Epidemiology of *Chlamydia trachomatis* in the Middle East and north Africa: a systematic review, meta-analysis, and meta-regression

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**Summary**

**Background** The epidemiology of *Chlamydia trachomatis* in the Middle East and north Africa is poorly understood. We aimed to provide a comprehensive epidemiological assessment of *C trachomatis* infection in the Middle East and north Africa.

**Methods** We did a systematic review of *C trachomatis* infection as well as a meta-analysis and meta-regression of *C trachomatis* prevalence. We searched PubMed and Embase, as well as regional and national databases up to March 13, 2019, using broad search terms with no language or year restrictions. Any document or report including biological measures for *C trachomatis* prevalence or incidence was eligible for inclusion. We extracted all measures of current (genital or rectal), recent, and ever infection with *C trachomatis*. We estimated pooled average prevalence in different populations using random-effects meta-analysis. Factors associated with prevalence and sources of between-study heterogeneity were determined using meta-regression.

**Findings** We identified a total of 1531 citations, of which 255 reports contributed to 552 *C trachomatis* prevalence measures from 20 countries. No incidence measures were identified. Pooled prevalence of current genital infection was 3·0% (95% CI 2·3–3·8) in general populations, 2·8% (1·0–5·2) in intermediate-risk populations, 13·2% (7·2–20·7) in female sex workers, 11·3% (9·0–13·7) in infertility clinic attendees, 12·4% (7·9–17·7) in women with miscarriage, 12·4% (9·4–15·7) in symptomatic women, and 17·4% (12·5–22·8) in symptomatic men. Pooled prevalence of current rectal infection was 7·7% (4·2–12·0) in men who have sex with men. Substantial between-study heterogeneity was found. Multivariable meta-regression explained 29·0% of variation. Population type was most strongly associated with prevalence. Additional associations were found with assay type, sample size, country, and sex, but not with sampling methodology or response rate (about 90% of studies used convenience sampling and >75% had unclear response rate). There was no evidence for temporal variation in prevalence between 1982 and 2018.

**Interpretation** *C trachomatis* prevalence in the Middle East and north Africa is similar to other regions, but higher than expected given its sexually conservative norms. High prevalence in infertility clinic attendees and in women with miscarriage suggests a potential role for *C trachomatis* in poor reproductive health outcomes in this region.

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**Introduction**

With more than 100 million incident infections every year,1 *Chlamydia trachomatis* is one of the most common sexually transmitted infections (STIs) worldwide.2,3 Although curable, control and early detection of *C trachomatis* infection are challenged by its largely asymptomatic nature.4 Untreated *C trachomatis* infection is associated with serious reproductive tract conditions including pelvic inflammatory disease, ectopic pregnancy, infertility among women, and epididymitis among men.4,5

Despite burdensome sequelae, STI control has long languished on health policy agendas. The 2030 Agenda on Sustainable Development6 aims to remedy this situation and led to WHO’s Global Health Sector Strategy on STIs.7 The strategy proposes an integrated approach for STI prevention and control that addresses core Sustainable Development Goals, mainly through securing universal access to sexual and reproductive health-care services and rights.7,8 The first strategic direction of this STI Strategy is “the need to understand the sexually transmitted infection epidemic and response as a basis for advocacy, political commitment, national planning, resource mobilization and allocation, implementation, and programme improvement.”9

The epidemiology of STIs, including *C trachomatis*, remains poorly understood in the Middle East and north Africa—a region comprising 10% of the world’s population.6,10 Here, political and sociocultural sensitivities have set STIs low on countries’ public health agendas, resulting in limited capacity for surveillance and programmes targeting sexual health, despite the possibility of a hidden disease burden.9 For example, the prevalence of primary infertility in the Middle East and north Africa, based on demographic and reproductive health surveys, has been
Evidence before this study
In a context of continuing stigma and political and sociocultural sensitivities, the Middle East and north Africa region has a dearth of epidemiological data about sexually transmitted infections. The prevalence of Chlamydia trachomatis and its distribution among populations at differing levels of risk of exposure remain largely unknown. A PubMed search using the search criteria (“Chlamydia”[MeSH] AND “Review”[Publication Type]) identified no systematic review and meta-analysis of regional scope for all subpopulations for this infection in the Middle East and north Africa or elsewhere.

Added value of this study
Using rigorous state-of-the-art methodologies with current empirical evidence, this study provided the first comprehensive epidemiological assessment of C. trachomatis infection in the Middle East and north Africa. The study searched diverse sources of data, beyond international electronic databases, and identified a large volume of published and unpublished data, some of which now appears in the literature for the first time. The scope of evidence allowed analyses that found revealing associations relevant for the Middle East and north Africa and elsewhere. Unexpectedly, given this region’s sexually conservative norms, the study estimated a C. trachomatis prevalence of 3% in the population at large, similar to estimates from other regions. The study also documented high C. trachomatis prevalence levels in infertility clinic attendees and in women with miscarriage, with odds of infection three-times higher than in the general population.

Implications of all the available evidence
There is a substantial C trachomatis infection and disease burden in the Middle East and north Africa that is neglected and poorly recognised despite its social and economic toll in a region comprising 10% of the world’s population. C. trachomatis infection appears to be consistently associated with infertility and poor reproductive health outcomes in this region, yet these conditions are not linked to the possibility of an underlying infectious cause. The Middle East and north Africa is far from achieving WHO’s Global Health Sector Strategy on Sexually Transmitted Infections, 2016–21. The findings of this study provide a scientific foundation to develop an evidence-informed public health response against C. trachomatis and its burdensome sequelae. The challenge will be to implement effective targeted, culturally appropriate, and gender-specific programmes to tackle C. trachomatis infection and improve sexual health in general.

Methods
Search strategy and selection criteria
We did a systematic review as well as a meta-analysis and meta-regression. We followed systematic review methods proposed by the Cochrane Collaboration,33 and report findings following the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines (appendix pp 5–6). We did exhaustive searches using PubMed and Embase, regional and national databases (WHO Index Medicus for the Eastern Mediterranean region, Iraqi Academic Scientific Journals database, and Iranian Scientific Information Database), abstract archives of International AIDS Society Conferences,34 as well as country-level and international organisations’ reports available through the Middle East and North Africa HIV/AIDS Epidemiology Synthesis Project database.35

Our searches were done up to March 13, 2019, using broad search terms (MeSH/Emtree terms exploded to cover all subheadings and free-text terms) with no language or year restrictions. The appendix (p 7) summarises the search criteria and search terms used. The Middle East and north Africa were defined as 23 countries extending from Morocco in the west to Pakistan in the east (appendix p 8). This definition for the Middle East and north Africa follows earlier convention applied in HIV and hepatitis C research,36–22 and is based on definitions by WHO, UNAIDS, and the World Bank.

Search results were checked for duplicates using Endnote (version 8.2). We screened titles and abstracts of unique citations. Full texts of citations deemed relevant or potentially relevant were retrieved for further screening by AS and HC. Any document or report including biological measures for C. trachomatis prevalence or incidence, or both, based on primary data was eligible for inclusion. Case reports, case series, editorials, commentaries, reviews, and reports about military personnel stationed in the Middle East and North Africa, but not from these countries, were excluded. Reference lists of literature reviews and all relevant articles were hand-searched for additional eligible reports.

In this Article, the term report refers to a document (article, conference abstract, or country-level report) containing outcome measures of interest (ie, prevalence or incidence) for one or more populations, and the term study refers to details of a specific outcome measure in a specific population. Consequently, one report could contribute multiple studies and one study could be published in different reports. Duplicate study results were included only once using the most detailed report.

Data analysis
Data from relevant reports were extracted by AS with input from LJA-R. Independent extraction was done by
HC, and discrepancies were settled by consensus, or by contacting authors. Data from non-English articles were extracted from the full text by native speakers.

We extracted all measures of current (genital or rectal), recent, and ever infection with C trachomatis. We stratified data according to the study population’s risk of exposure to C trachomatis or clinical manifestations (panel). Populations were defined as per original study authors’ specific population definition and inclusion criteria (such as for infertile populations or women with miscarriage). We classified women and men as symptomatic only if there was an indication for the presence of C trachomatis-related signs and symptoms. We subsequently synthesised data by type of assay used for C trachomatis detection and summarised these data using medians and ranges.

Studies applying the same assay to different biological specimens were included only once, based on a sequential order that prioritised, for women, C trachomatis detection in endocervical swabs, followed by vaginal and urine samples; and for men, detection in urethral swabs, followed by urine and semen samples. Studies applying nucleic acid amplification test (NAAT) and culture to the same biological specimen were included separately given our interest in studying their contribution to heterogeneity in C trachomatis prevalence, and in generating STI-estimation correction factors based on assay type.23–25 Studies applying other antigen detection assays to the same biological specimen were included only once based on assay sensitivity (direct fluorescence and enzyme-linked immunosassays on genital samples were prioritised over Giemsa staining).

We excluded studies using tissue specimens from the upper genital tract, or including less than ten participants. We stratified the analyses by sex where relevant. Studies reporting only an overall measure for men and women were classified according to the predominant sex in the sample.

We did risk of bias and precision assessments. Informed by the Cochrane approach,19 we classified studies as having low versus high risk of bias for each of three quality domains assessing rigour of sampling methodology (probability based vs non-probability based), type of C trachomatis ascertainment (biological assay vs other, such as self-report), and response rate (≥80% response rate or ≥80% of target sample size reached [the latter for studies using respondent-driven sampling] vs <80%). Studies with unavailable information about any given domain were classified as having unclear risk of bias for that domain. Studies were considered of higher precision if 200 participants or more underwent testing for C trachomatis, which was judged as an acceptable level of precision assuming a mean prevalence of 3% in the general population.

We produced forest plots to visualise estimates of prevalence and 95% CIs for each at-risk population, stratified by type of assay. Pooled average prevalence and 95% CIs were then estimated using meta-analysis for each stratum. A Freeman-Tukey type arcsine square-root transformation was first applied to stabilise variances of prevalence measures.26,27 Measures were then weighted using the inverse-variance method,28,29 before being pooled using a DerSimonian-Laird random-effects model.28 This model assumes a normal distribution for true effect sizes (ie, prevalence) across studies, which factors in sampling variation and true between-study heterogeneity.30

We did heterogeneity assessment using Cochran’s Q statistic to confirm existence of heterogeneity across studies,31 to quantify magnitude of between-study variation that is due to true differences in effect size rather than chance, and prediction interval to estimate the 95% CI of the distribution of true effect sizes.31,32 We did subgroup meta-analyses whenever five studies or more were available, using the R software (version 3.4.2).22 We did random-effects meta-regression analyses to identify sources of between-study heterogeneity and estimated the magnitude of their association with prevalence. We included risk of bias and precision domains in the meta-regression analyses. We considered the
following predictors a priori: at-risk population (panel), assay type (NAAT, culture, other assays detecting current infection, serological assays detecting anti-\textit{C trachomatis} immunoglobulins of class IgG, IgM, IgA, immunoglobulins not specified, and unclear), sampling methodology (non-probability-based sampling \textit{vs} probability-based sampling), sample size (<200 \textit{vs} \geq 200 participants), response rate (\geq 80\% \textit{vs} <80\% and unclear), year of publication, year of data collection, country (Egypt, Iran, Pakistan, and remaining countries; Egypt, Iran, and Pakistan being the most populous in the Middle East and north Africa),\textsuperscript{33} and sex (women \textit{vs} men; men-to-women transgenders who were biologically males were considered as men).

Studies that assessed \textit{C trachomatis} prevalence using different diagnostics or biomarkers were included independently. Missing values for year of data collection were imputed using data for year of publication adjusted...
| Country          | Study design                        | Sampling*                     | Sample size | Sex | Study context                      | Population characteristics | Specimen | Assay type        | Prevalence† |
|------------------|-------------------------------------|-------------------------------|-------------|-----|-----------------------------------|-----------------------------|----------|-------------------|-------------|
| Kadi et al (1990) | Algeria                             | Cross-sectional              | 69          | W   | Gynaecology clinic                | Gynaecology clinic attendees | Serum    | MIF (IgG)        | 17.4%       |
| Kadi et al (1990) | Algeria                             | Cross-sectional              | 180         | W   | Hospital                          | Women seeking rubella tests | Serum    | MIF (IgG)        | 26.6%       |
| Abdel Monem et al (2005) | Egypt                        | Case-control                  | 20          | W   | Antenatal clinic                  | Pregnant women              | Endocervical | Culture          | 15%         |
| Aboul Atta and Ibrahim (1995) | Egypt                      | Case-control                  | 20          | M   | Hospital                          | Controls in STI study       | Urethral | DFA               | 5%          |
| Badary (1996)    | Egypt                               | Case-control                  | 32          | W   | Gynaecology clinic                | Fertile women               | Endocervical | DFA              | 12.5%       |
| Berry and El Shabrawy (1996) | Egypt                      | Case-control                  | 30          | W   | Family planning clinic            | Family planning clinic attendees | Serum    | EIA (IgG)        | 3.3%        |
| Diab (1993)      | Egypt                               | Case-control                  | 30          | W   | Antenatal clinic                  | Women with full-term delivery | Serum    | EIA (IgG)        | 0           |
| Draz et al (2018) | Egypt                              | Case-control                  | 14          | W   | Gynaecology clinic                | Healthy women               | Endocervical | DFA              | 0           |
| El-Sayed et al (2002) | Egypt                          | Cross-sectional              | 108         | W   | Family planning clinic            | Family planning clinic attendees | Urine    | NAAT              | 2.8%        |
| El-Sayed et al (2002) | Egypt                          | Cross-sectional              | 604         | W   | Antenatal clinic                  | Antenatal clinic attendees  | Urine    | NAAT              | 1.3%        |
| Mosbah and Nabil | Egypt                              | Case-control                  | 90          | W   | Hospital                          | Pregnant women with pre-eclampsia | Endocervical | NAAT            | 4.4%        |
| Mosbah and Nabil (2016) | Egypt                        | Case-control                  | 90          | W   | Hospital                          | Normotensive pregnant women | Endocervical | NAAT            | 0           |
| Mousa (1990)     | Egypt                              | Cross-sectional              | 50          | W   | Gynaecology clinic                | Gynaecology clinic attendees | Endocervical | NAAT            | 2%          |
| Nada et al (2015) | Egypt                             | Case-control                  | 100         | W   | Gynaecology clinic                | Gynaecology clinic attendees | Endocervical | NAAT            | 2%          |
| Sullam et al (2001) | Egypt                       | Cross-sectional               | 1344        | W   | Community                         | Household survey of women   | Endocervical | ELISA            | 4.2%        |
| Zaki (1989)      | Egypt                              | Cross-sectional              | 100         | W   | Antenatal clinic                  | Pregnant women              | Endocervical | Culture          | 3%          |
| Ahmadi et al (2016) | Iran                          | Case-control                  | 109         | W   | Family planning clinic            | Family planning clinic attendees | Endocervical | NAAT            | 11.9%       |
| Ahmadi et al (2018) | Iran                          | Case-control                  | 165         | M   | Clinic                            | Fertile men                 | Semen    | NAAT              | 0.6%        |
| Ahmadi et al (2018) | Iran                          | Cross-sectional               | 4274        | W   | Primary health-care centre         | Primary health-care centre clinic attendees | Endocervical | Culture          | 1%          |
| Badami and Salari (2001) | Iran                       | Cross-sectional               | 250         | W   | Family planning clinic            | Family planning clinic attendees | Serum    | DFA               | 0.8%        |
| Badami and Salari (2001) | Iran                       | Cross-sectional               | 250         | W   | Family planning clinic            | Family planning clinic attendees | Serum    | DFA               | 3.2%        |
| Baghchehsaraei et al (2011) | Iran                       | Cross-sectional               | 328         | W   | Gynaecology clinic                | Gynaecology clinic attendees | Serum    | EIA (IgM)        | 10.3%       |
| Bagheri et al (2018) | Iran                          | Case-control                  | 60          | W   | Fertility centre                  | Pregnant women              | Vaginal  | NAAT              | 0           |
| Bagheri et al (2018) | Iran                          | Case-control                  | 60          | W   | Fertility centre                  | Pregnant women              | Serum    | ELISA (IgA)      | 6.7%        |
| Bagheri et al (2018) | Iran                          | Case-control                  | 60          | W   | Fertility centre                  | Pregnant women              | Serum    | ELISA (IgG)      | 1.7%        |
| Behroozi (2001)  | Iran                               | Case-control                  | 400         | W   | Antenatal clinic                  | Pregnant women              | Unclear  | DFA               | 2.8%        |
| Chamiari-Tabriz et al (2008) | Iran                     | Cross-sectional               | 991         | W   | Community                         | Married women               | Urine    | NAAT              | 12.8%       |
| Cheraghi et al (2014) | Iran                          | Cross-sectional               | 1448        | W   | Health centres                    | Non-pregnant women           | Endocervical | Unclear         | 0.2%        |
| Dehghan et al (2017) | Iran                          | Case-control                  | 250         | W   | Antenatal clinic                  | Antenatal clinic attendees  | Urine    | NAAT              | 0           |
| Dehghan et al (2017) | Iran                          | Case-control                  | 250         | W   | Antenatal clinic                  | Antenatal clinic attendees  | Serum    | EIA (IgA)        | 0           |
| Dehghan et al (2017) | Iran                          | Case-control                  | 250         | W   | Antenatal clinic                  | Antenatal clinic attendees  | Serum    | EIA (IgM)        | 0           |
| Dehghan et al (2017) | Iran                          | Case-control                  | 250         | W   | Antenatal clinic                  | Antenatal clinic attendees  | Serum    | EIA (IgG)        | 12.8%       |
| Goshayeshi et al (2015) | Iran                          | Case-control                  | 30          | W   | Fertility centre                  | Fertile women               | Endocervical | NAAT            | 3.3%        |
| Haghighi Hasanabad et al (2013) | Iran                      | Cross-sectional               | 399         | W   | Antenatal clinic                  | Pregnant adolescents        | Unclear  | NAAT              | 12.3%       |
| Jahromi et al (2010) | Iran                          | Case-control                  | 200         | W   | Gynaecology clinic                | Women with full-term delivery | Endocervical | DFA              | 5.2%        |
| Javannard et al (2018) | Iran                          | Cross-sectional               | 210         | W   | Gynaecology clinic                | Women undergoing routine pap smear | Endocervical | NAAT            | 11.4%       |

(Table 1 continues on next page)
| Country                  | Study design     | Sampling*                  | Sample size | Sex | Study context | Population characteristics       | Specimen | Assay type   | Prevalence† |
|-------------------------|------------------|----------------------------|-------------|-----|---------------|-----------------------------------|----------|--------------|-------------|
| Joolayi et al (2017)62  | Iran             | Case-control               | Convenience | 125 W Hospital | Pregnant women | Vaginal NAAT                     | 1.6%     |              |             |
| Joolayi et al (2017)62  | Iran             | Case-control               | Convenience | 125 W Hospital | Pregnant women | Serum ELISA (IgM)                | 1.6%     |              |             |
| Joolayi et al (2017)62  | Iran             | Case-control               | Convenience | 125 W Hospital | Pregnant women | Serum ELISA (IgG)                | 0        |              |             |
| Kajbaf and Gholamrezaedd (1998)63 | Iran          | Case-control               | Convenience | 50 W Antenatal clinic | Antenatal clinic attendees | Endocervical DFA                | 4%       |              |             |
| Kajbaf and Gholamrezaedd (1998)63 | Iran          | Case-control               | Convenience | 50 W Antenatal clinic | Antenatal clinic attendees | Serum ELISA (IgG)                | 6%       |              |             |
| Kamaryabi (2009)64      | Iran             | Case-control               | Convenience | 35 W Gynaecology clinic | Pregnant women | Serum ELISA (IgM)                | 20%      |              |             |
| Khezerdoust et al (2009)63 | Iran            | Cross-sectional            | Convenience | 1114 W Antenatal clinic | Pregnant women | Serum ELISA (IgG)                | 2.9%     |              |             |
| Masashi et al (2014)66  | Iran             | Case-control               | Convenience | 200 W Antenatal clinic | Pregnant women | Endocervical DFA                | 3.5%     |              |             |
| Masashi et al (2014)66  | Iran             | Case-control               | Convenience | 200 W Antenatal clinic | Pregnant women | Endocervical NAAT                | 8.7%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 70 W Antenatal clinic | Pregnant women | Serum ELISA (unclear)          | 4.3%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 250 W Family planning clinic | Healthy women | Endocervical DFA                | 0.8%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 104 W Antenatal clinic | Antenatal clinic attendees | Endocervical NAAT                | 5.8%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 239 W Hospital | Pregnant women | Endocervical NAAT                | 15.5%    |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 222 W Antenatal clinic | Pregnant women | Serum ELISA (IgM)                | 1.8%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 222 W Antenatal clinic | Pregnant women | Serum ELISA (IgG)                | 5.0%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 222 W Antenatal clinic | Pregnant women | Serum NAAT                      | 8.5%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 91 W Hospital | Pregnant women | Serum ELISA (IgG)                | 28.6%    |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 518 W Gynaecology clinic | Gynaecology clinic attendees | Endocervical NAAT                | 7.1%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 70 W Antenatal clinic | Pregnant women | Serum ELISA (IgG)                | 4.3%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 70 W Antenatal clinic | Antenatal clinic attendees | Endocervical NAAT                | 10.0%    |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 70 W Antenatal clinic | Antenatal clinic attendees | Endocervical Culture             | 8.6%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 100 W Antenatal clinic | Pregnant women | Serum ELISA (IgM)                | 2%       |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 100 W Antenatal clinic | Pregnant women | Serum ELISA (IgG)                | 18%      |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 30 W Gynaecology clinic | Women with full-term delivery | Urine NAAT                      | 4.7%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 30 W Gynaecology clinic | Women with full-term delivery | Urine NAAT                      | 4.4%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Case-control               | Convenience | 100 M Urology clinic | Asymptomatic men | Urine NAAT                      | 4%       |              |             |
| Ministry of Health and Medical Education (2008)67 | Iran | Cross-sectional             | Convenience | 76 W Gynaecology clinic | Pregnant women | Vaginal NAAT                    | 10.5%    |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 40 W Antenatal clinic | Women with full-term delivery | Serum ELISA (IgM)                | 0        |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 40 W Antenatal clinic | Women with full-term delivery | Serum ELISA (IgG)                | 7.5%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Cross-sectional             | Convenience | 198 W Hospital | Women with full-term delivery | Serum ELISA (IgG)                | 3.7%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 24 W Hospital | Pregnant women | Serum ELISA (IgM)                | 0        |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 24 W Hospital | Pregnant women | Serum ELISA (IgG)                | 8.3%     |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 30 W Hospital | Women with full-term delivery | Serum ELISA (unclear)           | 0        |              |             |
| Ministry of Health and Medical Education (2008)67 | Iraq | Case-control               | Convenience | 17 W Hospital | Pregnant women | Serum ELISA (IgM)                | 14.0%    |              |             |

(Table 1 continues on next page)
| Country | Study design | Sampling* | Sample size | Sex | Study context | Population characteristics | Specimen | Assay type | Prevalence† |
|---------|--------------|-----------|-------------|-----|---------------|-----------------------------|----------|------------|-------------|
| Al-Hamdani et al (2010) 83 Iraq | Case-control | Convenience | 17 W | Hospital | Pregnant women | Serum | ELISA (IgG) | 40% |
| Al-Hamdani et al (2010) 83 Iraq | Case-control | Convenience | 17 W | Hospital | Pregnant women | Serum | ELISA (IgA) | 14% |
| Al-Husseinei et al (2009) 84 Iraq | Case-control | Convenience | 100 W | Family planning clinic | Family planning clinic attendees | Serum | IFAT (unclear) | 5% |
| Al-Husseinei et al (2009) 84 Iraq | Case-control | Convenience | 100 W | Family planning clinic | Family planning clinic attendees | Endocervical | ELFA | 4% |
| Ali and Al-Kazaz (2018) 85 Iraq | Case-control | Convenience | 13 M | Clinic | Fertile men | Semen | NAAT | 0 |
| Alkhafaf (2013) 86 Iraq | Case-control | Convenience | 122 W | Hospital | Married women | Serum | ELISA (IgG) | 4% |
| Alkhafaf (2013) 86 Iraq | Case-control | Convenience | 168 W | Hospital | Unmarried woman | Serum | ELISA (IgG) | 10% |
| Hwaid et al (2013) 87 Iraq | Case-control | Simple random sampling | 91 W | Antenatal clinic | Pregnant women | Serum | ELISA (IgG) | 0 |
| Hwaid et al (2013) 87 Iraq | Case-control | Simple random sampling | 91 W | Antenatal clinic | Pregnant women | Serum | ELISA (IgM) | 4% |
| Ismail and Ali (2012) 88 Iraq | Case-control | Convenience | 50 W | Laboratories | General population women | Serum | ELISA (IgM) | 4% |
| Ismail and Ali (2012) 88 Iraq | Case-control | Convenience | 50 W | Laboratories | General population women | Serum | ELISA (IgG) | 10% |
| Ismail and Ali (2012) 88 Iraq | Case-control | Convenience | 50 W | Laboratories | General population women | Serum | ELISA (IgA) | 5% |
| Mohammed et al (2022) 89 Iraq | Case-control | Convenience | 23 W | Gynaecology clinic | Gynaecology clinic attendees | Endocervical | NAAT | 0 |
| Mohammed et al (2022) 89 Iraq | Case-control | Convenience | 20 W | Gynaecology clinic | Gynaecology clinic attendees | NAAT | 0 |
| Mohammed et al (2022) 89 Iraq | Case-control | Convenience | 20 W | Gynaecology clinic | Gynaecology clinic attendees | Serum | ELISA (IgG) | 0 |
| Yahya and Al-Siraj (2009) 90 Jordan | Cross-sectional | Convenience | 296 M | Laboratory | Fertile men | Serum | Culture | 0 |
| Abu Sarah et al (2013) 97 Jordan | Case-control | Convenience | 61 M | Urology clinics | Fertile men | Urine | NAAT | 1% |
| Al-Ramahi et al (2008) 98 Jordan | Case-control | Convenience | 146 W | Gynaecology clinic | Gynaecology clinic attendees | Endocervical | NAAT | 0 |
| As'ad (2004) 99 Jordan | Cross-sectional | Convenience | 144 W | Family planning clinic | Asymptomatic women | Vaginal | NAAT | 0 |
| Al-Wadi et al (2003) 100 Jordan | Case-control | Convenience | 61 M | Urology clinic | Non-urethritis patients | Urine | NAAT | 0 |
| Al-Wadi et al (2003) 100 Jordan | Case-control | Convenience | 39 M | Urology clinic | Non-urethritis patients | Urine | NAAT | 0 |
| Mahfuz et al (2008) 101 Jordan | Cross-sectional | Convenience | 186 W | Gynaecology clinic | Family planning clinic attendees | Endocervical | NAAT | 0 |
| Jordan Ministry of Health (2004) 102 Jordan | Cross-sectional | Convenience | 213 W | Hospital | Asymptomatic women | Endocervical | NAAT | 0 |
| Al-Awadhi et al (2018) 103 Kuwait | Cross-sectional | Convenience | 65338 W | Laboratory | Women undergoing pap smear 1997–2005 | Endocervical | NAAT | 0 |
| Al-Awadhi et al (2018) 103 Kuwait | Cross-sectional | Convenience | 56105 W | Laboratory | Women undergoing pap smear 2006–14 | Endocervical | NAAT | 0 |
| Al-Sweih et al (2011) 104 Kuwait | Cross-sectional | Convenience | 5938 W | Primary health-care centre | Kuwaiti women | Vaginal | NAAT | 1% |
| Al-Sweih et al (2011) 104 Kuwait | Cross-sectional | Convenience | 2601 W | Primary health-care centre | Expatriate women | Vaginal | NAAT | 2% |
| Al-Sweih et al (2011) 104 Kuwait | Cross-sectional | Convenience | 188 M | Gynaecology clinic | Fertile men | Semen | NAAT | 3% |
| Dee et al (2000) 105 Lebanon | Cross-sectional | Multistage random sampling | 506 W | Community | Ever-married women | Endocervical | ELISA | 0 |
| Hancali et al (2015) 106 Morocco | Cross-sectional | Convenience | 760 W | Family planning clinic | Family planning clinic attendees in 1999 | Unclear | NAAT | 4% |
| Hancali et al (2015) 106 Morocco | Cross-sectional | Convenience | 256 W | Family planning clinic | Family planning clinic attendees in 2011 | Unclear | NAAT | 4% |

*(Continued from previous page)
| Country                      | Study design          | Sampling*                          | Sample size | Sex | Study context                  | Population characteristics     | Specimen | Assay type  | Prevalence† |
|------------------------------|-----------------------|------------------------------------|-------------|-----|--------------------------------|--------------------------------|----------|-------------|-------------|
| (Continued from previous page)                                                                                                                                   |
| Hulstein et al (2018)         | Morocco               | Cross-sectional                    | Simple random sampling           | 163 | M Community                     | General population men         | Serum     | IFAT (IgG)  | 31%         |
| Hulstein et al (2018)         | Morocco               | Cross-sectional                    | Simple random sampling           | 174 | W Community                     | General population women       | Serum     | IFAT (IgG)  | 37%         |
| Morocco Ministry of Health     | Morocco               | Cross-sectional                    | Convenience                       | 323 | W Antenatal clinic              | Pregnant women                 | Urine     | NAAT        | 27%         |
| Morocco Ministry of Health     | Morocco               | Cross-sectional                    | Convenience                       | 518 | W Family planning clinic        | Family planning clinic attendees | Urine     | NAAT        | 5%          |
| The Middle East and North      | Morocco               | Cross-sectional                    | Convenience                       | 252 | W Antenatal clinic              | Pregnant women                 | Unclear   | NAAT        | 36%         |
| Africa HIV/AIDS Epidemiology   | Morocco               | Cross-sectional                    | Convenience                       | 537 | W Family planning clinic        | Family planning clinic attendees | Unclear   | NAAT        | 3%          |
| Synthesis Project (2017)       | Morocco               | Cross-sectional                    | Convenience                       | 81  | W Hospital                      | Pregnant women                 | Serum     | MIF (unclear) | 14%         |
| Radouani et al (1998)         | Morocco               | Case-control                       | Convenience                       | 200 | M Hospital                      | Blood donors                   | Serum     | MIF (unclear) | 5%          |
| Radouani et al (1998)         | Morocco               | Case-control                       | Convenience                       | 200 | M Hospital                      | Blood donors                   | Serum     | MIF (unclear) | 5%          |
| Takourt et al (1995)          | Morocco               | Case-control                       | Convenience                       | 200 | M Hospital                      | Blood donors                   | Serum     | MIF (unclear) | 5%          |
| Takourt et al (1995)          | Morocco               | Case-control                       | Convenience                       | 200 | M Hospital                      | Blood donors                   | Serum     | MIF (unclear) | 10%         |
| Mir et al (2009)              | Pakistan              | Cross-sectional                    | Multistage systematic random      | 2383| M Community                     | General population men         | Urine     | NAAT        | 0           |
| Wasti et al (1997)            | Pakistan              | Cross-sectional                    | Convenience                       | 300 | W                              | Antenatal clinic and family    | Endocervical | DFA       | 3%          |
| Al-Thani et al (2013)         | Qatar                 | Cross-sectional                    | Convenience                       | 133 | W                            | Primary health-care centre     | Endocervical | NAAT      | 5%          |
| Al-Thani et al (2013)         | Qatar                 | Cross-sectional                    | Convenience                       | 218 | W    Primary health-care centre | Non-Qatari women               | Endocervical | NAAT      | 5%          |
| Alzahrani et al (2010)        | Saudi Arabia          | Cross-sectional                    | Simple random sampling            | 95  | W Antenatal clinic              | Pregnant women                 | Endocervical | ELISA     | 10%         |
| Awad et al (2013)             | Saudi Arabia          | Cross-sectional                    | Convenience                       | 144 | W Gynaecology clinic            | Antenatal clinic attendees     | Urine     | NAAT        | 11%         |
| Bashir (1987)                 | Saudi Arabia          | Cross-sectional                    | Convenience                       | 100 | W Primary health-care centre    | Primary health-care centre      | Serum     | MIF (IgG)  | 0           |
| Bashir (1987)                 | Saudi Arabia          | Cross-sectional                    | Convenience                       | 100 | M Primary health-care centre    | Primary health-care centre      | Serum     | MIF (IgG)  | 2%          |
| Ghazi et al (2006)            | Saudi Arabia          | Cross-sectional                    | Simple random sampling            | 1600| W Antenatal clinic              | Saudi pregnant women           | Serum     | ELISA (IgG) | 8%          |
| Ghazi et al (2006)            | Saudi Arabia          | Cross-sectional                    | Simple random sampling            | 1460| W Antenatal clinic              | Saudi pregnant women           | Serum     | ELISA (IgM) | 1.5%        |
| Hossein (1988)                | Saudi Arabia          | Cross-sectional                    | Convenience                       | 112 | M Hospital                      | Blood donors                   | Serum     | MIF (IgM)  | 0           |
| Hossein (1988)                | Saudi Arabia          | Cross-sectional                    | Convenience                       | 112 | M Hospital                      | Blood donors                   | Serum     | MIF (IgG)  | 1.8%        |
| Kamel (2013)                  | Saudi Arabia          | Randomised controlled trial        | Convenience                       | 100 | W Antenatal clinic              | Antenatal clinic attendees     | Serum     | ELISA (IgG) | 4%          |
| Massoud et al (1993)          | Saudi Arabia          | Case-control                       | Convenience                       | 100 | W Hospital                      | Asymptomatic women             | Serum     | NAAT        | 0           |
| Massoud et al (1993)          | Saudi Arabia          | Case-control                       | Convenience                       | 100 | M Hospital                      | Asymptomatic men               | Serum     | NAAT        | 2%          |
| Ismail et al (1990)           | Somalia               | Cross-sectional                    | Convenience                       | 194 | W Community                     | Women                          | Endocervical | EIA       | 12.4%       |

(Table 1 continues on next page)
The search identified a total of 1531 citations: 509 through PubMed, 557 through Embase, and 465 through regional databases. Three reports were subsequently excluded. In total, 255 reports contributing 552 prevalence measures met the eligibility criteria for inclusion, but no incidence measures were identified.

Evidence covered 20 (87%) of 23 countries, encompassing a total of 256 769 C. trachomatis test results (tables 1 and 2; appendix pp 9–14). Iran contributed the largest number of measures or studies (n=176), followed by Egypt (n=89), Iraq (n=72), Saudi Arabia (n=45), Pakistan (n=42), and Morocco (n=32). Most studies assessed current infection (n=318), whereas the rest reported different serological measures (n=211), such as ever infection (anti-C trachomatis IgG; n=117). Details of C. trachomatis testing protocol were specified in 424 (77%) of 552 studies; 320 (75%) of the 424 used commercial assays, 62 (15%) used in-house validated tests, 29 (7%) used culture, and 13 (3%) used a non-validated in-house test.

In general populations (n=137), prevalence of current genital infection ranged from 0 to 19·9% with a median of 3·0%, whereas ever infection prevalence ranged from 0 to 37·9% with a median of 4·7% (tables 1 and 3). In populations at high risk (n=40), current infection prevalence in female sex workers (n=20) ranged from 0·9% to 72·9% with a median of 8·4%, whereas ever infection prevalence ranged from 19·8% to 100% with a median of 90·0% (tables 2 and 3). In men who have sex with men (including male sex workers and male-to-female transenders; n=20), current infection prevalence ranged from 0 to 8·8% with a median of 1·2% for genital infections and from 3·6% to 18·3% with a median of 6·3% for rectal infections, but no ever infection measure was identified.

### Table 1: Studies reporting Chlamydia trachomatis prevalence in general populations in the Middle East and north Africa

| Country            | Study design | Sampling* | Sample size | Sex | Study context     | Population characteristics | Specimen | Assay type | Prevalence† |
|--------------------|--------------|-----------|-------------|-----|-------------------|---------------------------|----------|------------|-------------|
| (Continued from previous page) |

| Country            | Study design | Sampling* | Sample size | Sex | Study context     | Population characteristics | Specimen | Assay type | Prevalence† |
|--------------------|--------------|-----------|-------------|-----|-------------------|---------------------------|----------|------------|-------------|
| Ismail et al (1990)  | Somalia      | Cross-sectional | Convenience | 189 | M | Community | Men | Urethral | EIA | 6% |
| Nur et al (2000)    | Somalia      | Cross-sectional | Convenience | 54  | M | Hospital | Blood donors | Serum | EIA (IgG) | 22% |
| WHO (2005a)        | Somalia      | Cross-sectional | Convenience | 4723 | W | Antenatal clinic | Pregnant women | Urine | NAAT | 17% |
| WHO (2005b)        | Somalia      | Cross-sectional | Convenience | 509  | W | Antenatal clinic | Pregnant women | Urine | NAAT | 34% |
| Ahmed et al (2018)  | Sudan        | Case-control | Convenience | 93   | W | Hospital | Healthy pregnant women | Serum | ELISA (IgG) | 0% |
| Ahmed et al (2018)  | Sudan        | Case-control | Convenience | 93   | W | Hospital | Pregnant women with pre-eclampsia | Serum | ELISA (IgG) | 0% |
| Almoth et al (2000) | Sudan        | Case-control | Convenience | 139  | W | Antenatal clinic | Antenatal clinic attendees | Serum | EIA (IgG) | 36% |
| Oktash et al (2004) | Sudan        | Cross-sectional | Convenience | 151  | W | Antenatal clinic | Pregnant women | Endocervical and urethral | EIA | 19% |
| Alkayer et al (2017) | Syria        | Case-control | Convenience | 21   | W | Hospital | Pregnant women | Serum | ELISA (IgG) | 47% |
| Ghazal-Aswad et al (2006) | United Arab Emirates | Cross-sectional | Multistage cluster sampling | 727  | W | Clinics | Primary health-care centre and clinic attendees | Endocervical and urethral | EIA | 25% |

DFA=direct fluorescent assay. EIA=enzyme immunoassay. ELFA=enzyme-linked fluorescence assay. IFA=indirect fluorescent antibody test. M=men or sample predominantly of men. NAAT=nucleic acid amplification test. STI=sexually transmitted infection. W=women or sample predominantly of women. *Non-probability sampling refers to a sampling method in which the data collection process does not allow individuals to have equal chance of being selected; an example is convenience sampling for which individuals are selected on the basis of ease of accessibility (first-come first-served basis). **Probability-based sampling refers to a sampling method in which data collection process is based on a random selection of study participants; an example is random sampling from a sampling frame. †The extracted prevalence measure is for the baseline measurement.
| Country          | Study design          | Sampling*                      | Sample size | Sex | Study context  | Population characteristics | Specimen | Assay type | Prevalence† |
|------------------|-----------------------|--------------------------------|-------------|-----|----------------|----------------------------|----------|------------|-------------|
| Algeria          | Cross-sectional       | Convenience                    | 44          | W   | Community      | Female sex workers          | Serum    | MIF (IgG)  | 100%        |
| Egypt            | Cross-sectional       | Convenience                    | 52          | W   | Community      | Female sex workers          | Urine    | NAAT       | 7.7%        |
| Egypt            | Cross-sectional       | Convenience                    | 80          | M   | Community      | Men who have sex with men   | Urine    | NAAT       | 8.8%        |
| Iran             | Cross-sectional       | Convenience                    | 116         | W   | Community      | Female sex workers          | Endocervical | Culture | 6.9%        |
| Iran             | Cross-sectional       | Convenience                    | 154         | W   | Community      | Female sex workers          | Serum    | MIF (IgG)  | 29.2%       |
| Iran             | Cross-sectional       | Convenience                    | 154         | W   | Community      | Female sex workers          | Serum    | MIF (IgM)  | 94.2%       |
| Iran             | Cross-sectional       | Convenience                    | 91          | W   | Mixed          | Female sex workers          | Serum    | ELISA (IgG) | 19.8%       |
| Iran             | Cross-sectional       | Convenience                    | 278         | W   | Community      | Female sex workers          | Vaginal  | NAAT       | 9%          |
| Iran             | Cross-sectional       | Convenience                    | 1337        | W   | Community      | Female sex workers          | Vaginal  | NAAT       | 6%          |
| Iraq             | Case-control          | Convenience                    | 30          | W   | STI clinic     | Women with multiple partners | Endocervical | ELFA     | 30%         |
| Iraq             | Case-control          | Convenience                    | 30          | W   | STI clinic     | Women with multiple partners | Serum    | IFAT (unclear) | 36.7%   |
| Morocco          | Cross-sectional       | Convenience                    | 519         | W   | NGOs           | Female sex workers          | Endocervical and vaginal | NAAT   | 20.7%       |
| Morocco          | Cross-sectional       | Convenience                    | 141         | W   | STI clinic     | Female sex workers          | Endocervical and urine      | NAAT   | 22.7%       |
| Morocco          | Cross-sectional       | Convenience                    | 368         | W   | Community      | Female sex workers in Agadir | Endocervical | NAAT       | 22.4%       |
| Morocco          | Cross-sectional       | Convenience                    | 247         | M   | Community      | Men who have sex with men in Agadir | Urine    | NAAT       | 5.4%        |
| Morocco          | Cross-sectional       | Convenience                    | 252         | M   | Community      | Men who have sex with men in Marrakech | Urine    | NAAT       | 6.5%        |
| Pakistan         | Cross-sectional       | Convenience                    | 426         | M   | Community      | Female sex workers in Rawalpindi | Endocervical | NAAT       | 1.7%        |
| Pakistan         | Cross-sectional       | Convenience                    | 107         | W   | Community      | Female sex workers in Abbottabad | Endocervical | NAAT       | 0.9%        |
| Pakistan         | Cross-sectional       | Convenience                    | 195         | M   | Community      | Male sex workers in Rawalpindi (Bantha) | Urine    | NAAT       | 0           |
| Pakistan         | Cross-sectional       | Convenience                    | 195         | M   | Community      | Male sex workers in Rawalpindi (Khotki) | Rectal   | NAAT       | 4.7%        |
| Pakistan         | Cross-sectional       | Convenience                    | 364         | M   | Community      | Male sex workers in Rawalpindi (Khotki) | Urine    | NAAT       | 0           |
| Pakistan         | Cross-sectional       | Convenience                    | 364         | M   | Community      | Male sex workers in Rawalpindi (Khotki) | Rectal   | NAAT       | 3.6%        |
| Pakistan         | Cross-sectional       | Convenience                    | 253         | M   | Community      | Male sex workers in Rawalpindi (Khusra) | Urine    | NAAT       | 0           |
| Pakistan         | Cross-sectional       | Convenience                    | 253         | M   | Community      | Male sex workers in Rawalpindi (Khusra) | Rectal   | NAAT       | 9.9%        |
| Pakistan         | Cross-sectional       | Convenience                    | 83          | M   | Community      | Male sex workers in Abbottabad (Bantha) | Urine    | NAAT       | 1.2%        |
| Pakistan         | Cross-sectional       | Convenience                    | 83          | M   | Community      | Male sex workers in Abbottabad (Bantha) | Rectal   | NAAT       | 4.9%        |
| Pakistan         | Cross-sectional       | Convenience                    | 20          | M   | Community      | Male sex workers in Abbottabad (Khotki and Khusra) | Urine    | NAAT       | 0           |
| Pakistan         | Cross-sectional       | Convenience                    | 20          | M   | Community      | Male sex workers in Abbottabad (Khotki and Khusra) | Rectal   | NAAT       | 6.3%        |
| Pakistan         | Cross-sectional       | Convenience                    | 730         | W   | Community      | Female sex workers in Lahore | Endocervical | NAAT       | 7.7%        |
| Pakistan         | Cross-sectional       | Convenience                    | 2531        | M   | Drop in centre | Men who have sex with men in Lahore | Unclear | Unclear | 35.2%       |
| Pakistan         | Cross-sectional       | Systematic random sampling     | 383         | W   | Red-light      | Female sex workers in Lahore | Endocervical | NAAT       | 11%         |
| Pakistan         | Cross-sectional       | Snowball                       | 348         | W   | Community      | Female sex workers in Karachi | Endocervical | NAAT       | 5.2%        |

(Table 2 continues on next page)
Rehan et al (2009)\(^{14}\) 141 Pakistan Cross-sectional Respondent-driven sampling 395 M Community Male sex workers in Lahore Urethral NAAT 1·5%
Rehan et al (2009)\(^{14}\) 141 Pakistan Cross-sectional Snowball 396 M Community Male sex workers in Karachi Urethral NAAT 1·2%
Rehan et al (2009)\(^{14}\) 141 Pakistan Cross-sectional Snowball 394 M Community Male sex workers in Karachi Rectal NAAT 10·4%
Rehan et al (2009)\(^{14}\) 141 Pakistan Cross-sectional Systematic random cluster sampling 197 M Community Hijras in Karachi Urethral NAAT 0
Rehan et al (2009)\(^{14}\) 141 Pakistan Cross-sectional Systematic random cluster sampling 198 M Community Hijras in Lahore Urethral NAAT 1·5%
Znazen et al (2010)\(^{142}\) 142 Tunisia Cross-sectional Convenience 188 W Community Female sex workers Endocervical NAAT 72·9%
Znazen et al (2010)\(^{142}\) 142 Tunisia Cross-sectional Convenience 183 W Community Female sex workers Serum MIF (IgG) 85·8%
Abdel Aleem et al\(^{143}\) 143 Egypt Case-control Convenience 144 W Infertility clinic Women with mixed infertility diagnosis Serum ELISA (IgG) 52%
Abdel Aleem et al\(^{143}\) 143 Egypt Case-control Convenience 104 M Infertility clinic Men with unclear infertility diagnosis Serum ELISA (IgG) 24%
Abdel Monem et al (2005)\(^{14}\) 143 Egypt Case-control Convenience 150 W Infertility clinic Women with unclear infertility diagnosis Endocervical Culture 24%
Abdel Monem et al (2005)\(^{14}\) 143 Egypt Case-control Convenience 150 W Infertility clinic Women with unclear infertility diagnosis Endocervical EIA 22·7%
Abdella et al (2015)\(^{144}\) 143 Egypt Case-control Convenience 50 W Infertility clinic Women with idiopathic infertility Serum ELISA (IgM) 4%
Abdella et al (2015)\(^{144}\) 143 Egypt Case-control Convenience 50 W Infertility clinic Women with idiopathic infertility Serum ELISA (IgG) 36%
Abdella et al (2015)\(^{144}\) 143 Egypt Case-control Convenience 50 W Infertility clinic Women with idiopathic infertility Endocervical NAAT 6%
Azab and Hassouna (2008)\(^{145}\) 145 Egypt Cross-sectional Convenience 70 W Infertility clinic Nearly half of women with TFI Serum ELISA (IgG) 28·6%
Badary (1996)\(^{146}\) 145 Egypt Case-control Convenience 60 W Infertility clinic Women with idiopathic infertility Endocervical DFA 33%
Berry and El Shabrawy (1996)\(^{146}\) 145 Egypt Case-control Convenience 70 W Infertility clinic Women with unclear infertility diagnosis Serum EIA (IgG) 18·6%
Elkayal et al (2015)\(^{144}\) 145 Egypt Case-control Convenience 100 W Infertility clinic Women with mixed infertility diagnosis Endocervical ELISA 3%
Elkayal et al (2015)\(^{144}\) 145 Egypt Case-control Convenience 100 W Infertility clinic Women with mixed infertility diagnosis Endocervical NAAT 3%
El Sayed et al (1997)\(^{147}\) 145 Egypt Cross-sectional Convenience 22 W Infertility clinic Women with TFI Serum MIF (IgG) 81·8%
El Sayed et al (1997)\(^{147}\) 145 Egypt Cross-sectional Convenience 78 W Infertility clinic Women without TFI Serum MIF (IgG) 7·7%
Inhorn and Buss (1993)\(^{148}\) 145 Egypt Case-control Convenience 83 W Hospital Majority of women without TFI Unclear Unclear 33%
Makled et al (2013)\(^{149}\) 145 Egypt Cross-sectional Simple random sampling 27 W Infertility clinic Women with TFI Serum ELISA (IgG) 85·2%
Makled et al (2013)\(^{149}\) 145 Egypt Cross-sectional Simple random sampling 51 W Infertility clinic Women without TFI Serum ELISA (IgG) 13·7%
Nada et al (2015)\(^{145}\) 145 Egypt Case-control Convenience 100 W Infertility clinic Women with idiopathic infertility Endocervical NAAT 15%
Sadik et al (1993)\(^{145}\) 145 Egypt Case-control Convenience 43 W Infertility clinic Infertile women in infertile couples with sperm antibodies Unclear DFA 18·6%
Sadik et al (1993)\(^{145}\) 145 Egypt Case-control Convenience 37 W Infertility clinic Women partners in infertile couples with sperm antibodies Unclear DFA 18·9%
Sadik et al (1993)\(^{145}\) 145 Egypt Case-control Convenience 62 M Infertility clinic Men partners in infertile couples with sperm antibodies Unclear DFA 19·4%

(Table 2 continues on next page)
| Country          | Study design | Sampling*          | Sample size | Sex | Study context          | Population characteristics                               | Specimen  | Assay type      | Prevalence†   |
|------------------|--------------|--------------------|-------------|-----|------------------------|----------------------------------------------------------|-----------|----------------|--------------|
| (Continued from previous page) |
| Sadek et al (1993)150 Egypt Case-control Convenience 18 M Infertility clinic Infertile men in infertile couples with sperm antibodies Unclear DFA 22.2% |
| Siam and Hefzy (2012)151 Egypt Case-control Convenience 90 W Gynaecology clinic Women with idiopathic infertility Serum ELISA (IgG) 20% |
| Siam and Hefzy (2012)151 Egypt Case-control Convenience 90 W Gynaecology clinic Women with idiopathic infertility Urine NAAT 4.4% |
| Younis et al (2000)152 Egypt Cross-sectional Convenience 30 W Infertility clinic Women with TFI Serum MIF (IgG) 46.7% |
| Younis et al (2000)152 Egypt Cross-sectional Convenience 14 W Infertility clinic Women without TFI Serum MIF (IgG) 50.0% |
| Zaitun and Zaitoun (1990)153 Egypt Cross-sectional Convenience 20 W Infertility clinic Women with TFI Serum Unclear 25% |
| Zaitun and Zaitoun (1990)153 Egypt Cross-sectional Convenience 30 W Infertility clinic Women without TFI Serum Unclear 3.3% |
| Zaki (1988)154 Egypt Cross-sectional Convenience 100 W Infertility clinic Women with unclear infertility diagnosis Endocervical Culture 7% |
| Zytoon (1994)155 Egypt Cross-sectional Convenience 75 W Infertility clinic Women with mixed infertility diagnosis Endocervical Culture 65.3% |
| Ahmadi et al (2018)49 Iran Case-control Convenience 165 M Infertility clinic Men with male factor infertility Semen NAAT 4.2% |
| Badami and Salari (2001)51 Iran Case-control Convenience 125 W Infertility clinic Women with unclear infertility diagnosis Serum DFA 8.8% |
| Badami and Salari (2001)51 Iran Case-control Convenience 125 W Infertility clinic Women with unclear infertility diagnosis Serum Unclear 20.8% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Urine NAAT 4.8% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Urine NAAT 4.4% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Serum EIA (IgM) 4% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Serum ELISA (IgA) 0 |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Serum ELISA (IgG) 15.6% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 W Infertility clinic Women with mixed infertility diagnosis Serum EIA (IgM) 1.2% |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 M Infertility clinic 40% of men had male factor infertility Serum ELISA (IgA) 0 |
| Dehghan et al (2017)57 Iran Case-control Convenience 250 M Infertility clinic 40% of men had male factor infertility Serum ELISA (IgG) 18% |
| Golshani et al (2007)59 Iran Cross-sectional Convenience 200 M Infertility clinic Majority of men had male factor infertility Semen NAAT 18.0% |
| Goshayeshi et al (2015)60 Iran Case-control Convenience 100 W Infertility clinic Women with unclear infertility diagnosis Endocervical NAAT 21.0% |
| Hajikhani et al (2013)61 Iran Cross-sectional Convenience 51 W Infertility clinic Women with TFI Endocervical Culture 3.9% |
| Hajikhani et al (2013)61 Iran Cross-sectional Convenience 51 W Infertility clinic Women with TFI Endocervical NAAT 11.7% |
| Joolayi et al (2017)62 Iran Case-control Convenience 32 W Infertility clinic Women with TFI Vaginal NAAT 9.4% |
| Joolayi et al (2017)62 Iran Case-control Convenience 68 W Infertility clinic Women with ovarian and other infertility Vaginal NAAT 2.9% |
| Joolayi et al (2017)62 Iran Case-control Convenience 32 W Infertility clinic Women with TFI Serum ELISA (IgM) 9.4% |
| Joolayi et al (2017)62 Iran Case-control Convenience 68 W Infertility clinic Women with ovarian and other infertility Serum ELISA (IgM) 4.4% |

(Table 2 continues on next page)
| Country                  | Study design | Sampling | Sample size | Sex | Study context                          | Population characteristics | Specimen | Assay type       | Prevalence† |
|-------------------------|--------------|----------|-------------|-----|---------------------------------------|-----------------------------|----------|------------------|-------------|
| Joolayi et al (2017)   | Iran         | Case-control | 32  W       | Infertility clinic | Women with TFI | Serum | ELISA (IgG) | 0            |
| Joolayi et al (2017)   | Iran         | Case-control | 68  W       | Infertility clinic | Women with ovarian and other infertility | Serum | ELISA (IgG) | 0            |
| Kajbaf and Gholamnezhad (1998) | Iran | Case-control | 101  W      | Infertility clinic | Women with mixed infertility diagnosis | Endocervical DFA | 7.9%    |
| Kajbaf and Gholamnezhad (1998) | Iran | Case-control | 101  W      | Infertility clinic | Women with mixed infertility diagnosis | Serum | ELISA (IgG) | 17.8%       |
| Kalantar et al (2007)  | Iran         | Cross-sectional | 91  W       | Infertility clinic | Majority of women had female factor infertility | Serum | ELISA (IgG) | 0            |
| Kalantar et al (2007)  | Iran         | Cross-sectional | 91  W       | Infertility clinic | Majority of women had female factor infertility | Vaginal NAAT | 0         |
| Kamyabi (2009)         | Iran         | Case-control | 35  W       | Gynaecology clinic | Women with mixed infertility diagnosis | Serum | ELISA (IgG) | 22.9%       |
| Mansour Ghanaie (2014) | Iran         | Cross-sectional | 135  W      | Infertility clinic | Majority of women without TFI | Endocervical NAAT | 19.3%    |
| Ministry of Health and Medical Education (2008) | Iran | Case-control | 46  W       | Infertility clinic | Women with unclear infertility diagnosis | Serum | ELISA (IgG) | 23.9%       |
| Ministry of Health and Medical Education (2008) | Iran | Case-control | 150  W      | Infertility clinic | Women with idiopathic infertility | Endocervical DFA | 15.3%    |
| Ministry of Health and Medical Education (2008) | Iran | Case-control | 150  W      | Infertility clinic | Women with idiopathic infertility | Endocervical NAAT | 32%      |
| Ministry of Health and Medical Education (2008) | Iran | Case-control | 125  W      | Infertility clinic | Women with unclear infertility diagnosis | Endocervical DFA | 8.8%     |
| Ministry of Health and Medical Education (2008) | Iran | Cross-sectional | 100  M      | Infertility clinic | Men with unclear infertility diagnosis | NAAT | 9%          |
| Moazenechi et al (2018) | Iran         | Cross-sectional | 1080  M     | Infertility clinic | Men with unclear infertility diagnosis | Serum | ELISA (IgA) | 4.3%        |
| Moazenechi et al (2018) | Iran         | Cross-sectional | 1080  M     | Infertility clinic | Men with unclear infertility diagnosis | Semen | NAAT | 10%         |
| Moussavi et al (2014)  | Iran         | Case-control | 104  W      | Infertility clinic | Women with unclear infertility diagnosis | Endocervical NAAT | 4.8%     |
| Nan Bakhsh et al (2008) | Iran         | Cross-sectional | 144  W      | Infertility clinic | Women with mixed infertility diagnosis | Serum | ELISA (IgG) | 11.1%       |
| Nikbakht et al (2008)  | Iran         | Case-control | 125  W      | Infertility clinic | Women with TFI | Unclear | ELISA (unclear) | 23.2%    |
| Peivandi et al (2009)  | Iran         | Cross-sectional | 110  W      | Infertility clinic | Majority of women with TFI | Serum | MIF (IgG) | 24.5%       |
| Rashidi et al (2007)   | Iran         | Cross-sectional | 300  W      | Infertility clinic | Women with mixed infertility diagnosis | Unclear | ELISA (unclear) | 32.3%    |
| Rashidi et al (2013)   | Iran         | Case-control | 44  W       | Infertility clinic | Women with TFI | Urine | NAAT | 4.5%        |
| Rashidi et al (2013)   | Iran         | Case-control | 190  W      | Infertility clinic | Women with ovarian and other infertility | Urine | NAAT | 14.2%       |
| Rashidi et al (2013)   | Iran         | Case-control | 44  W       | Infertility clinic | Women with TFI | Serum | ELISA (IgM) | 2.3%       |
| Rashidi et al (2013)   | Iran         | Case-control | 190  W      | Infertility clinic | Women with ovarian and other infertility | Serum | ELISA (IgM) | 0.5%        |
| Rashidi et al (2013)   | Iran         | Case-control | 44  W       | Infertility clinic | Women with TFI | Serum | ELISA (IgG) | 9.1%        |
| Rashidi et al (2013)   | Iran         | Case-control | 190  W      | Infertility clinic | Women with ovarian and other infertility | Serum | ELISA (IgG) | 8.4%        |
| Sadpour et al (2012)   | Iran         | Cross-sectional | 120  M      | Infertility clinic | Men with male factor infertility | Semen | NAAT | 3%          |

(Table 2 continues on next page)
## Table 2 Continued from previous page

| Country | Study design | Sampling | Sample size | Sex | Study context | Population characteristics | Specimen | Assay type | Prevalence† |
|---------|--------------|----------|-------------|-----|---------------|----------------------------|----------|-----------|-------------|
| Sattari et al (2017) | Iran | Case-control | Convenience | 184 | W | Infertility clinic | Majority of women without TFI | Serum | ELISA (IgM) | 5.4% |
| Sattari et al (2017) | Iran | Case-control | Convenience | 184 | W | Infertility clinic | Majority of women without TFI | Serum | ELISA (IgG) | 35.9% |
| Siahkali and Amini (2018) | Iran | Cross-sectional | Convenience | 60 | M | Infertility clinic | Men with idiopathic infertility | Semen | NAAT | 5.0% |
| Abid and Al-Zwaid (2015) | Iraq | Case-control | Convenience | 61 | M | Infertility clinic | Women with mixed infertility | Serum | ELISA (IgG) | 30.0% |
| Ahmed (2012) | Iraq | Case-control | Convenience | 47 | W | Infertility clinic | Women with unclear infertility diagnosis | Endocervical NAAT | 29.8% |
| Al-Husseinei et al (2009) | Iraq | Case-control | Convenience | 54 | W | Infertility clinic | Women with unclear infertility diagnosis | Endocervical ELFA | 9.3% |
| Al-Husseinei et al (2009) | Iraq | Case-control | Convenience | 54 | W | Infertility clinic | Women with unclear infertility diagnosis | Serum | IFAT (unclear) | 11.1% |
| Ali and Al-Kazaz (2018) | Iraq | Case-control | Convenience | 63 | M | Clinic | Men with male factor infertility | Semen | NAAT | 17.4% |
| Al-Kattan and Mohammed (2013) | Iraq | Cross-sectional | Convenience | 54 | W | Infertility clinic | Women with TFI or adhesions | Serum | ELISA (IgG) | 51.9% |
| Al-Kattan and Mohammed (2013) | Iraq | Cross-sectional | Convenience | 67 | W | Infertility clinic | Women without TFI or endometriosis | Serum | ELISA (IgM) | 86.6% |
| Dawood (2011) | Iraq | Cross-sectional | Convenience | 30 | W | Hospital | Women with unclear infertility diagnosis | Serum | ELISA (IgA) | 3.3% |
| Dawood (2011) | Iraq | Cross-sectional | Convenience | 30 | W | Hospital | Women with unclear infertility diagnosis | Serum | ELISA (IgG) | 53.3% |
| Dawood (2011) | Iraq | Cross-sectional | Convenience | 100 | W | Hospital | Women with unclear infertility diagnosis | Endocervical NAAT | 30.0% |
| Ismail and Ali (2012) | Iraq | Case-control | Convenience | 52 | W | Infertility clinic | Women with unclear infertility diagnosis | Serum | ELISA (IgG) | 29.9% |
| Ismail and Ali (2012) | Iraq | Case-control | Convenience | 52 | W | Infertility clinic | Women with unclear infertility diagnosis | Serum | ELISA (IgM) | 42.3% |
| Ismail and Ali (2012) | Iraq | Case-control | Convenience | 52 | W | Infertility clinic | Women with unclear infertility diagnosis | Serum | ELISA (IgA) | 3.8% |
| Mohammed et al (2017) | Iraq | Case-control | Convenience | 80 | W | Gynaecology clinic | Women with mixed infertility diagnosis | Endocervical NAAT | 13.8% |
| Mohammed et al (2017) | Iraq | Case-control | Convenience | 80 | W | Gynaecology clinic | Women with mixed infertility diagnosis | Serum | ELISA (IgG) | 2.5% |
| Yahya and Al-Siraj (2009) | Iraq | Cross-sectional | Convenience | 296 | M | Laboratory | Men with unclear infertility diagnosis | Serum | Culture | 4.0% |
| Abusarah et al (2013) | Jordan | Case-control | Convenience | 81 | M | Gynaecology clinic | Men with male factor infertility | Urine | NAAT | 4.9% |
| Al-Ramahi et al (2008) | Jordan | Case-control | Convenience | 66 | W | Infertility clinic | Women with idiopathic infertility | Endocervical NAAT | 3.0% |
| Al-Ramahi et al (2008) | Jordan | Case-control | Convenience | 19 | W | Infertility clinic | Women with TFI | Endocervical NAAT | 0.0% |
| Al-Ramahi et al (2008) | Jordan | Case-control | Convenience | 38 | W | Infertility clinic | Women with male factor infertility | Endocervical NAAT | 7.9% |
| Al-Ramahi et al (2008) | Jordan | Case-control | Convenience | 29 | W | Infertility clinic | Women with male factor infertility | Endocervical NAAT | 3.4% |
| Al-Sweih et al (2012) | Kuwait | Case-control | Convenience | 127 | M | Infertility clinic | Men with unclear infertility diagnosis | Semen | NAAT | 3.9% |
| Radouani et al (1998) | Morocco | Case-control | Convenience | 200 | M | Infertility clinic | Majority of men had male factor infertility | Serum | MIF (unclear) | 21.5% |
| Radouani et al (1998) | Morocco | Case-control | Convenience | 81 | W | Infertility clinic | Women with unclear infertility diagnosis | Serum | MIF (unclear) | 44.4% |

*(Table 2 continues on next page)*
| Country          | Study design          | Sampling* | Sample size | Sex | Study context          | Population characteristics         | Specimen | Assay type | Prevalence† |
|-----------------|-----------------------|-----------|-------------|-----|------------------------|------------------------------------|----------|------------|-------------|
| Al Subhi et al (2013) | Oman                 | Cross-sectional | Convenience | 51  W  | Infertility clinic      | Women with TFI                      | Endocervical | EIA       | 5.9%        |
| Al Subhi et al (2013) | Oman                 | Cross-sectional | Convenience | 167 W | Infertility clinic      | Women without TFI                   | Endocervical | EIA       | 4.8%        |
| Qayum and Khalid-bin-Saleem (2013) | Pakistan | Cross-sectional | Convenience | 80  W  | Gynaecology clinic     | Women with unclear infertility diagnosis | Urine     | Unclear   | 7.5%        |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 69  W  | Infertility clinic      | Women undergoing IVF in 2000        | Serum     | ELISA (IgM) | 11.6%       |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 268 W | Infertility clinic      | Women undergoing IVF in 2001        | Serum     | ELISA (IgM) | 23.9%       |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 316 W | Infertility clinic      | Women undergoing IVF in 2002        | Serum     | ELISA (IgM) | 33.5%       |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 399 W | Infertility clinic      | Women undergoing IVF in 2003        | Serum     | ELISA (IgM) | 9.3%        |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 586 W | Infertility clinic      | Women undergoing IVF in 2004        | Serum     | ELISA (IgM) | 4.6%        |
| Al-Hindi et al (2010) | Palestine        | Cross-sectional | Convenience | 316 W | Infertility clinic      | Women undergoing IVF in 2005        | Serum     | ELISA (IgM) | 2.8%        |
| Abdul Jabbar (1990)    | Saudi Arabia      | Cross-sectional | Convenience | 13  W  | Infertility clinic      | Women with TFI                      | Endocervical | DFA       | 53.8%       |
| Abdul Jabbar (1990)    | Saudi Arabia      | Cross-sectional | Convenience | 18  W  | Infertility clinic      | Women without TFI                   | Endocervical | DFA       | 11.1%       |
| Abdul Jabbar (1990)    | Saudi Arabia      | Cross-sectional | Convenience | 34  M  | Infertility clinic      | Men with unclear infertility diagnosis | Urethral | DFA       | 26.4%       |
| Alfarraj et al (2015)  | Saudi Arabia      | Case-control  | Convenience | 100 W | Infertility clinic      | Women with mixed infertility diagnosis | Endocervical | NAAT     | 8.0%        |
| Hossain (1988)         | Saudi Arabia      | Cross-sectional | Convenience | 41  W  | Gynaecology clinic      | Women with unclear infertility diagnosis | Serum     | MIF (IgM) | 0           |
| Hossain (1988)         | Saudi Arabia      | Cross-sectional | Convenience | 41  W  | Gynaecology clinic      | Women with unclear infertility diagnosis | Serum     | MIF (IgG) | 16.7%       |
| Kamel (2013)           | Saudi Arabia      | Randomised controlled trial | Convenience | 640 W | Gynaecology clinic      | Women with unclear infertility diagnosis | Endocervical | Culture | 12.0%       |
| Kamel (2013)           | Saudi Arabia      | Randomised controlled trial | Convenience | 640 W | Gynaecology clinic      | Women with unclear infertility diagnosis | Serum     | ELISA (IgA) | 5%          |
| Sabra and Al-Harbi (2014) | Tunisia      | Cross-sectional | Convenience | 148 M | Infertility clinic      | Men with male factor infertility    | Semen     | Giemsa stain | 8.1%        |
| Almoath et al (2005)   | Sudan             | Case-control  | Convenience | 81  W  | Infertility clinic      | More than half of women with TFI    | Serum     | EIA (IgG) | 14%         |
| Alkayer et al (2017)   | Syria             | Case-control  | Convenience | 23  W  | Hospital               | Women with mixed infertility diagnosis | Serum     | ELISA (IgG) | 17.1%       |
| Gdoura et al (2001a)   | Tunisia           | Cross-sectional | Convenience | 92  M  | Infertility clinic      | Men with unclear infertility diagnosis | Urethral | NAAT     | 18.5%       |
| Gdoura et al (2001b)   | Tunisia           | Cross-sectional | Convenience | 92  M  | Infertility clinic      | Men with unclear infertility diagnosis | Serum     | MIF (IgG) | 9.8%        |
| Gdoura et al (2001a)   | Tunisia           | Cross-sectional | Convenience | 92  M  | Infertility clinic      | Men with unclear infertility diagnosis | Urethral | DFA       | 4.3%        |
| Gdoura et al (2001a)   | Tunisia           | Cross-sectional | Convenience | 92  M  | Infertility clinic      | Men with unclear infertility diagnosis | Urethral | Culture    | 11.1%       |
| Gdoura et al (2001a)   | Tunisia           | Cross-sectional | Convenience | 92  M  | Infertility clinic      | Men with unclear infertility diagnosis | Urethral | Unclear   | 8.7%        |
| Gdoura et al (2001b)   | Tunisia           | Cross-sectional | Convenience | 92  W  | Infertility clinic      | Partners of infertile men            | Endocervical | NAAT     | 26.1%       |
| Country       | Study design | Sampling     | Sample size | Sex | Study context | Population characteristics | Specimen | Assay type | Prevalence† |
|---------------|--------------|--------------|-------------|-----|---------------|----------------------------|----------|------------|-------------|
| Tunisia       | Cross-sectional | Convenience | 92          | W   | Infertility clinic | Partners of infertile men | Serum    | MIF (IgG) | 17.4%       |
| Tunisia       | Cross-sectional | Convenience | 104         | M   | Infertility clinic | Men with male factor infertility | Urine    | NAAT       | 39.4%       |
| Tunisia       | Cross-sectional | Convenience | 85          | M   | Infertility clinic | Men with unclear infertility diagnosis | Semen    | NAAT       | 15.2%       |

**Women with miscarriage (or abortion of unknown cause)**

| Country | Study design | Sampling | Sample size | Sex | Study context | Population characteristics | Specimen | Assay type | Prevalence† |
|---------|--------------|----------|-------------|-----|---------------|----------------------------|----------|------------|-------------|
| Egypt   | Cross-sectional | Convenience | 100         | W   | Gynaecology clinic | Presenting with abortion | Endocervical Culture | 5%          |
| Iran    | Case-control  | Convenience | 109         | W   | Family planning clinic | Spontaneous abortion | Endocervical NAAT | 22.9%       |
| Iran    | Cross-sectional | Convenience | 70          | W   | Hospital | Recent or recurrent miscarriage | Vaginal NAAT | 1.4%       |
| Iran    | Case-control  | Convenience | 97          | W   | Fertility centre | Recent or recurrent miscarriage | Vaginal NAAT | 11.3%      |
| Iran    | Case-control  | Convenience | 97          | W   | Fertility centre | Recent or recurrent miscarriage | Serum ELISA (IgA) | 2.1%       |
| Iran    | Case-control  | Convenience | 97          | W   | Fertility centre | Recent or recurrent miscarriage | Serum ELISA (IgG) | 4.1%       |
| Iran    | Case-control  | Convenience | 220         | W   | Gynaecology clinic | Spontaneous abortion | Endocervical DFA | 25.5%       |
| Iran    | Cross-sectional | Convenience | 84          | W   | Hospital | Presenting with abortion | Unclear Unclear | 2.3%       |
| Iran    | Case-control  | Convenience | 125         | W   | Hospital | Recent or recurrent abortion | Endocervical DFA | 7.2%       |
| Iran    | Case-control  | Convenience | 77          | W   | Gynaecology clinic | Spontaneous abortion | Urine NAAT | 9.3%       |
| Iran    | Cross-sectional | Convenience | 124         | W   | Gynaecology clinic | Presenting with abortion | Vaginal NAAT | 15.3%      |
| Iraq    | Case-control  | Convenience | 79          | W   | Hospital | Presenting with abortion | Serum ELISA (IgG) | 6.4%       |
| Iraq    | Case-control  | Convenience | 60          | W   | Antenatal clinic | Recent or recurrent miscarriage | Serum ELISA (IgM) | 38.3%      |
| Iraq    | Case-control  | Convenience | 60          | W   | Antenatal clinic | Recent or recurrent miscarriage | Serum ELISA (IgG) | 33.3%      |
| Iraq    | Case-control  | Convenience | 60          | W   | Hospital | Recurrent miscarriage | Serum ELISA (unclear) | 0          |
| Iraq    | Case-control  | Convenience | 89          | W   | Family planning clinic | Recent or recurrent abortion | Endocervical ELFA | 12.4%      |
| Iraq    | Case-control  | Convenience | 89          | W   | Family planning clinic | Recent or recurrent abortion | Serum IFAT (unclear) | 14.6%      |
| Iraq    | Case-control  | Convenience | 123         | W   | Hospital | Spontaneous abortion | Serum ELISA (IgG) | 17.1%      |
| Iraq    | Cross-sectional | Convenience | 120         | W   | Hospital | Recent or recurrent abortion | Endocervical NAAT | 17.5%      |
| Iraq    | Case-control  | Convenience | 120         | W   | Hospital | Recent or recurrent abortion | Serum ELISA (IgG) | 14.2%      |
| Iraq    | Case-control  | Convenience | 62          | W   | Gynaecology clinic | Three or more miscarriages | Serum ELISA (IgM) | 16.1%      |
| Iraq    | Case-control  | Convenience | 34          | W   | Gynaecology clinic | Less than three miscarriages | Serum ELISA (IgM) | 29.4%      |
| Iraq    | Cross-sectional | Convenience | 184         | W   | Gynaecology clinic | Presenting with abortion | Serum ELISA (IgG) | 21.2%      |
| Iraq    | Cross-sectional | Convenience | 184         | W   | Gynaecology clinic | Presenting with abortion | Serum ELISA (IgG) | 8.2%       |
| Saudi Arabia | Cross-sectional | Convenience | 12          | W   | Hospital | Recurrent miscarriage | Endocervical Culture | 16.7%      |

(Continued from previous page)

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High prevalence was observed in infertility clinic attendees, for both women and men (n=135), in which current infection prevalence ranged from 0 to 65·3% with a median of 9·2%, whereas ever infection prevalence ranged from 0 to 85·2% with a median of 18·6% (tables 2 and 3). Similarly, high prevalence was observed in women with miscarriage (n=27), in which current infection prevalence ranged from 1·4% to 25·5% with a median of 14·2%, whereas ever infection prevalence ranged from 0·1% to 33·3% with a median of 14·2% (tables 2 and 3).

Table 3 summarises the prevalence for other at-risk populations, and table 2 and the appendix (pp 9–14) include the full data.

The summarised and study-specific risk of bias and precision assessments are shown in the appendix (pp 15–27). Briefly, 166 (30·1%) of 552 prevalence measures were based on samples including 200 participants or more, and were classified as having higher precision. Although convenience sampling was the most common sampling methodology (495 [89·7%] of 552), probability-based sampling methods, such as respondent-driven sampling, are of increasing use for populations at high risk of bias in two or more quality domains. Response rate was, however, unclear for 417 (75·5%) of 552 studies. Prevalence studies were overall of reasonable quality; only eight (1·4%) of 552 had high risk of bias in two or more quality domains.

Table 3 shows the meta-analyses’ results for the pooled average C trachomatis prevalence for each at-risk population, stratified by type of assay used for infection ascertainment. Current infection prevalence was estimated at 3·0% (95% CI 2·3–3·8) in general populations, 2·8% (1·0–5·2) in populations at intermediate risk, 13·2% (7·2–20·7) in female sex workers, 1·2% (0·2–2·8) for genital infections and 7·7% (4·2–12·0) for rectal infections in men who have sex with men, 11·3% (9·0–13·7) in infertility clinic attendees, 12·4% (7·9–17·7) in women with miscarriage, 12·4% (9·4–15·7) in symptomatic women, and 17·4% (12·5–22·8) in symptomatic men.

Meanwhile, pooled average prevalence of ever infection was estimated at 6·9% (4·3–10·0) in general populations, 1·4% (0·8–2·4) in populations at intermediate risk, 80·9% (43·8–100) in female sex workers, 21·5% (16·3–27·2) in infertility clinic attendees, 12·4% (6·6–19·5) in women with miscarriage, 37·1% (22·4–53·0) in women with ectopic pregnancy, 22·7% (15·4–31·0) in symptomatic women, and 16·9% (9·4–25·8) in symptomatic men (table 3).

Evidence for heterogeneity in C trachomatis prevalence estimates was observed; p values for Cochran’s Q statistic was <0·0001 in most meta-analyses (table 3). Prediction intervals were generally wide affirming high heterogeneity. P was also mostly more than 70%, indicating that most variability is due to true differences in effect size across studies rather than chance.

Figures 2 and 3 and the appendix (pp 28–40) summarise the results of subgroup meta-analyses in various sub-populations. These data show the results stratified by sex or by genital versus rectal infection (the latter only for men who have sex with men), for studies reporting current infection prevalence based on NAAT and those reporting ever infection prevalence, as well as by assay type for studies reporting current infection prevalence. Subgroup meta-analyses in infertile populations stratified by infertility diagnosis and by assay type are shown in the appendix (pp 41–42).
Table 4 summarises results of the meta-regression analyses. In the univariable analyses, at-risk population, assay type, sampling methodology, sample size, year of publication, year of data collection, country, response rate, and sex were associated with prevalence at p≤0·2. Alignment with meta-regression underlying assumption

| Studies (n) | Samples | C trachomatis positive (median [range]) | Pooled average C trachomatis prevalence (estimate [95% CI]) | Heterogeneity measures |
|------------|---------|----------------------------------------|------------------------------------------------------------|------------------------|
|            | Tested  | C trachomatis positive                  | Q (p value)* | I² (95% CI) | Prediction interval‡ |
| General populations |         |                                      |               |              |                      |
| Current genital infection |         |                                      |               |              |                      |
| NAAT | 48 | 25 397 | 748 | 2.9% (0-15.5) | 3.1 (2.2-4.2) | 714.3 (p=0.0001) | 91.4% (89.4-93.0) | 0.0-12.4 |
| Culture | 4 | 4464 | 55 | 5.8% (1.0-15.0) | 4.3 (0.3-11.4) | 22.5 (p=0.0001) | 86.6% (67.7-94.5) | 0.0-50.9 |
| Other§ | 23 | 128 013 | 328 | 3.5% (0-19.9) | 2.4 (1.6-3.4) | 722.3 (p=0.0001) | 97.0% (95.2-97.5) | 0.0-7.2 |
| Overall current genital infection | 75 | 157 874 | 1131 | 3.0% (0-19.9) | 3.0 (2.3-3.8) | 2703.5 (p=0.0001) | 97.3% (96.9-97.6) | 0.0-10.9 |
| Anti-C trachomatis immunoglobulins |         |                                      |               |              |                      |
| IgG (ever infection) | 35 | 5877 | 525 | 4.7% (0-37.9) | 6.9 (4.3-10.0) | 226.1 (p=0.0001) | 86.7% (82.2-90.1) | 0.0-30.2 |
| IgM (recent infection) | 13 | 2843 | 74 | 1.6% (0-14.0) | 1.8 (0.3-3.9) | 77.7 (p=0.0001) | 84.6% (75.1-90.4) | 0.0-12.4 |
| IgA | 4 | 377 | 12 | 4.3% (0-40.4) | 6.2 (0-21.6) | 37.8 (p=0.0003) | 92.1% (82.9-96.3) | 0.0-93.7 |
| Not specified (IgG, IgM, or IgA) | 9 | 1081 | 61 | 4.5% (0-14.8) | 4.3 (1.9-7.4) | 34.5 (p=0.0001) | 76.8% (55.7-87.8) | 0.0-17.3 |
| Unclear | 1 | 250 | 8 | 3.2 (1.4-6.2) | -- | -- | -- | -- |
| Populations at intermediate risk |         |                                      |               |              |                      |
| Current genital infection |         |                                      |               |              |                      |
| NAAT | 12 | 2815 | 69 | 1.5% (0-38.0) | 2.6 (0.8-5.2) | 117.4 (p=0.0001) | 75.6% (56.0-86.5) | 0.0-16.1 |
| Culture | -- | -- | -- | -- | -- | -- | -- | -- |
| Other§ | 1 | 308 | 15 | -- | 4.9 (2.8-7.9) | -- | -- | -- |
| Overall current genital infection | 13 | 3123 | 84 | 2.0% (0-38.0) | 2.8 (1.0-5.2) | 127.0 (p=0.0001) | 90.6% (85.7-93.8) | 0.0-15.8 |
| Anti-C trachomatis immunoglobulins |         |                                      |               |              |                      |
| IgG (ever infection) | 1 | 1041 | 15 | -- | 1.4 (0-8.2.4) | -- | -- | -- |
| IgM (recent infection) | -- | -- | -- | -- | -- | -- | -- | -- |
| IgA | -- | -- | -- | -- | -- | -- | -- | -- |
| Not specified (IgG, IgM, or IgA) | -- | -- | -- | -- | -- | -- | -- | -- |
| Unclear | -- | -- | -- | -- | -- | -- | -- | -- |
| Populations at high risk |         |                                      |               |              |                      |
| Female sex workers |         |                                      |               |              |                      |
| Current genital infection |         |                                      |               |              |                      |
| NAAT | 12 | 4877 | 590 | 8.4% (0-97.9) | 12.9 (6.5-21.0) | 602.1 (p=0.0001) | 98.2% (97.6-98.6) | 0.0-52.0 |
| Culture | 1 | 116 | 8 | -- | 6.9 (3.0-13.1) | -- | -- | -- |
| Other§ | 1 | 30 | 9 | -- | 30.0 (14.7-49.4) | -- | -- | -- |
| Overall current genital infection | 14 | 5023 | 607 | 8.4% (0-97.9) | 13.2 (7.2-20.7) | 611.7 (p=0.0001) | 97.9% (97.3-98.3) | 0.0-50.9 |
| Anti-C trachomatis immunoglobulins |         |                                      |               |              |                      |
| IgG (ever infection) | 4 | 472 | 364 | 90.0% (19.8-100) | 80.9 (43.8-100.0) | 209.9 (p=0.0001) | 98.6% (97.7-99.1) | 0.0-100.0 |
| IgM (recent infection) | 1 | 154 | 45 | -- | 29.2 (22.2-37.1) | -- | -- | -- |
| IgA | -- | -- | -- | -- | -- | -- | -- | -- |
| Not specified (IgG, IgM, or IgA) | 1 | 30 | 11 | -- | 36.7 (19.9-56.1) | -- | -- | -- |
| Unclear | -- | -- | -- | -- | -- | -- | -- | -- |
| Men who have sex with men |         |                                      |               |              |                      |
| Current genital infection |         |                                      |               |              |                      |
| NAAT | 12 | 2680 | 51 | 12.8% (0-8.8) | 1.2 (0.2-2.8) | 76.2 (p=0.0001) | 85.6% (76.5-91.1) | 0.0-9.5 |
| Culture | -- | -- | -- | -- | -- | -- | -- | -- |
| Other§ | -- | -- | -- | -- | -- | -- | -- | -- |
| Current rectal infection |         |                                      |               |              |                      |
| PCR | 7 | 1506 | 129 | 6.3% (3.6-18.3) | 7.7 (4.2-12.0) | 40.6 (p=0.0001) | 85.2% (71.5-92.3) | 0.0-24.9 |
| Overall current infection | 19 | 4186 | 180 | 3.6% (0-18.3) | 3.0 (1.2-5.4) | 231.8 (p=0.0001) | 92.2% (89.3-94.4) | 0.0-17.9 |

(Table 3 continues on next page)
| Studies (n) | Samples | C. trachomatis prevalence (median [range]) | Pooled average C. trachomatis prevalence (estimate [95% CI]) | Heterogeneity measures |
|------------|---------|------------------------------------------|-------------------------------------------------|---------------------|
|            | Tested  | Tested C. trachomatis positive             | Q (p value)*                                    | I² (95% CI) Prediction interval‡ |
| (Continued from previous page) |
| Anti-C. trachomatis immunoglobulins |
| IgG (ever infection) | - | - | - | - | - | - | - |
| IgM (recent infection) | - | - | - | - | - | - | - |
| IgA | - | - | - | - | - | - | - |
| Not specified (IgG, IgM, or IgA) | - | - | - | - | - | - | - |
| Unclear | 1 | 2531 | 890 | - | 35.2 (33.3–37.1) | - | - |
| Infertility clinic attendees |
| Current genital infection |
| NAAT | 37 | 4653 | 539 | 8.0% (0–39.4) | 10.2 (7.5–13.1) | 310.9 (p<0.0001) | 88.4% (85.0–91.0) | 0.1–31.0 |
| Culture | 7 | 1149 | 176 | 9.5% (1.1–65.3) | 14.4 (4.8–27.7) | 140.8 (p<0.0001) | 95.7% (93.3–97.3) | 0.0–69.2 |
| Other§ | 20 | 1844 | 203 | 10.2% (3.0–53.8) | 12.3 (8.5–16.5) | 112.8 (p<0.0001) | 83.2% (75.1–88.6) | 0.5–33.7 |
| Overall current genital infection | 64 | 7646 | 918 | 9.2% (0–65.3) | 11.3 (9.0–13.7) | 574.9 (p<0.0001) | 89.0% (86.7–90.9) | 0.2–33.3 |
| Anti-C. trachomatis immunoglobulins |
| IgG (ever infection) | 37 | 3608 | 689 | 18.6% (0–85.2) | 21.5 (16.3–27.2) | 531.8 (p<0.0001) | 93.2% (91.6–94.6) | 0.2–59.7 |
| IgM (recent infection) | 17 | 3145 | 332 | 4.6% (0–86.7) | 10.2 (5.0–16.8) | 435.4 (p<0.0001) | 96.3% (95.2–97.2) | 0.0–47.0 |
| IgA | 6 | 2302 | 82 | 3.6% (0–5.0) | 1.8 (0.1–4.7) | 54.4 (p<0.0001) | 90.8% (82.8–95.1) | 0.0–16.4 |
| Not specified (IgG, IgM, or IgA) | 5 | 760 | 211 | 23.2% (11.1–44.4) | 26.1 (17.9–35.3) | 27.5 (p<0.0001) | 85.4% (67.8–93.4) | 2.6–61.8 |
| Unclear | 6 | 430 | 73 | 14.8% (3.3–33.0) | 14.9 (7.0–24.8) | 30.0 (p<0.0001) | 83.3% (65.1–92.0) | 0.0–53.3 |
| Women with miscarriage |
| Current genital infection |
| NAAT | 6 | 597 | 87 | 13.3% (1.4–22.9) | 12.9 (7.4–19.5) | 24.4 (p<0.0002) | 79.5% (55.3–90.6) | 0.1–38.9 |
| Culture | 2 | 112 | 7 | 10.9% (5.0–16.7) | 7.1 (0.0–21.8) | 2.1 (p<0.1483) | 52.1% (0.0–88.0) | - |
| Other§ | 3 | 434 | 76 | 12.4% (7.2–25.5) | 14.4 (4.9–27.6) | 21.9 (p<0.0001) | 90.8% (76.1–96.5) | 0.0–100.0 |
| Overall current genital infection | 11 | 1143 | 170 | 12.4% (1.4–25.5) | 12.4 (7.9–17.7) | 58.0 (p<0.0001) | 82.8% (70.5–89.9) | 0.6–34.3 |
| Anti-C. trachomatis immunoglobulins |
| IgG (ever infection) | 7 | 675 | 84 | 14.2% (4.1–33.3) | 12.4 (6.6–19.5) | 33.5 (p<0.0001) | 82.1% (64.2–91.0) | 0.0–39.6 |
| IgM (recent infection) | 5 | 352 | 82 | 21.2% (0–38.3) | 21.2 (11.9–32.2) | 16.2 (p<0.0028) | 75.3% (39.1–89.9) | 0.0–61.8 |
| IgA | 1 | 97 | 2 | - | 2.1 (0.3–7.3) | - | - |
| Not specified (IgG, IgM, or IgA) | 2 | 149 | 13 | 7.3% (0–14.6) | 4.7 (0.0–27.9) | 16.1 (p<0.0001) | 93.8% (80.0–98.1) | - |
| Unclear | 1 | 84 | 2 | - | 2.3 (0.3–8.3) | - | - |
| Women with ectopic pregnancy |
| Current genital infection |
| NAAT | 2 | 54 | 20 | 37.5% (30.0–45.0) | 37.1 (22.4–53.0) | 1.4 (p=0.2418) | 27.0% | - |
| Culture | 1 | 24 | 1 | - | 4.2 (0.1–21.1) | - | - |
| Other§ | - | - | - | - | - | - | - |
| Overall current genital infection | - | - | - | - | - | - | - |
| Anti-C. trachomatis immunoglobulins |
| IgG (ever infection) | 2 | 54 | 20 | - | 37.1 (22.4–53.0) | 1.4 (p=0.2418) | 27.0% | - |
| IgM (recent infection) | 1 | 24 | 1 | - | 4.2 (0.1–21.1) | - | - |
| IgA | - | - | - | - | - | - | - |
| Not specified (IgG, IgM, or IgA) | - | - | - | - | - | - | - |
| Unclear | - | - | - | - | - | - | - |
| Symptomatic women |
| Current genital infection |
| NAAT | 49 | 14398 | 1123 | 8.0% (0–68.0) | 8.8 (6.2–11.7) | 1506.7 (p<0.0001) | 96.8% (95.0–97.3) | 0.0–54.4 |
| Culture | 10 | 2951 | 752 | 12.9% (0.7–69.4) | 18.4 (4.1–40.9) | 1511.0 (p<0.0001) | 99.4% (99.3–99.5) | 0.0–97.2 |
| Other§ | 31 | 4796 | 729 | 14.7% (0–89.3) | 16.8 (11.6–22.7) | 723.8 (p<0.0001) | 95.9% (94.9–96.6) | 0.0–54.4 |

*(Table 3 continues on next page)*
of normal random effects was confirmed through normal probability plots (appendix p 43). Graphical illustrations of the fitted regression line for year of publication and year of data collection are shown in the appendix (p 44). Only at-risk population, assay type, sample size, country, and sex remained associated with Chlamydia trachomatis prevalence in a multivariable model. No evidence was found for a temporal variation in prevalence (p=0.281 for year of publication), for sampling methodology (p=0.347), or for response rate (p=0.237). This model explained 29.0% of prevalence variation.

Relative to general populations, the adjusted odds ratio (aOR) was 11·28 (95% CI 5·78–22·01) for women with ectopic pregnancy, 4·93 (1·03–23·52) for women with ectopic pregnancy, 4·16 (1·72–10·08) for men who have sex with men, 3·39 (2·47–4·87) for symptomatic women, and 1·39 (1·00–1·94) for populations at intermediate risk. Other factors associated with Chlamydia trachomatis prevalence were women versus men (aOR 1·61, 95% CI 1·05–2·46), Pakistan versus other Middle East or North African countries (0·39, 0·22–0·69), ever infection (anti-Chlamydia trachomatis IgG; 2·17, 1·54–3·06) and current infection prevalence using assays other than NAAT or culture versus NAAT (1·47, 1·02–2·13), and studies with higher (≥200 participants) versus lower precision (0·63, 0·48–0·83).

**Discussion**

We provided a comprehensive assessment of Chlamydia trachomatis epidemiology in the Middle East and north Africa. Unexpectedly, given this region’s sexually conservative norms and low observed levels of several viral STIs, C. trachomatis current infection prevalence was 3% in the population at large, similar to WHO prevalence estimates for the Western Pacific region (about 4%) and European region (about 3%), where broad C. trachomatis control programmes, including opportunistic testing, are standard in some high-income countries, but higher than that for South-east Asia region (about 1·5%) and lower than that for the African region (about 5%) and the region of the Americas (about 5·5%). This high prevalence suggests substantial infection and disease burden that needs to be tackled through sexual health and STI-specific programmes, for both women and men. Although these findings were based on a volume of epidemiological evidence, most studies used convenience for this region of about 3% in 2012 and about 3·5% in 2016. The prevalence was also in line with WHO estimates for the Western Pacific region (about 4%) and European region (about 3%), where broad C. trachomatis control programmes, including opportunistic testing, are standard in some high-income countries, but higher than that for South-east Asia region (about 1·5%) and lower than that for the African region (about 5%) and the region of the Americas (about 5·5%). This high prevalence suggests substantial infection and disease burden that needs to be tackled through sexual health and STI-specific programmes, for both women and men.
sampling (about 90%) or had unclear response rate (>75%). Meta-regression, however, did not identify an effect for these factors on observed prevalence. A summary of this study and its results in Arabic language can be found in the appendix (p 4).

Although infection prevalence in the population at large suggests active transmission networks for \textit{C} trachomatis and other STIs, it might not necessarily reflect prevalent sexual risk behaviours. This outcome might reflect, at least in part, poor access to and utilisation of STI services—there is very limited capacity in the Middle East and north Africa for STI prevention and treatment, not to mention \textit{C} trachomatis screening and broader sexual health programmes. As observed elsewhere, such as in Alaskan Eskimo populations and populations in South Pacific Islands, poor \textit{C} trachomatis diagnosis and specific treatment can result in unusually high prevalence, probably because \textit{C} trachomatis is largely asymptomatic, and if untreated, shedding can persist even for years, thereby increasing the potential for reinfection within couples and for transmission in the population.

The high prevalence found in populations at high risk such as female sex workers, in context of evidence suggesting strong partial immunity against reinfection, is consistent with the important role of commercial sex networks in infection transmission. Independent evidence supports existence of hidden pockets of high sexual-risk behaviour driving STI incidence in the Middle East and north Africa. Among male STI patients, 77% in Kuwait and 80% in Somalia reported paying a female sex worker for sex, and among migrant workers in Pakistan 22% reported sex with a female sex worker. Higher levels of sexual-risk behaviour and emerging HIV epidemics have been also documented among men who have sex with men, male sex workers, and male-to-female transgenders in systematic reviews. Sexual networks, however, remain poorly investigated in the Middle East and north Africa, owing to cultural sensitivities.

The possible role of \textit{C} trachomatis infection in poor reproductive health outcomes remains unappreciated and neglected by the public health establishment in the Middle East and north Africa, despite substantial social and economic implications for women and their families. A main finding of this study is the high current \textit{C} trachomatis infection prevalence in infertility clinic attendees, with odds of infection three-times higher than in the general population. By contrast, studies among infertility clinic attendees in Europe usually show that current \textit{C} trachomatis infection is uncommon, but serological evidence of past infection, assumed to have resulted in fallopian tube scarring, is common. This finding suggests a role for \textit{C} trachomatis in infertility in the Middle East and north Africa. Indeed, this region appears to have the highest rate of primary infertility worldwide, which remains unexplained. The Middle East and north Africa is also a region where infertility has multiple detrimental sociocultural consequences, and where several countries have had rapidly declining fertility rates to even below replacement level. The prevalence of current \textit{C} trachomatis infection was also high in women.
with miscarriage and in pregnant women—similar to that found in pregnant women in low-income and middle-income countries elsewhere.220–222 This stigmatised and largely asymptomatic infection might not be visible to the public eye, but its reproductive health sequelae are visible, even if not explicitly linked to the underlying cause.

**C trachomatis** prevalence in women was higher than in men (two-times higher odds). This difference possibly reflects a longer duration of infection in women, considering that infection in men is more symptomatic (nearly two-times higher prevalence in symptomatic men than in symptomatic women), and therefore more likely to be treated. Ever infection (anti-C trachomatis IgG) prevalence was two-times higher than current infection prevalence, but the epidemiological relevance of ever infection prevalence might be limited given challenges in **C trachomatis** serology interpretation.219

The Middle East and north Africa is burdened by **C trachomatis** infection, but the public health response remains rudimentary and far from achieving WHO’s Global Health Sector Strategy on STIs.8 Evidence for some differences in **C trachomatis** prevalence by country has been reported, but remarkably, no evidence was found for a variation in prevalence over time (1982–2018). Lingering STI stigma prevents those infected from accessing proper health care, including those most at risk. The role of screening and treatment for asymptomatic **C trachomatis** within established programmes, such as for family planning, primary health care, or HIV, needs careful consideration given the cost and uncertain effect on prevalence at modest levels of uptake.223

Current STI surveillance focused on inefficient routine case reporting is not capturing the reality of the transmission dynamics.221 Although routine case reporting could be improved with more consistency and universality in reporting and emphasis on aetiological approaches,221 its usefulness for a robust long-term evaluation of infection trends is rather limited. Sentinel surveillance of different at-risk populations should be explored, as recommended by the WHO Global Health Sector Strategy on STIs,4 to better identify outbreaks or emerging epidemics, strategically direct resources for prevention, treatment, and control, and monitor and evaluate STI programmes.224 The recent progress in HIV surveillance in the Middle East and north Africa, in the form of repeated rounds of HIV-integrated biobehavioural surveillance surveys,222,223 should be extended to STIs.224,225

Our study has important but unavoidable limitations. Quantity and quality of available data varied by country and population, particularly for populations at high risk where most data came from only a few countries—eg, most studies of men who have sex with men were from the Middle East and north Africa.225,226 The wide array of diagnostics used for ascertainment might have also introduced detection bias. Factors that might have contributed to differences in **C trachomatis** positivity rates across studies include sampling variation and potential selection bias, spatial or temporal variability in prevalence, and possibly unreported underlying comorbidities. This study did not assess other STIs that might have also contributed to infertility, pregnancy-related morbidity, and other health conditions in women with **C trachomatis** infection. Such

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### Table

| Study                                      | Positive (n/N) | Prevalence (%CI) | Weight (%) |
|--------------------------------------------|----------------|-----------------|------------|
| **Men**                                    |                |                 |            |
| Shakhaki and Amini (2018)                  | 3/60           | 5.0 (3.0–13.9)  | 2.6        |
| Ali and Al-Karaz (2018)                    | 11/93          | 17.5 (9.1–29.1) | 2.6        |
| Abusarar et al (2013)                      | 4/81           | 4.9 (1.4–12.2)  | 2.7        |
| Sellami et al (2014)                       | 13/85          | 15.3 (8.4–24.7) | 2.7        |
| Gouda et al (2001a)                       | 17/92          | 18.5 (11.3–27.9) | 2.8      |
| Ministry of Health and Medical Education (2008) | 9/100        | 9.0 (4.2–16.4)  | 2.8        |
| **Total**                                  | 269/2527       | 10.4 (6.6–14.9) | 36.9       |

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**Figure 3:** Meta-analysis of studies reporting **Chlamydia trachomatis** current infection prevalence assessed using nucleic acid amplification test in infertility clinic attendees in the Middle East and north Africa

Data are stratified by sex. Error bars are 95% CI.
potential biases might have contributed to some of the unexplained heterogeneity observed in the prevalence levels. Given potential limitations in the representativeness of the prevalence measures as well as heterogeneity across studies, the calculated pooled prevalence should be interpreted as a pooled average, rather than strictly

| Studies (n) | Samples (n) | Univariable analyses | Variance explained R² | Multivariable analysis |
|------------|-------------|----------------------|-----------------------|-----------------------|
|            |             | OR (95% CI)          | p value               | LR test p value       |
|            |             | Adjusted OR (95% CI) | p value               | LR test p value       |
| Population |             |                      |                       |                       |
| General    | 137         | 168,302              | 1.00 (ref)            | <0.0001               | 19.0%               |
|            |             | -                     | -                     | -                     | 1.00 (ref)           | -                     | <0.0001               |
| Populations at intermediate risk | 14 | 4154 | 0.70 (0.32-1.54) | 0.374 | - | - | 1.81 (0.79-4.33) | 0.157 |
| Female sex workers | 20 | 5679 | 8.99 (4.57-17.71) | <0.0001 | - | - | 11.28 (5.78-22.01) | <0.0001 |
| Men who have sex with men | 20 | 6717 | 0.83 (0.42-1.64) | 0.591 | - | - | 4.16 (1.72-10.08) | 0.002 |
| Infertility clinic attendees | 135 | 17,891 | 3.77 (2.67-5.31) | <0.0001 | - | - | 3.39 (2.41-4.77) | <0.0001 |
| Women with miscarriage | 27 | 2500 | 3.53 (1.94-6.40) | <0.0001 | - | - | 2.78 (1.57-4.93) | 0.001 |
| Women with ectopic pregnancy | 3 | 78 | 8.25 (1.58-43.08) | 0.012 | - | - | 4.93 (1.03-23.52) | 0.045 |
| Symptomatic women | 140 | 29,402 | 3.74 (2.66-5.26) | <0.0001 | - | - | 3.47 (2.47-4.87) | <0.0001 |
| Symptomatic men | 56 | 22,036 | 5.76 (3.68-9.03) | <0.0001 | - | - | 7.17 (4.05-12.68) | <0.0001 |
| Assay type |             |                      |                       |                       |
| NAAT (current infection) | 197 | 64,083 | 1.00 (ref) | - | <0.0001 | 7.1% | 1.00 (ref) | - | <0.0001 |
| Culture (current infection) | 29 | 13,536 | 1.92 (1.05-3.50) | 0.034 | - | - | 1.10 (0.62-1.95) | 0.742 |
| Other (current infection) | 92 | 137,924 | 1.90 (1.30-2.79) | <0.0001 | - | - | 1.47 (1.02-2.13) | 0.041 |
| Anti-Chlamydia trachomatis immunoglobulins |             |                      |                       |                       |
| IgG (ever infection) | 117 | 14,935 | 2.99 (2.10-4.26) | <0.0001 | - | - | 2.17 (1.54-3.06) | <0.0001 |
| IgM (recent infection) | 49 | 7890 | 1.17 (1.72-9.19) | 0.517 | - | - | 0.90 (0.57-1.40) | 0.627 |
| IgA | 16 | 3141 | 0.92 (0.42-2.02) | 0.386 | - | - | 0.78 (0.39-1.56) | 0.481 |
| Not specified (IgG, IgM, or IgA) | 29 | 6146 | 2.81 (2.66-5.26) | <0.0001 | - | - | 2.25 (1.54-3.06) | <0.0001 |
| Unclear | 23 | 9114 | 2.53 (1.80-4.94) | <0.0001 | - | - | 1.49 (0.81-2.75) | 0.200 |
| Sampling methodology |             |                      |                       |                       |
| Non-probability-based sampling | 495 | 227,208 | 1.00 (ref) | - | <0.0001 | 3.5% | 1.00 (ref) | - | 0.347 |
| Probability-based sampling | 57 | 29,561 | 0.37 (0.24-0.56) | <0.0001 | - | - | 0.80 (0.50-1.27) | 0.347 |
| Sample size |             |                      |                       |                       |
| <200 | 386 | 37,282 | 1.00 (ref) | - | <0.0001 | 6.0% | 1.00 (ref) | - | 0.001 |
| ≥200 | 166 | 223,987 | 0.42 (0.32-0.56) | <0.0001 | - | - | 0.63 (0.48-0.83) | 0.001 |
| Response rate |             |                      |                       |                       |
| ≥80% | 112 | 38,732 | 1.00 (ref) | - | 0.187 | 0.1% | 1.00 (ref) | - | 0.237 |
| <80% or unclear | 440 | 218,037 | 0.80 (0.57-1.12) | 0.187 | - | - | 0.83 (0.61-1.13) | 0.237 |
| Year of publication |             |                      |                       |                       |
| 2009 or earlier | 552 | 256,769 | 0.96 (0.95-0.98) | <0.0001 | <0.0001 | 4.4% | 0.99 (0.98-1.01) | 0.281 |
| Year of data collection | 552 | 256,769 | 0.96 (0.95-0.98) | <0.0001 | <0.0001 | 4.2% | - | - |
| Country |             |                      |                       |                       |
| Other Middle East or north African countries | 245 | 189,529 | 1.00 (ref) | - | <0.0001 | 5.2% | 1.00 (ref) | - | 0.013 |
| Egypt | 89 | 7434 | 1.58 (1.08-2.31) | 0.018 | - | - | 1.05 (0.73-1.51) | 0.774 |
| Iran | 176 | 38,647 | 0.80 (0.59-1.08) | 0.145 | - | - | 0.90 (0.68-1.19) | 0.472 |
| Pakistan | 42 | 21,159 | 0.31 (0.19-0.52) | <0.0001 | - | - | 0.39 (0.22-0.69) | 0.002 |
| Sex |             |                      |                       |                       |
| Men | 133 | 42,393 | 1.00 (ref) | - | 0.131 | 0.2% | 1.00 (ref) | - | 0.029 |
| Women | 419 | 214,376 | 1.27 (0.93-1.74) | 0.131 | - | - | 1.61 (1.05-2.46) | 0.029 |

Adjusted R² in the final multivariable model was 29.0%. LR=likelihood ratio. NAAT=nucleic acid amplification test. OR=Odds ratio. *Predictors with p≤0.2 in the univariable model were considered significant. †Predictors with p≤0.05 in the multivariable model were considered significant. ‡Other assays detecting current infection such as direct fluorescence assays, Giemsa staining, and enzyme-linked immunoassays applied to genital samples. §Includes assays such as enzyme-linked immunosassay and micro-immunofluorescence. ¶Non-probability sampling refers to a sampling method in which the data collection process does not allow individuals to have equal chance of being selected; an example is convenience sampling for which individuals are selected on the basis of ease of accessibility (first-come first-served basis).127,128 Probability-based sampling refers to a sampling method in which data collection process is based on a random selection of study participants; an example is random sampling from a sampling frame.128 Another example of probability-based sampling is respondent-driven sampling, which is a sampling method specifically designed to sample hard-to-reach populations and is based on chain referral with the probability of selection calculated at each step in the network to produce adjusted prevalence estimates.129 Only year of publication was considered for the multivariable meta-regression analysis because of collinearity with year of data collection.

Table 4: Results of meta-regressions to identify associations and sources of between-study heterogeneity for Chlamydia trachomatis prevalence in the Middle East and north Africa
an estimate of the mean prevalence in the considered population or subpopulation.

In conclusion, *C. trachomatis* current infection prevalence in the population at large in the Middle East and north Africa is at 3%, similar to other regions, but higher than expected given these countries’ sexually conservative norms. The high prevalence (>10%) in infertility clinic attendees and in women with miscarriage, provides suggestive evidence for the potential role of *C. trachomatis* in poor reproductive outcomes in the Middle East and north Africa. In the context of very limited programming for sexual health and STIs, our findings highlight an important, yet neglected and poorly recognised infection and disease burden, despite the social and economic impact. There is an urgent need for targeted and culturally appropriate programmes promoting sexual health for different at-risk populations. Tackling this infection with appropriate interventions is essential to control disease sequelae, to address the WHO Global Health Strategy on STIs, and to accomplish key health Sustainable Development Goals.

**Contributors**

AS contributed to the study design, did the systematic searches of the literature, selection of studies for inclusion, and the data extraction and data analyses. HC contributed to the study design, double extracted the data, updated the systematic review, and did the data analyses. AS and HC wrote the first draft of the paper. JGH contributed to identification of unpublished data. NL contributed to the data extraction, analyses, and drafting of the Article. LJA-R conceived and led the design of the study, data extraction, data analyses, and drafting of the Article. All authors contributed to discussion and interpretation of the results and to the writing of the manuscript. All authors have read and approved the final manuscript.

**Declaration of interests**

We declare no competing interests.

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