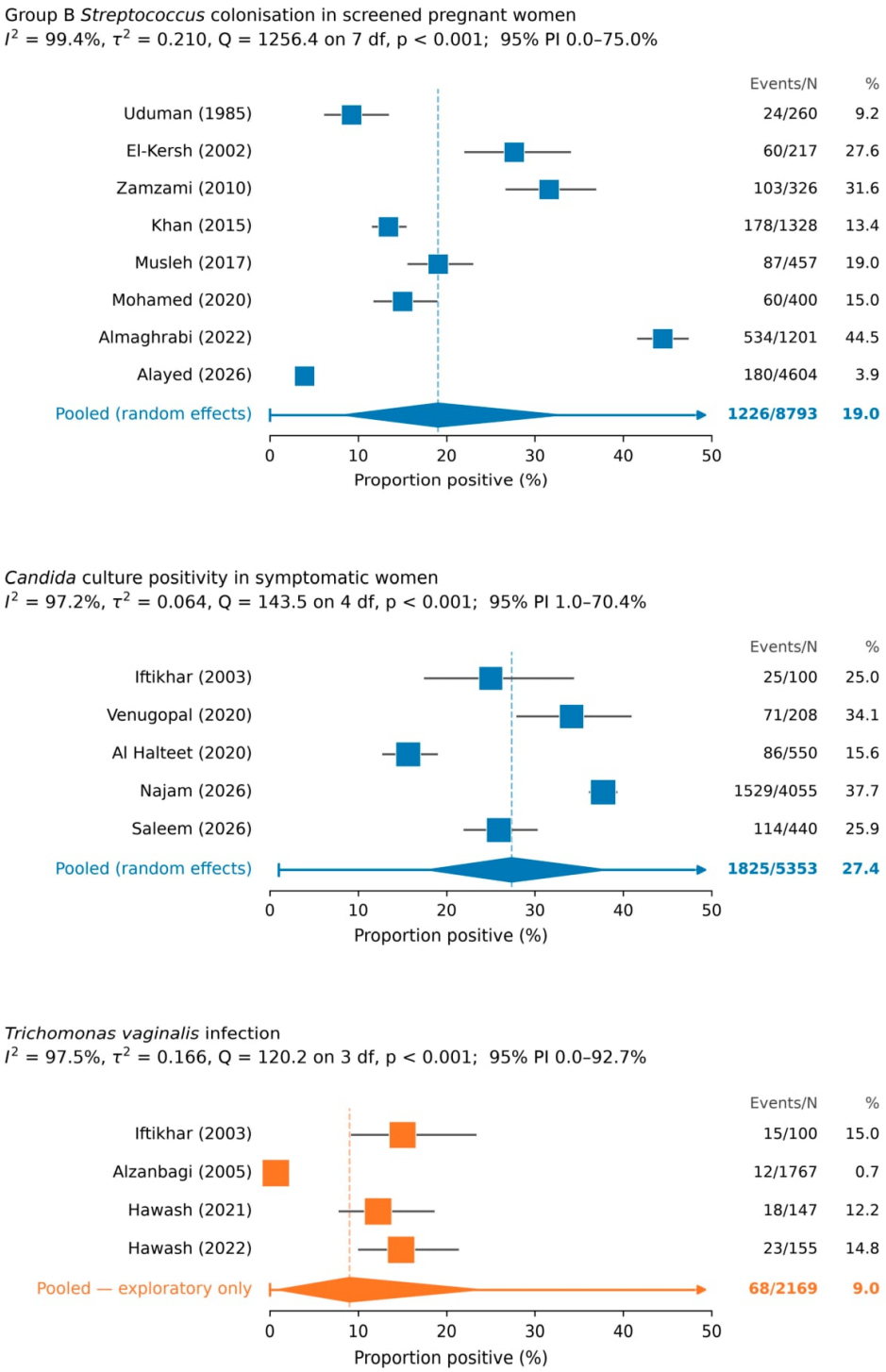


Figure 2. Pooled proportions for vulvovaginal outcomes in Saudi studies, by the population each study sampled. The denominators are screened pregnant women for colonisation and symptomatic women attending clinical services for Candida and trichomoniasis; none of these values represents a prevalence in the general female population. The panel labelled culture-confirmed vulvovaginal candidiasis reports Candida culture positivity among symptomatic women (Section 3.4). Random-effects estimates on Freeman–Tukey double-arcsine-transformed proportions, back-transformed at the harmonic mean sample size. Marker area is proportional to random-effects weight, and horizontal bars are Wilson 95% confidence intervals. The capped line through each diamond is the 95% prediction interval; an arrowhead indicates a bound beyond the plotted axis. The trichomoniasis diamond is drawn in orange and labelled exploratory because an I-squared of 97.5% and a 20-fold spread in individual estimates make pooling inappropriate as a primary analysis.

3.5. Organism and Species Distribution

Species distributions are given in Table 3. Every candidiasis study that identified Candida isolates to species level found C. albicans most common, but its share of isolates varied from 42.1% to 70.7%, so non-albicans species account for between three in ten and more than half of isolates, depending on the series. The largest series, consisting of 1712 isolates from symptomatic non-pregnant women in Riyadh, reported C. albicans in 70.7% and non-albicans Candida species in 18.6% [54].

Table 3. Organism and species distribution among positive specimens and isolates, one row per study. Percentages are as reported in the source; where a source reported only percentages, no count is shown.

Study	Population and Denominator	Isolates or Positive Specimens (n)	Distribution as Reported
Al-Hedaithy [40]	Yeast isolates from women with clinical vaginitis	500	*C. albicans* 59%, *C. glabrata* 31%, *C. tropicalis* 4%, *C. krusei* 3.2%, *Saccharomyces cerevisiae* 1.6%, *C. parapsilosis* 0.6%, *C. kefyr* 0.6%
Al-Akeel [35]	Stored vaginal yeast isolates, in vitro study	157	*C. albicans* 126 isolates and non-albicans *Candida* species 31 isolates; percentages not reported
Al Halteet [36]	*Candida*-positive specimens from postmenopausal women with diabetes	86	*C. albicans* 59.3%, *C. glabrata* 24.4%, *C. krusei* 16.3%
Venugopal [33]	*Candida*-positive specimens from symptomatic women	Not reported	*C. albicans* 68%, *C. tropicalis* 27%, *C. glabrata* 2.7%
Yassin [47]	*Candida* isolates from women with vaginitis	166	*C. albicans* 63%; three non-albicans species not named individually, at 20%, 13% and 4%
Saleem [50]	*Candida*-positive specimens from patients with pelvic inflammatory disease	Not reported	*C. albicans* 69.8%, *C. glabrata* 7.0%
Saleem [51]	*Candida*-positive specimens from pregnant women	114	*C. albicans* 42.1%, *C. glabrata* 19.3%, *C. tropicalis* 12.3%
Mohamed [46]	Group B *Streptococcus* isolates from screened pregnant women	60	Multiplex PCR genotyping: Ia 30.0%, III 25.0%, V 25.0%, II 11.7%, VI 5.0%, Ib 3.3%. Latex agglutination: V 26.7%, III 21.7%, Ia 10.0%, II 6.7%, VI 5.0%, Ib 1.7%, non-specific 18.3%, non-typable 10.0%
Najam [54]	Isolates from culture-positive high vaginal swabs of symptomatic non-pregnant women	1712 isolates from 1690 positive specimens	*C. albicans* 70.7%, non-albicans *Candida* species 18.6%, other organisms 10.7%; non-albicans species not identified individually

The study-level shares are not repeated in the text. *C. glabrata* was the second most frequent species in four of the five series that name every species recovered, and *C. tropicalis* was the second most frequent in one; two further series report non-albicans *Candida* as a single group without naming the species [33,36,40,50,51].

For Group B *Streptococcus*, one study typed all 60 isolates by capsular gene multiplex PCR, finding serotype Ia in 18 (30.0%), serotypes III and V in 15 each (25.0%), serotype II in 7 (11.7%), serotype VI in 3 (5.0%) and serotype Ib in 2 (3.3%) [46]. The same study found latex agglutination unable to type 6 isolates and non-specific in a further 11, so conventional serotyping assigned a specific type to only 43 of the 60 isolates, whereas genotyping assigned all 60.

No included study characterised the bacterial vaginosis-associated community beyond the diagnostic category, and none reported *Lactobacillus* abundance, so the relationship between lactobacillary depletion and the Saudi estimates cannot be examined.

3.6. Antimicrobial and Antifungal Susceptibility

Susceptibility findings are reported in full in Table S2 and summarised by organism and agent in Table 4. Fifty-one susceptibility rows were extracted, of which 19 carry both a denominator and a resistant count; a breakpoint standard is named in 22 of the 51. No organism-agent combination was reported by more than two studies, so none was pooled. Antifungal results for Candida and antibacterial results for Group B Streptococcus are presented separately throughout because the organisms, the testing methods and the clinical consequences differ.

Group B *Streptococcus*. Only two studies tested isolates, both on the same MicroScan Gram-positive panel, and they are the only method-comparable pair in the dataset. Across their 238 isolates, no resistance to penicillin G, ampicillin or vancomycin was detected, and erythromycin resistance was close to 16% in each. Clindamycin resistance differed between them, at 5.1% of 178 and 16.7% of 60 isolates; only the second study reports D-zone testing against CLSI M100-S22 criteria, while the first names no breakpoint standard, so the difference between them cannot be separated from the difference in reporting. The smaller study additionally found no resistance to daptomycin or linezolid and resistance to levofloxacin in 2 of 60 isolates [44,46].

Candida. Reported fluconazole activity cannot be reconciled across studies. Five studies report a fluconazole result, and they span 0% to 85% resistance (Table 4). They used reference broth microdilution against CLSI M27-A3, two different Vitek 2 configurations and, in one case, a method that is not named; they tested different populations, from unselected symptomatic women to pregnant women to a pre-selected set of C. albicans isolates; and only one names an interpretive standard. The highest figure, 85% in 163 C. albicans isolates, comes from the only study using a reference method, and the lowest come from reports that give no denominator for the susceptible proportion. A sixth study reports disc-diffusion results against CLSI criteria but without extractable denominators, and these are shown in Table S2 only [33,36,37,50,51].

The quality of this evidence was appraised separately against four requirements: a named testing method, a named interpretive standard with its version, results reported by species, and counts rather than bare percentages. Of the six studies reporting Candida susceptibility, the method is named in five, an interpretive standard in two, results are given by species in three, and classified isolate counts against a stated denominator in one. No study reports MIC distributions, and none distinguishes acquired resistance from a non-wild-type phenotype defined against an epidemiological cut-off value, so results from automated commercial systems and from reference broth microdilution cannot be treated as interchangeable estimates of the same quantity. Intrinsic resistance is a further source of non-comparability: the two C. krusei isolates reported as fluconazole-resistant are resistant as a property of the species rather than through acquired resistance. The 0% to 85% range should therefore not be read as a trend over time, nor as evidence about the current activity of fluconazole in Saudi Arabia. No included study reported susceptibility testing for Trichomonas vaginalis, and no study reported metronidazole or tinidazole susceptibility for bacterial vaginosis-associated organisms.

Table 4. Reported susceptibility by organism and agent, summarised across studies. Each row aggregates every extracted result for that organism-agent pair; study-level detail, including study, city, year, organism, extracted counts and testing method, is given in Table S2, and the population of each study in Table 1. Results from the in vitro biofilm study are excluded because susceptibility there was measured after deliberate experimental exposure (Section 3.1).

Organism	Agent	Studies (k)	Isolates Tested	Reported Resistance	Testing Method	Interpretive Standard Named
Group B *Streptococcus*	Penicillin G	2	178 and 60	0% in both	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Ampicillin	2	178 and 60	0% in both	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Vancomycin	2	178 and 60	0% in both	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Erythromycin	2	178 and 60	15.7% (28/178) and 16.7% (10/60)	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Clindamycin	2	178 and 60	5.1% (9/178) and 16.7% (10/60)	MicroScan Gram-positive panel; D-zone testing in one study	CLSI M100-S22 in one of two
Group B *Streptococcus*	Levofloxacin	1	60	3.3% (2/60)	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Daptomycin	1	60	0% (0/60)	MicroScan Gram-positive panel	No
Group B *Streptococcus*	Linezolid	1	60	0% (0/60)	MicroScan Gram-positive panel	No
Candida species	Fluconazole	5	163 *C. albicans*; 114; 24 tested by species; two studies not reported	0%; 5%; 11.1% in *C. albicans* (2/18), 0% in *C. glabrata* (0/4) and 100% in *C. krusei* (2/2); 47.4%; 85%	Reference broth microdilution; Vitek 2 Compact; VITEK 2 AST-YS01; one method not named	CLSI M27-A3 in one of five
Candida species	Voriconazole	2	114; not reported	3.5% and 3%	Vitek 2 Compact; Vitek 2	No
Candida species	Itraconazole	2	163; 114	3% and 21.1%	Reference broth microdilution; Vitek 2 Compact	CLSI M27-A3 in one of two
Candida species	Amphotericin B	2	163; 3 *C. glabrata*	5% and 0% (0/3)	Reference broth microdilution; VITEK 2 AST-YS01	CLSI M27-A3 in one of two
Candida species	Nystatin	1	114	31.6%	Vitek 2 Compact	No
Candida species	Clotrimazole	1	114	33.3%	Vitek 2 Compact	No
Candida species	Caspofungin	1	Not reported	3% (97% reported susceptible)	Vitek 2	No
Candida species	Clotrimazole, fluconazole, itraconazole, nystatin and terbinafine	1	Not reported	Counts of resistant isolates reported without a denominator; not interpretable as a proportion	Disc diffusion	CLSI, version not stated

3.7. Risk of Bias

Of the 23 included studies, 11 were rated low risk, 4 moderate risk and 8 high risk (Figure S1, Table S3). Performance was strongest on sample size (21 of 23 adequate) and validity of condition measurement (19 of 23), and weakest on response rate, which was unclear in 15 studies, and on statistical analysis, unclear in 11.

Appraisal used the published methods, participant flow and response rates of each report. Where a published report does not describe an item, the item is rated unclear, so the ratings describe the completeness of reporting as much as the conduct of the study, and a summary label of high risk should not be read as a demonstrated methodological failure. Seven studies were rated no on the sampling frame item for a substantive reason rather than for absent reporting, namely enrolment conditional on a laboratory result, restriction to a clinically atypical population, or a denominator consisting of isolates rather than women [35–37,39,40,47,50].

3.8. Subgroup and Sensitivity Analyses

Subgroup analyses were specified in advance for region, setting, symptom status, pregnancy status, diagnostic method and study period; three further groupings, by sampling site, sampling frequency and timing of sampling, were examined post hoc. Subgroup results are given in Table S4 and Figure 3. Only the Group B *Streptococcus* pool contained enough studies for subgroup analysis. Of the prespecified groupings, only two included at least three studies because the Group B Streptococcus studies uniformly concern asymptomatic pregnant women screened in antenatal or intrapartum settings.

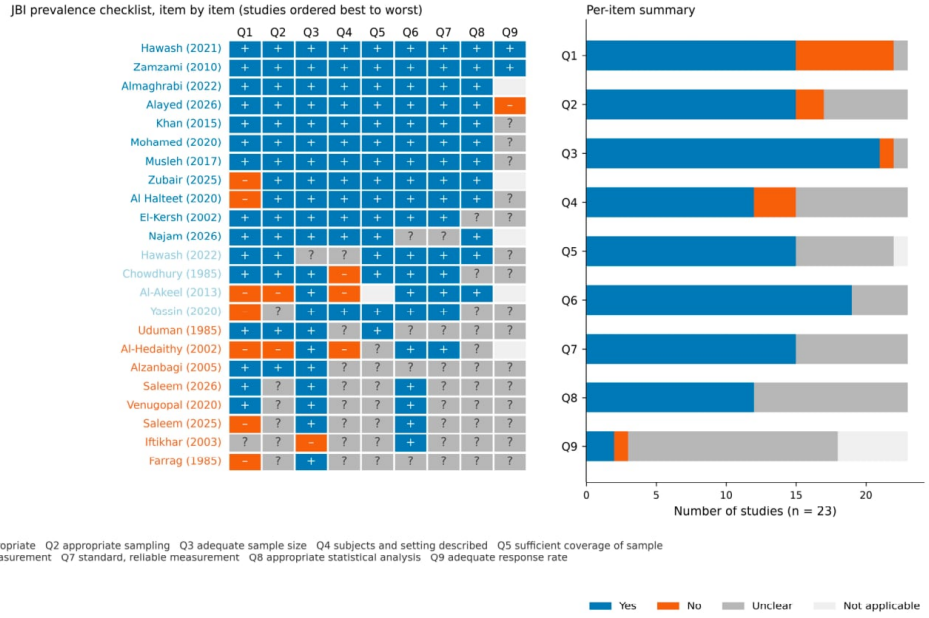


Figure 3. Subgroup and sensitivity analyses. The **left** panel shows individual Group B Streptococcus colonisation estimates grouped by region with Wilson 95% confidence intervals; only the Western cluster contained enough studies to pool (k = 4). The **right** panel shows leave-one-out and pre-specified sensitivity analyses for the two primary pooled outcomes against their primary estimates. Farrag [49] is absent because its population is not pregnant and no city is reported.

By region, the four Western Province studies pooled to 25.1% (95% CI 10.3 to 43.7) with I-squared 99.1%. The two Central studies reported 3.9% and 27.6%, and the two Eastern studies 9.2% and 19.0%; neither pair was pooled. Within-region heterogeneity is therefore as large as between-region heterogeneity, and region does not explain the variation. By study period, the three studies published up to 2010 pooled to 21.9% (95% CI

9.2 to 38.1) and the five published after 2010 to 17.4% (95% CI 4.7 to 35.8). The intervals overlap almost completely, and the latter group contains both the lowest and the highest estimate in the review, so this contrast carries no temporal signal. Subgroup analysis by setting, symptom status, pregnancy status and diagnostic method was not performed: the Group B Streptococcus studies uniformly concern antenatal or intrapartum screening of asymptomatic pregnant women, and the candidiasis and trichomoniasis pools contain too few studies to subdivide.

Three further groupings bear directly on the comparability of these studies. By sampling site, the two studies that swabbed the vagina alone reported 9.2% and 13.4% and were not pooled, whereas the six vagino-rectal studies pooled to 22.0% (95% CI 6.7 to 42.7); the direction of that difference matches the international finding that vaginal-only sampling recovers fewer colonised women than combined vaginal and rectal sampling. By timing, the five studies that screened during antenatal care pooled to 16.8% (95% CI 7.4 to 29.1) and the three that sampled women in labour to 22.8% (95% CI 5.7 to 46.8), with intervals that overlap substantially. By sampling frequency, the two studies that sampled more than once during pregnancy reported 27.6% and 31.6% and were not pooled, while the six studies using a single swab set pooled to 15.9% (95% CI 4.9 to 31.6). Each grouping moves the point estimate, but none resolves the heterogeneity: I-squared remains above 98% in every subgroup large enough to pool. Full subgroup results are given in Table S4.

Sensitivity analyses are given in Table S5 and Figure 3. Leave-one-out analysis moved the Group B Streptococcus estimate between 15.9% and 22.0%, and the Candida estimate between 24.7% and 31.0%; no single study drives either result, including the two largest. Excluding the study whose numerator was derived from a reported percentage gave 25.8% for Candida culture positivity and 17.4% for Group B Streptococcus colonisation. Excluding the single study rated high risk of bias from the colonisation pool left seven studies and resulted in an estimate of 20.6%. Substituting the Paule–Mandel variance estimator left both point estimates unchanged at 19.0% and 27.4% and narrowed the confidence intervals.

Re-estimating the two primary pools without the Freeman–Tukey transformation also changed little (Table S6). On the logit scale with restricted maximum likelihood, colonisation pooled to 17.4% (95% CI 9.9 to 28.8) and Candida culture positivity to 27.1% (95% CI 19.6 to 36.0). A binomial–normal generalised linear mixed model gave 17.3% (95% CI 10.2 to 27.9) and 27.0% (95% CI 20.2 to 35.1). For the three method-documented trichomoniasis studies the two alternatives gave 14.0% and 13.9%. The choice of transformation, variance estimator and back-transformation is therefore not what drives these estimates. The prediction intervals remain wide under every model, from 2.1% to 67.0% for colonisation and from 8.1% to 60.9% for Candida under the mixed model.

One sensitivity result is informative about heterogeneity rather than robustness. Removing the study of postmenopausal women with diabetes from the Candida pool raised the estimate to 31.0% and reduced I-squared from 97.2% to 90.5%, identifying that study's distinct population as one source of heterogeneity in that outcome [36].

4. Discussion

4.1. Principal Findings

Twenty-three Saudi studies met the eligibility criteria, and they are distributed very unevenly across the conditions this review set out to describe. Group B Streptococcus colonisation in pregnancy and vulvovaginal candidiasis account for most of the evidence; four studies cover trichomoniasis; bacterial vaginosis has one study with a denominator of all symptomatic women tested; no eligible study reported aerobic vaginitis. Group B Streptococcus colonisation pooled to 19.0% (95% CI 8.2 to 32.9) across 8793 screened pregnant women, and Candida culture positivity to 27.4% (95% CI 17.8 to 38.1) across

5353 symptomatic women attending clinical services. Neither figure is a prevalence in the general female population, and neither was obtained from a community sample. Both carry heterogeneity that pooling does not resolve, and the prediction intervals are wide enough that neither figure constrains what a new Saudi study would observe. Trichomoniasis was not pooled as a primary outcome, but the reason for its heterogeneity is identifiable: the single study reporting no detection method accounts for essentially all of it, and the three studies that document their methods agree closely at 13.8% (95% CI 12.3 to 15.4), although agreement among three studies that differ in method and recruitment is statistical rather than clinical, and the restricted estimate remains exploratory. *Candida albicans* predominated everywhere but never overwhelmingly, accounting for between 42.1% and 70.7% of isolates, with *C. glabrata* second in four of the five series that name every species. Group B Streptococcus remained fully susceptible to penicillin G, ampicillin and vancomycin in the only two studies that tested them, across 238 isolates in total, with erythromycin resistance close to 16% in both. Reported fluconazole resistance in *Candida* spans 0% to 85%, a range driven by differences in method and population rather than by any identifiable trend.

4.2. Interpretation

The between-study variation has several identifiable sources, and the subgroup analyses help separate them. Region does not explain it: within the Western Province, which was the only region with enough studies to pool, I-squared remained at 96.2%, and the two Central studies differ from each other more than the regional means differ among themselves. Study period does not explain it either, since the apparent decline after 2010 rests on one study contributing two-thirds of the later subgroup's participants. The comparison also leaves population and diagnostic method uncontrolled, so the difference between historical and recent studies cannot be read as a temporal trend.

Population selection explains more. Removing the study restricted to postmenopausal women with diabetes reduced candidiasis heterogeneity from I-squared 97.2% to 90.5%, which is what would be expected if that population genuinely differs in candidiasis risk rather than being measured differently [36]. The screening protocol matters in the same way for colonisation: the lowest colonisation estimate, 3.9%, comes from a retrospective audit of routine screening records, whereas the highest, 44.5%, comes from a retrospective series of women swabbed at both sites on admission in labour, and the next highest, 31.6%, from a prospective study that sampled twice during pregnancy [32,52]. Repeat sampling detects transient carriage that a single swab misses, and one study makes this explicit, reporting that 10 of 66 initially positive women had lost carriage at follow-up while 4 of 151 initially negative women had acquired it [41]. Cumulative carriage across multiple samples and point prevalence from one sample are different quantities. The subgroup analyses quantify this: the six studies using a single swab set the pooled estimate at 15.9%, whereas the two that sampled repeatedly report 27.6% and 31.6%. Sampling site acts in the same direction, with the two vaginal-only studies well below the vagino-rectal pool of 22.0%. Neither grouping reduces heterogeneity, so these are contributing sources of variation rather than an explanation of it.

Diagnostic method is the clearest single driver, and trichomoniasis demonstrates this most clearly. Wet mount microscopy has limited sensitivity against nucleic acid amplification, and one included study measured this directly, reporting wet mount sensitivity of 69.5% against nested PCR [49]. A study that detects 0.7% using an undocumented method and studies that detect 12% to 15% using documented methods are not plausibly describing different populations so much as different detection thresholds.

The distinction between detection, colonisation and diagnosed infection runs through all of these findings and is not a technicality. Group B *Streptococcus* colonisation is asymp-

tomatic in the mother; its clinical significance is the risk of vertical transmission, and treating a 19.0% colonisation prevalence as though it were a prevalence of vulvovaginal infection would misrepresent what was measured. The same applies to *Candida*: recovery from a symptomatic woman with compatible findings supports a diagnosis of candidiasis, whereas recovery from an unselected woman may represent carriage. Keeping these outcome streams separate reduces the number of studies available for any one pooled estimate, which is why several of the pools here are small, but merging them would produce figures with no clinical meaning. All included studies are observational, and most are cross-sectional.

4.3. Comparison with Other Evidence

The pooled colonisation estimate of 19.0% sits close to international figures. A synthesis of 390 articles on maternal Group B Streptococcus colonisation, covering 299,924 pregnant women in 85 countries, gave an adjusted worldwide colonisation prevalence of 18% (95% CI 17 to 19), with regional estimates ranging from 11% to 35% [56]. A separate synthesis of 131 studies, also of Group B Streptococcus colonisation in pregnancy, reported 15.5% (95% CI 14.2 to 17.0) worldwide and 14.0% (95% CI 11.0 to 16.8) across Islamic countries, and also found that vaginal-only sampling yields a lower figure than combined vaginal–rectal sampling, at 11.1% against 18.1% [57]. That sampling-site effect is relevant here because the Saudi studies mix vaginal-only and vagino-rectal protocols, and the difference is of the same order as the spread between them.

The Group B Streptococcus serotype distribution in the one Saudi study using molecular typing, with Ia at 30% and III and V at 25% each, is consistent with the global pattern in which Group B Streptococcus serotypes I to V account for 98% of colonising isolates, and serotype III alone accounts for about 25% [46,56]. Saudi macrolide and lincosamide resistance near 16% also aligns with global surveillance, which reports low resistance to penicillin (0.7%), ampicillin (1%) and vancomycin (0.59%), alongside substantially higher erythromycin and clindamycin resistance, and recommends susceptibility testing before using either [22].

The candidiasis estimate of 27.4% is lower than the global pooled prevalence of 32.6% (95% CI 29 to 36), derived from 114 studies and 1,222,829 women, although the two quantities are not directly comparable. That synthesis restricted inclusion to population-based studies, whereas every Saudi estimate pooled here comes from women who presented to clinical services with symptoms, and it also reported an I-squared of 99.8%, so the comparison is between two heterogeneous quantities rather than between two stable ones [58]. A systematic review of recurrent vulvovaginal candidiasis in the general female population illustrates the same distinction, since population-based and clinic-based denominators answer different questions [59]. The predominance of *C. albicans* in Saudi series matches the global picture, in which it was the leading pathogen in 79 of 114 studies [58].

The most striking contrast concerns bacterial vaginosis. A global meta-analysis placed general-population prevalence between 23% and 29% across regions, with 25% for the Middle East and North Africa [18], and a systematic review restricted to Nugent-diagnosed series documented wide variation between and within countries [60]. In Saudi Arabia, bacterial vaginosis is the least studied of the major conditions, with a single study providing a usable denominator of women tested and no study using Nugent scoring. Whether the condition is genuinely less frequent here or simply less investigated cannot be resolved from the available evidence.

4.4. Clinical and Public Health Implications

Where laboratory support exists, the variation documented here argues against managing vaginal discharge based on symptoms alone. Symptoms do not distinguish bacterial vaginosis, candidiasis, and trichomoniasis; one in four symptomatic women in the one

study that looked had no pathogen identified at all [42], and the series that quantified mixed infection found it often enough that a pathway stopping at the first positive would miss cases [34]. Testing also matters for the specific question of trichomoniasis, where the evidence assembled here indicates that detection depends heavily on the method chosen. According to the Saudi evidence, the most sensitive approach is nucleic acid amplification: the one included study that compared methods directly reported a wet mount sensitivity of 69.5% against nested PCR, and the lowest estimate in the review came from the study that documents no method at all. Wet mount microscopy alone should therefore be regarded as the least sensitive of the methods used in these studies, and an undocumented method as uninterpretable. For candidiasis, species-level identification has direct therapeutic consequences. Non-albicans species accounted for a third to a half of isolates, *C. glabrata* was consistently the second most common, and the two *C. krusei* isolates tested were fluconazole-resistant, as that species characteristically is [36]. Empiric azole treatment without identification will therefore fail in a predictable minority of cases.

The resistance evidence is not adequate to guide empiric therapy. Fluconazole resistance reported between 0% and 85% across methods that are not interchangeable cannot support a recommendation either to retain or to abandon fluconazole as first-line treatment, and the single study reporting 85% should not be generalised on its own. A prescribing audit of 403 pregnant patients in Tabuk puts this in context: bacterial vaginosis accounted for 14.1% of antimicrobial prescriptions in pregnancy, and 22.6% of all prescriptions departed from guideline recommendations, most often in drug choice for the trimester [61]. What the evidence does support is narrower: that susceptibility testing should accompany species identification in recurrent or treatment-refractory candidiasis, and that laboratories should state the breakpoint standard used, which is not stated for more than half of the susceptibility results here. For Group B *Streptococcus*, the Saudi data are reassuring on first-line prophylaxis, with no penicillin or ampicillin resistance in 238 tested isolates across two studies. Erythromycin and clindamycin resistance near 16% is clinically relevant for women with penicillin allergy and supports testing rather than assuming macrolide or lincosamide susceptibility in that group. For surveillance, the gaps in the evidence are as informative as the estimates. Several populous regions have no eligible study, no study has sampled a community rather than a clinical population, and no multicentre study exists, so there is at present no basis for a national figure for any of these conditions. Routine laboratory reporting of vaginal isolates with species identification and standardised susceptibility testing would address much of this without requiring new research infrastructure.

4.5. Strengths and Limitations

The review keeps diagnosed infection separate from colonisation and detection throughout, preserves each study's own denominator, and declines to pool where populations, criteria or methods are not comparable, or to pool any resistance outcome. Extraction recorded the denominator type and provenance for every row, and percentages were recomputed from numerators and checked against the published values; a susceptibility result that had been recorded with its polarity reversed was identified and corrected in this way. The Freeman–Tukey back-transformation was verified by round-trip rather than assumed. Decisions that rested on reviewer judgement, including two inclusions and the derivation of two numerators from reported percentages, are stated explicitly and tested in sensitivity analyses.

Some limitations remain. The electronic search was run in PubMed/MEDLINE and the Saudi Digital Library and was supplemented by hand-searching and citation searching, which identified two further eligible studies published in journals that MEDLINE does not index; a formal multi-database search of Embase, Scopus, Web of Science and CINAHL was

not undertaken, so the statement that a condition has not been studied in Saudi Arabia is best read as an absence of evidence identified by this strategy. Study selection was examined independently by three colleagues who took no part in drafting the review, working alongside the authors, as described in Section 2.3 and recorded in the Acknowledgements. Data extraction and risk-of-bias appraisal were performed by a single reviewer with a structured adjudication pass over borderline records, which altered six decisions; that pass was an internal consistency check rather than duplicate independent extraction, and no inter-rater agreement statistic is therefore reported. Where a published report does not describe a methodological item, that item is recorded as unclear. Finally, no included study characterised the vaginal microbiota directly or measured Lactobacillus abundance, so the mechanistic account given in the introduction is drawn from the wider literature and is not tested by the Saudi evidence assembled here.

5. Conclusions and Recommendations

The most defensible findings from the Saudi literature are narrow. Group B Streptococcus colonises roughly one in five screened pregnant women, with a pooled estimate of 19.0% (95% CI 8.2 to 32.9) that is consistent with international figures but surrounded by heterogeneity that no available subgroup explains. Candida was cultured from roughly one in four symptomatic women attending clinical services, at 27.4% (95% CI 17.8 to 38.1), with the same caveat and with the further qualification that a positive culture in a symptomatic woman is not by itself a confirmed diagnosis of vulvovaginal candidiasis. Trichomoniasis was detected in approximately 13.8% of women tested when only the studies that document a detection method are considered. That restricted estimate is the most internally consistent in the review, but it rests on three studies with different methods and recruitment criteria and is reported as exploratory. Candida albicans predominates but accounts for two-fifths to seven-tenths of isolates. Group B Streptococcus remained fully susceptible to penicillin G and ampicillin in the 238 isolates tested, which come from the only two Saudi studies that performed susceptibility testing.

The evidence is not representative of Saudi Arabia. Four regions have no eligible study; although a questionnaire-based description of bacterial vaginosis in 456 pregnant women has been published from Najran without a prevalence denominator [62], every study was conducted in a clinical or laboratory population rather than a community sample, and the literature is concentrated in a small number of tertiary centres in Riyadh, Jeddah, Makkah, Taif and the Eastern Province. Bacterial vaginosis, which international evidence places among the most common causes of vaginal symptoms, has one eligible Saudi study with a usable denominator of women tested and none using Nugent scoring. No eligible study reported aerobic vaginitis as a defined clinical entity. Both statements describe the absence of eligible evidence identified by a MEDLINE-only search; neither should be read as evidence that these conditions are rare in Saudi Arabia or that they have never been investigated here.

The resistance evidence is the weakest component. No more than two studies have examined any organism-agent combination, breakpoint standards are unreported in more than half of susceptibility results, and fluconazole resistance estimates vary by two orders of magnitude between methods. These data cannot currently support empiric treatment recommendations.

Five priorities follow for future work.

1. Multicentre sampling that includes the regions currently unrepresented, with at least one community or primary-care population rather than tertiary referral series alone.
2. Consistent diagnostic criteria applied and reported in full, specifically Nugent scoring or Amsel's criteria for bacterial vaginosis and explicit criteria for aerobic vaginitis, so

that Saudi estimates become comparable both with each other and with the international literature.
3. Species-level identification in all studies reporting Candida, given that non-albicans species comprise a third to a half of isolates and differ in intrinsic azole susceptibility.
4. Standardised susceptibility testing with the breakpoint standard and its version stated, reported as counts classified as susceptible, intermediate or dose-dependent, or resistant against a named denominator rather than as a bare percentage.
5. Studies that assess bacterial vaginosis, candidiasis, trichomoniasis and aerobic vaginitis within a single cohort using explicit criteria for each, as has been done in the region elsewhere [63], which would allow the frequency of mixed infection to be estimated rather than inferred.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/antibiotics15111152/s1: Table S1: Specimen types, diagnostic criteria and laboratory methods of the 23 included studies; Table S2: Antimicrobial and antifungal susceptibility findings in full; Table S3: Risk-of-bias assessment by study and JBI domain; Table S4: Subgroup analyses of Group B Streptococcus colonisation; Table S5: Sensitivity analyses for the two primary pooled outcomes; Table S6: Pooled estimates under alternative transformations and variance estimators; Figure S1: Risk of bias across the 23 included studies (JBI prevalence checklist).

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