Biological Determinants of Infertility in Sub-Saharan Africa: A Systematic Review and Meta-Analysis of Age, Body Mass Index and Sexually Transmitted Infections

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ABSTRACT

Background: Infertility affects about one in six people worldwide and carries heavy social and economic consequences in sub-Saharan Africa, where childbearing is central to social identity and fertility care is scarce. Female age, body mass index (BMI) and sexually transmitted infections (STIs) are biologically plausible determinants, but evidence from the region is fragmented across small facility studies and national surveys that use different definitions. This review aimed to estimate the pooled association of these three biological factors with infertility among women in sub-Saharan Africa.

Methods: A systematic review and meta-analysis was conducted following the PRISMA 2020 statement. Searches were run through a web search engine indexing PubMed/PubMed Central, African Journals Online, the Directory of Open Access Journals, the DHS Program publications database and publisher platforms for observational studies published between January 2020 and October 2026 that reported adjusted odds ratios (AORs) for the association of age, BMI or STI history with infertility. Risk of bias was appraised with an adapted Newcastle–Ottawa Scale. AORs were pooled on the log scale using DerSimonian–Laird random-effects models, with Hartung–Knapp–Sidik–Jonkman (HKSJ) intervals as a small-sample check. Heterogeneity was assessed with Cochran's Q, I^2, τ^2 and prediction intervals; robustness with subgroup, leave-one-out and overlap-exclusion analyses; and small-study effects with funnel plots and the Egger and Begg tests. Certainty of evidence was rated using GRADE.

Results: Eight studies from Ethiopia, Nigeria, Somalia, Uganda and a ten-country East African survey analysis, comprising 63,223 women, were included. Advanced female age was associated with almost three-fold higher odds of infertility (pooled AOR = 2.94; 95% CI 1.87–4.60; k = 6; I^2 = 82.6%), and a history of STI with more than three-fold higher odds (AOR = 3.45; 95% CI 2.34–5.08; k = 4; I^2 = 0%). Underweight women had higher odds of infertility than women of normal weight (AOR = 1.72; 95% CI 1.55–1.91; k = 3; I^2 = 0%), whereas pooled associations for overweight (AOR = 1.44; 95% CI 0.77–2.70) and obesity (AOR = 1.12; 95% CI 0.73–1.70) were not statistically significant and were highly heterogeneous. The age and STI associations were robust in all sensitivity analyses, and there was no evidence of small-study effects. Certainty of evidence was low for age, STI history and underweight, and very low for overweight and obesity.

Conclusion: Advanced age, a history of STI and underweight are consistent biological determinants of infertility among women in sub-Saharan Africa, while the role of excess weight remains uncertain. Infertility prevention in the region should prioritise early detection and treatment of STIs, nutritional support and

counselling on age-related fertility decline, and national surveys such as the Uganda Demographic and Health Survey should be exploited further to clarify the role of BMI.

Keywords: Infertility; female age; body mass index; sexually transmitted infections; meta-analysis; sub-Saharan Africa; Uganda

INTRODUCTION

Infertility, defined by the World Health Organization as a disease of the reproductive system characterised by the failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse, is a major and growing global health problem. The World Health Organization's 2023 report estimated a lifetime prevalence of 17.5%, meaning that roughly one adult in six experiences infertility at some point, with similar prevalence in high-income (17.8%) and low- and middle-income countries (16.5%) (World Health Organization [WHO], 2023). The underlying systematic review reported a pooled lifetime prevalence of 17.5% and a 12-month period prevalence of 12.6% (Cox et al., 2022). Analyses of the Global Burden of Disease study show that the number of women living with infertility rose by more than 84% between 1990 and 2021, to about 110 million, with the highest burden among women aged 35–39 years (Liu et al., 2025).

In sub-Saharan Africa, the consequences of infertility are particularly severe. Childbearing is closely tied to marriage, social standing, inheritance and security in old age, and involuntary childlessness exposes women to stigma, marital instability, intimate partner violence and economic hardship (Inhorn & Patrizio, 2015). At the same time, access to diagnosis and assisted reproduction remains very limited and largely out of pocket, so that prevention and early management of modifiable causes are the most realistic strategies for most women. Earlier global analyses had already identified sub-Saharan Africa as a region with high levels of secondary infertility, which is often a consequence of preventable infection (Mascarenhas et al., 2012). A recent regional meta-analysis estimated the pooled prevalence of infertility in sub-Saharan Africa at 16.98%, with very high heterogeneity between countries and studies (Gedef et al., 2025).

Among the determinants of female infertility, three biological factors are of particular interest because they are measurable in routine practice and national surveys, and because two of them are modifiable. First, female age is the strongest known determinant of natural fertility; ovarian reserve and oocyte quality decline progressively from the early thirties, with increasing rates of chromosomal error, mitochondrial dysfunction and oxidative damage in ageing oocytes (Zhu et al., 2022). Second, body mass index (BMI) affects reproduction at both extremes. Obesity disrupts the hypothalamic–pituitary–ovarian axis, induces insulin resistance and chronic low-grade inflammation, and impairs oocyte quality and endometrial receptivity (Yong et al., 2023), while undernutrition suppresses gonadotrophin secretion and ovulation. Third, sexually transmitted infections, especially *Chlamydia trachomatis* and *Neisseria gonorrhoeae*, can ascend the genital tract and cause pelvic inflammatory disease, tubal occlusion and adhesions, which are leading causes of tubal-factor infertility (Passos et al., 2022; Rodrigues et al., 2025).

Despite this biological plausibility, the evidence from sub-Saharan Africa is fragmented. Facility-based case-control studies typically recruit small samples of clinically diagnosed women and rely on self-reported exposures, whereas analyses of Demographic and Health Surveys (DHS) use large, nationally representative samples but define infertility indirectly from reproductive histories. Effect sizes therefore vary widely, and the individual studies are rarely large enough to provide precise estimates. Two recent reviews have addressed infertility in the region. Addisu et al. (2025) pooled factors associated with female infertility in Ethiopia only, and Gedef et al. (2025) estimated prevalence and broad categories of risk factors across sub-Saharan Africa. Neither review examined BMI, and neither focused specifically on the biological determinants or distinguished between the different BMI categories.

In Uganda, infertility has received comparatively little research and policy attention despite its social importance. National survey analyses show that secondary infertility, which is more often linked to preventable causes such as infection, is far more common than primary infertility, affecting around 7% of women at risk across the 2006, 2011 and 2016 surveys (Zaake et al., 2024). At the same time, the country has a young population, a high burden of sexually transmitted infections and a nutritional transition in which

undernutrition coexists with rising overweight in urban areas. Understanding which biological factors carry the greatest risk is therefore important both for designing prevention programmes and for specifying the models used to analyse national data.

This gap matters for countries such as Uganda, where national survey data spanning 2006 to 2022 offer an opportunity to study infertility determinants with multilevel models, but where the choice and interpretation of biological covariates depend on what is already known from the region. A systematic synthesis of recent evidence on age, BMI and STIs is therefore needed both to inform prevention and to provide benchmarks against which national survey analyses can be compared.

The objective of this systematic review and meta-analysis was to estimate the pooled association between three biological factors, namely female age, body mass index and history of sexually transmitted infection, and infertility among women in sub-Saharan Africa, using studies published in the last five years. Specifically, the review sought to answer three questions: (i) Is advanced female age associated with higher odds of infertility? (ii) Is underweight, overweight or obesity associated with infertility relative to normal BMI? (iii) Is a history of STI associated with infertility?

METHODS

Protocol and reporting

The review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines (Stroup et al., 2000), and methods followed the Cochrane Handbook where applicable (Higgins et al., 2024). The protocol was not prospectively registered.

Eligibility criteria

Eligibility was defined using the population, exposure, comparison, outcome and study design framework. Studies were eligible if they (i) included women of reproductive age (15–49 years) or couples living in a sub-Saharan African country; (ii) assessed at least one of the following exposures: female age, BMI category or history of STI (self-reported, clinically diagnosed or laboratory-confirmed); (iii) compared women with infertility with fertile, pregnant or non-infertile women, or estimated the odds of infertility in a population sample; (iv) reported an adjusted odds ratio (AOR) with a 95% confidence interval (CI), or data from which an effect estimate could be derived; (v) used an observational design (cross-sectional, case-control or cohort); and (vi) were published in English between January 2020 and October 2026. The five-year publication window was chosen to capture the most recent evidence, including analyses of the latest national surveys.

Studies were excluded if they compared subtypes of infertility with one another without a fertile or general-population comparison group (for example, tubal versus non-tubal infertility), if they reported only means or unadjusted comparisons for the exposures of interest, if they were reviews, editorials or case reports, or if the full text or effect estimates could not be obtained. Studies of male infertility were also excluded.

Information sources and search strategy

Thirty-eight search queries were run through a web search engine indexing PubMed/PubMed Central, African Journals Online (AJOL), the Directory of Open Access Journals (DOAJ), the DHS Program publications database and publisher platforms, and the result entries of each query were screened; and the reference lists of the two recent regional reviews (Addisu et al., 2025; Gedef et al., 2025) were screened for additional studies. The search combined terms for the population, the outcome, the exposures and the effect measure, adapted to each source. The full strategy is presented in Table 1. The last search was conducted on 29 October 2026.

Table 1. Search strategy and information sources

Component	Specification
Sources searched	38 queries run through a web search engine indexing PubMed/PubMed Central, African Journals Online (AJOL), the Directory of Open Access Journals (DOAJ), the DHS Program publications database and publisher platforms (PLOS, BioMed Central/Springer, Wiley, Oxford Academic, Frontiers, Dove Medical Press, Pan African Medical Journal); reference lists of recent systematic reviews
Population terms	woman OR women OR female OR couple *AND ("sub-Saharan Africa" OR Africa* OR Uganda OR Ethiopia OR Kenya OR Tanzania OR Rwanda OR Somalia OR Nigeria OR Ghana OR Cameroon OR Malawi OR Zambia OR Sudan OR Eritrea)
Outcome terms	infertil *OR subfertil* OR "primary infertility" OR "secondary infertility" OR "tubal factor" OR "inability to conceive"
Exposure terms	age OR "maternal age" OR "body mass index" OR BMI OR obes *OR overweight OR underweight OR undernutrition OR "sexually transmitted" OR STI OR STD OR chlamydia OR gonorrh* OR "pelvic inflammatory disease"
Effect-measure terms	"odds ratio" OR AOR OR "risk factor*″ OR determinant* OR "associated factor*"
Limits	Published January 2020 to October 2026; English language; human studies
Records retrieved	346 result entries (235 after removal of duplicates)
Date of last search	29 October 2026

Note: Search strings were adapted to the syntax of each database. Truncation (*) and Boolean operators were used where supported.

Study selection

Retrieved records were screened by title and abstract, and potentially relevant reports were assessed in full text against the eligibility criteria. When a study reported results in both the abstract and the tables, and these differed, the values in the results tables were used. When two reports drew on the same national survey, both were retained only if they addressed different outcomes or samples; overlap was otherwise handled in sensitivity analysis (section 2.7). The selection process is summarised in the PRISMA flow diagram (Figure 1).

Data extraction

A standardised extraction form was used to record the first author, year of publication, country, data source, study design and setting, sample size, definition of infertility, exposure definitions and reference categories, AORs with 95% CIs, and the covariates adjusted for. Extracted values were checked twice against the source tables and text. Where studies reported several age categories, the estimate comparing the oldest with the youngest reported category was extracted, so that the pooled estimate reflects the contrast between older and younger women. One study (Adam et al., 2026) used the oldest age group as its reference category; its estimate for the youngest group was therefore inverted (OR = 1/AOR, with the confidence limits inverted and exchanged) so that all age estimates express the odds for older relative to younger women. For BMI, separate estimates were extracted for underweight (BMI < 18.5 kg/m²), overweight (25.0–29.9 kg/m²) and obesity (≥ 30.0 kg/m²), each relative to normal BMI. For STI, the estimate for the woman's own history of STI was extracted; where both partner-specific and female estimates were reported, the female estimate was used.

Risk of bias assessment

The methodological quality of the included studies was assessed using the Newcastle–Ottawa Scale (Wells et al., n.d.), adapted for cross-sectional studies (Modesti et al., 2016). Four domains were judged: selection of participants (representativeness and sampling), comparability (adjustment for confounders), ascertainment of the exposure, and ascertainment of the outcome. Each domain was rated as low, moderate or high risk of bias, and an overall judgement was made for each study.

Statistical analysis

AORs and their 95% CIs were transformed to the natural-log scale, and standard errors were derived as SE = [ln(upper limit) − ln(lower limit)] / (2 × 1.96). Because the studies differed in setting, design, definition of infertility and exposure categories, random-effects models were specified a priori, and between-study variance (τ^2) was estimated using the DerSimonian and Laird method (DerSimonian & Laird, 1986). As the number of studies per exposure was small, the Hartung–Knapp–Sidik–Jonkman (HKSJ) adjustment was also applied, since it provides more appropriate coverage when few studies are pooled (IntHout et al., 2014).

Heterogeneity was assessed using Cochran's Q test (significance at $p < 0.10$), the I^2 statistic, interpreted as low (25%), moderate (50%) and high (75%) (Higgins et al., 2003), and τ^2. Ninety-five per cent prediction intervals were calculated for exposures with at least four studies to describe the range of effects expected in a new setting (Riley et al., 2011).

Sensitivity analyses comprised (i) leave-one-out analysis; (ii) exclusion of the multi-country DHS analysis (Roba et al., 2022), whose Ethiopian and Ugandan samples partly overlap with those of the single-country survey analyses (Legese et al., 2023; Zaake et al., 2024); and (iii) for age, restriction to studies whose upper age category began at 35 years or above. A subgroup analysis compared DHS-based studies with facility- and community-based primary studies, using the Q-between test. Small-study effects were explored using funnel plots, Egger's regression test (Egger et al., 1997) and Begg's rank correlation test (Begg & Mazumdar, 1994) for exposures with at least four studies, recognising that these tests have low power with fewer than ten studies. Statistical significance was set at $p < 0.05$. Analyses were performed in Python 3 (NumPy and SciPy), using code written for this review.

Handling of multiple, overlapping and inconsistent estimates

Several decisions were needed to ensure that each study contributed a single, comparable estimate to each analysis. When a study reported estimates for several categories of the same exposure, only the estimate for the contrast of interest was extracted, so that no study contributed more than once to any pooled estimate. When a study reported separate models for primary and secondary infertility, the model for primary infertility, or for total infertility where available, was preferred, for the reasons given in section 3.2. When a study reported a female and a male partner estimate for STI history, the female estimate was used, because the review concerned biological determinants in women.

Internal inconsistencies were found in some articles. In four studies, the values in the abstract or text differed from those in the results tables; in each case the table values were used, as tables usually present the direct output of the statistical model. In one study, the labels of the BMI categories did not match their numerical ranges, making it impossible to determine which estimate corresponded to which category; the BMI estimates of that study were therefore excluded rather than guessed. Some reported confidence intervals were asymmetric around the point estimate on the log scale, probably because of rounding or reporting errors; standard errors were nevertheless derived from the reported limits, which gives a conservative weight to such studies.

Certainty of evidence

The certainty of evidence for each exposure was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Guyatt et al., 2008). Evidence from

observational studies started at low certainty and was downgraded for risk of bias, inconsistency, indirectness, imprecision or publication bias, or upgraded for a large effect or a dose–response gradient.

RESULTS

Study selection

The 38 search queries returned 346 records. After 111 duplicate records were removed, 235 records were screened by title and abstract, and 218 were excluded as irrelevant, duplicates of the same article on another platform, or outside the scope of the review. The study selection process is shown in Figure 1. Seventeen reports were sought for full-text retrieval. Four could not be included because they were unpublished theses whose full texts were unavailable (n = 2) or because the full text or effect estimates could not be accessed (n = 2), including a Cameroonian case-control study of laboratory-confirmed STIs and secondary infertility (Mbah et al., 2022). Of the thirteen reports assessed for eligibility, five were excluded: two compared subtypes of infertility without a fertile comparison group (Akabueze et al., 2024; Tesfai et al., 2025), one reported no eligible effect estimate, and two were systematic reviews whose reference lists were screened (Addisu et al., 2025; Gedef et al., 2025). Eight studies were therefore included in the qualitative and quantitative synthesis.

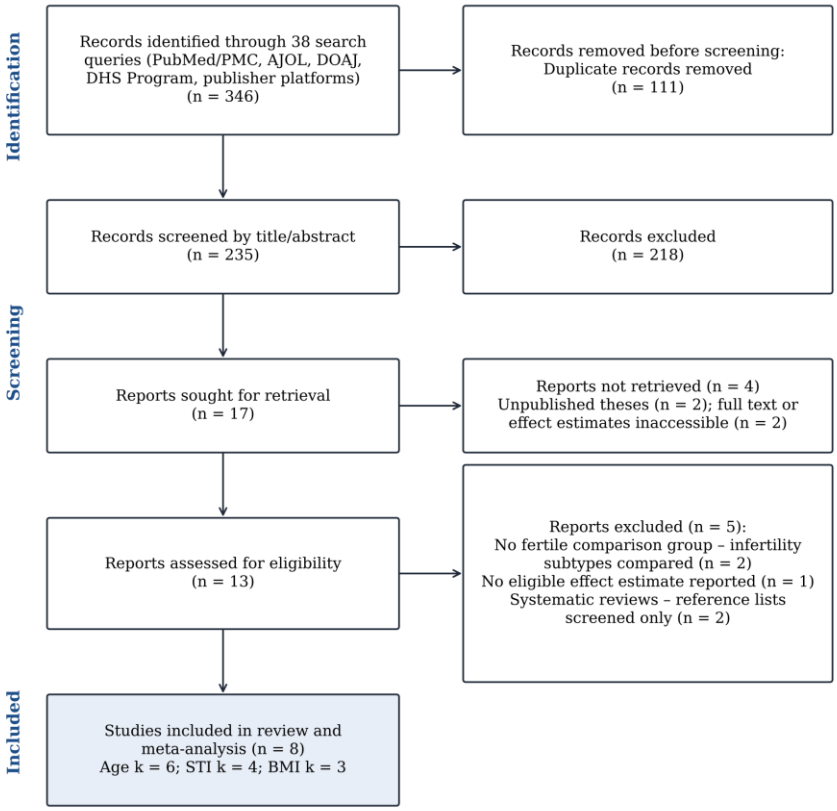

Figure 1. PRISMA 2020 flow diagram of study selection. Note: Records are the result entries returned by 38 search queries run on 29 October 2026; duplicates were identified by URL, DOI or PubMed Central identifier.

Characteristics of included studies

The characteristics of the eight included studies are summarised in Table 2. Together they comprised 63,223 women, although the multi-country survey analysis partly overlaps with two single-country survey analyses. Four studies were conducted in Ethiopia (Abocherugn et al., 2026; Bayu et al., 2020; Haile et al., 2025; Legese et al., 2023), one each in Nigeria (Odelola & Akadri, 2023), Somalia (Adam et al., 2026) and Uganda (Zaake et al., 2024), and one pooled DHS data from ten East African countries, including Ethiopia, Kenya, Rwanda and Uganda (Roba et al., 2022). Three studies were secondary analyses of DHS data, one was

a community-based survey of couples, and four were facility-based case-control or comparative cross-sectional studies. Seven of the eight studies were published in or after 2022.

Table 2. Characteristics of the included studies

Study	Country / data	Design and setting	N	Outcome definition	Biological factors extracted
Bayu et al. (2020)	Ethiopia (Dessie)	Unmatched case-control; referral hospital and private clinic	281	Clinically diagnosed infertility (cases) vs fertile women	STI history
Roba et al. (2022)	10 East African countries; DHS after 2010	Multilevel analysis of national surveys	38,020	Secondary infertility (DHS-based)	Age; BMI
Legese et al. (2023)	Ethiopia; EDHS 2016	Analysis of national survey	6,141	Primary and secondary (total) infertility, DHS-based	Age; BMI
Odelola & Akadri (2023)	Nigeria (Sagamu)	Comparative cross-sectional; teaching hospital	294	Tubal factor infertility vs pregnant controls	Previous STI
Zaake et al. (2024)	Uganda; UDHS 2006, 2011, 2016	Analysis of three national surveys	16,537	Primary infertility (≥5 years in union, no live birth)	Age
Haile et al. (2025)	Ethiopia (Gamo and South Omo Zones)	Unmatched case-control; public health facilities	760	Clinically diagnosed infertility vs fertile controls	Age; STI history
Abocherugn et al. (2026)	Ethiopia (Merhabete Woreda)	Community-based cross-sectional; couples	800	Couple infertility (survey-based)	Age; BMI; STI history
Adam et al. (2026)	Somalia (Mogadishu)	Cross-sectional; three reproductive health centres; convenience sampling	390	Infertile vs non-infertile women attending clinics	Age

Note: DHS, Demographic and Health Survey; EDHS, Ethiopian DHS; UDHS, Uganda DHS; BMI, body mass index; STI, sexually transmitted infection. Sample sizes are those analysed for the extracted estimates.

Definitions of infertility varied considerably. Facility-based studies compared clinically diagnosed infertile women with fertile or pregnant controls, while survey analyses defined infertility from reproductive histories, using either a 12-month or a five-year exposure window. Zaake et al. (2024) analysed primary and secondary infertility separately; the primary infertility estimate was extracted for the main analysis because the

definition of secondary infertility in that study is mechanically related to age through the time since the last birth. All studies reported adjusted estimates from multivariable logistic or multilevel logistic regression.

Narrative description of the included studies

Bayu et al. (2020) conducted an unmatched case-control study of 93 infertile women and 188 fertile controls attending a referral hospital and a private gynaecology clinic in Dessie, northern Ethiopia. In the final model, a history of STI was associated with almost three-fold higher odds of infertility, alongside multiple sexual partners, early age at first pregnancy and late menarche. Age itself was not retained in the final model, and BMI was reported only descriptively.

Roba et al. (2022) pooled DHS data collected after 2010 in ten East African countries (Burundi, Comoros, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Uganda, Zambia and Zimbabwe), analysing 38,020 women with multilevel mixed-effects logistic regression. Secondary infertility, defined from marital duration, previous pregnancy, non-use of contraception and the absence of a birth in the previous year, affected 16.3% of women. Women older than 35 years, underweight women and overweight women had higher odds of secondary infertility, while obesity was not significantly associated.

Legese et al. (2023) analysed 6,141 women in the 2016 Ethiopian DHS and found an infertility prevalence of 24.2%. Women older than 35 years and underweight women had higher odds of infertility, whereas overweight and obesity were not associated. Smoking was also a significant risk factor, and education and wealth were protective. Because the abstract and the results table of this article report slightly different estimates, the table values were extracted.

Odelola and Akadri (2023) compared 147 women with tubal-factor infertility and 147 pregnant controls at a teaching hospital in Ogun State, Nigeria. Previous STI, early age at first intercourse and multiple sexual partners were independent risk factors, and chlamydial IgG seropositivity was more than twice as common among women with tubal-factor infertility.

Zaake et al. (2024) analysed three rounds of the Uganda DHS (2006, 2011 and 2016), including 16,537 women in the analysis of primary infertility and 12,628 in the analysis of secondary infertility. The prevalence of primary infertility declined from 1.4% to 0.8% and that of secondary infertility remained around 7%. Older age and greater household wealth were associated with primary infertility, while age, education, wealth and region were associated with secondary infertility. BMI and STI history were not examined.

Haile et al. (2025) conducted an unmatched case-control study of 152 cases and 608 controls in public health facilities in the Gamo and South Omo zones of southern Ethiopia. Women aged 30 years or older and women with a history of STI had considerably higher odds of infertility, as did women with rural residence, a history of abortion, irregular menstruation and current alcohol use. The BMI categories in this study were labelled inconsistently with their numerical ranges, and the BMI estimates were therefore not extracted.

Abocherugn et al. (2026) surveyed 800 couples in Merhabete Woreda, North Shewa, Ethiopia, and found an infertility prevalence of 23.4%. Female age, overweight, obesity, a history of STI in either partner, low male education and high psychological stress were associated with infertility. This was the only included study that reported significant associations for both overweight and obesity.

Adam et al. (2026) studied 390 women (227 infertile and 163 non-infertile) attending three reproductive health centres in Mogadishu, Somalia. Fallopian tube blockage, polycystic ovary syndrome and female genital mutilation or cervical injury were strongly associated with infertility, whereas age was not significant in the adjusted model.

Risk of bias

The risk-of-bias judgements are presented in Table 3. The three DHS-based analyses were judged to be at low overall risk of bias because of their nationally representative sampling, measured BMI and adjustment for

sociodemographic confounders, although their outcome definitions are indirect. The community-based study of couples was rated as low to moderate risk. The three facility-based case-control and comparative studies were rated as moderate risk, mainly because of hospital-based selection and self-reported STI histories, and the Somali study was rated as high risk because of convenience sampling.

Table 3. Risk-of-bias assessment of the included studies (adapted Newcastle–Ottawa Scale)

Study	Selection	Comparability (adjustment)	Exposure ascertainment	Outcome ascertainment	Overall risk of bias
Bayu et al. (2020)	Moderate	Low	Moderate (self-report)	Low (clinical)	Moderate
Roba et al. (2022)	Low	Low	Low (measured BMI)	Moderate (DHS proxy)	Low
Legese et al. (2023)	Low	Low	Low (measured BMI)	Moderate (DHS proxy)	Low
Odelola & Akadri (2023)	Moderate	Low	Moderate (self-report)	Low (clinical)	Moderate
Zaake et al. (2024)	Low	Low	Low	Moderate (DHS proxy)	Low
Haile et al. (2025)	Moderate	Low	Moderate (self-report)	Low (clinical)	Moderate
Abocherugn et al. (2026)	Low	Low	Moderate (self-report STI)	Moderate (survey-based)	Low to moderate
Adam et al. (2026)	High (convenience)	Low	Low	Moderate	High

Note: Judgements were based on the information reported in each article.

Female age and infertility

Six studies, with 62,648 women, reported the association between female age and infertility. As shown in Figure 2, five of the six studies found significantly higher odds of infertility among older women, with AORs ranging from 1.99 among Ugandan women aged 40–49 years compared with 20–29 years (Zaake et al., 2024) to 7.37 among Ethiopian women aged 30 years or older compared with younger women (Haile et al., 2025). The Somali facility-based study was the only exception, showing no significant age difference (OR = 0.83; 95% CI 0.42–1.67) (Adam et al., 2026).

The pooled random-effects estimate indicated that older women had almost three times higher odds of infertility than younger women (pooled AOR = 2.94; 95% CI 1.87–4.60; $z = 4.70$; $p < 0.001$). The association remained significant with the more conservative HKSJ adjustment (95% CI 1.32–6.55; $p = 0.018$). Heterogeneity was high ($Q = 28.74$, $df = 5$, $p < 0.001$; $I^2 = 82.6\%$; $\tau^2 = 0.237$), and the 95% prediction interval (0.66–13.09) indicates that the strength of the association in a new setting could vary considerably.

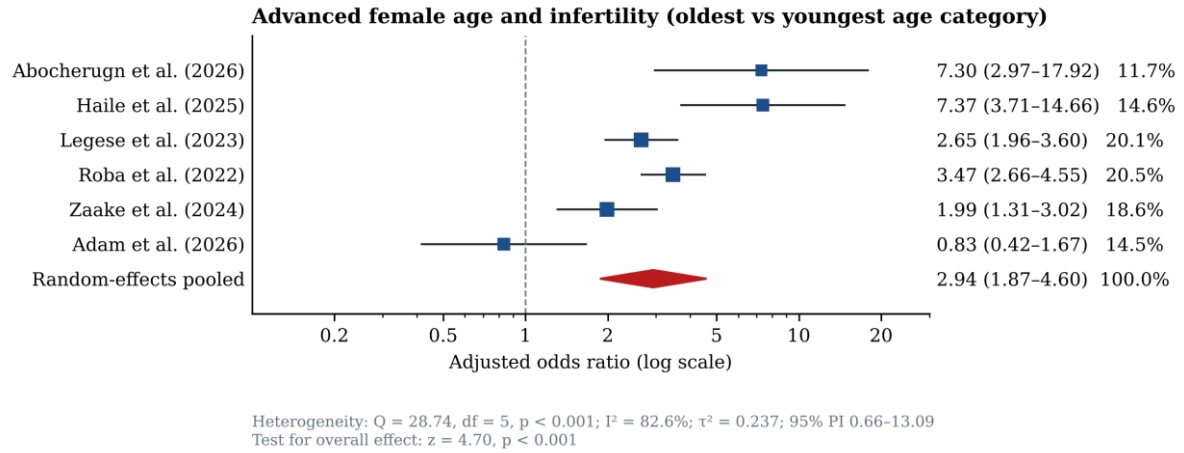

Figure 2. Forest plot of the association between advanced female age and infertility. Note: Squares represent study-specific adjusted odds ratios, with size proportional to random-effects weight; horizontal lines are 95% confidence intervals; the diamond is the pooled estimate. PI, prediction interval.

History of sexually transmitted infection and infertility

Four studies, with 2,135 women, assessed the association between a history of STI and infertility (Figure 3). All four reported significantly higher odds of infertility among women with a history of STI, with AORs ranging from 2.80 (Bayu et al., 2020) to 6.01 (Haile et al., 2025). The pooled estimate showed that women with a history of STI had more than three times higher odds of infertility than women without such a history (pooled AOR = 3.45; 95% CI 2.34–5.08; z = 6.25; p < 0.001). There was no evidence of heterogeneity (Q = 1.49, df = 3, p = 0.684; I^2 = 0%; τ^2 = 0), and the HKSJ interval (2.21–5.38) and the prediction interval (1.47–8.08) both excluded the null, indicating that a positive association can be expected in comparable settings.

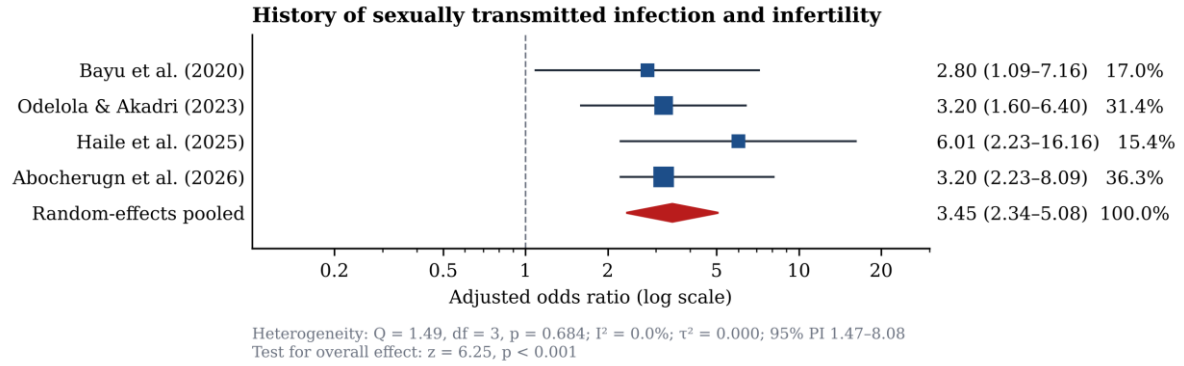

Figure 3. Forest plot of the association between history of sexually transmitted infection and infertility. Note: Squares represent study-specific adjusted odds ratios, with size proportional to random-effects weight; the diamond is the pooled estimate.

The included study from Nigeria also measured *Chlamydia trachomatis* IgG antibodies: 63.9% of women with tubal-factor infertility were seropositive, compared with 25.2% of pregnant controls (Odelola & Akadri, 2023). Although this serological comparison was not adjusted and was therefore not pooled, it is consistent with the self-reported STI findings. By contrast, the Cameroonian case-control study that tested for current infection with four pathogens using nucleic acid amplification did not find an association between active STI and secondary infertility (Mbah et al., 2022), suggesting that it is past rather than current infection that carries the risk.

Body mass index and infertility

Three studies, with 44,961 women, reported associations for BMI categories (Figure 4). For underweight, all three estimates were above one, and the pooled estimate showed significantly higher odds of infertility

among underweight women than among women of normal weight (pooled AOR = 1.72; 95% CI 1.55–1.91; p < 0.001), with no heterogeneity (I^2 = 0%). This pooled estimate was dominated by the two large survey analyses, which contributed almost 99% of the weight.

For overweight, the study estimates pointed in different directions: higher odds in the multi-country analysis (AOR = 1.72) and the Ethiopian community study (AOR = 2.73), but lower, non-significant odds in the Ethiopian national survey (AOR = 0.78). The pooled estimate was not statistically significant (pooled AOR = 1.44; 95% CI 0.77–2.70; p = 0.252), and heterogeneity was high (I^2 = 87.8%). For obesity, both national survey analyses found no association (AORs 0.86 and 0.92), whereas the community study of couples reported higher odds (AOR = 3.12). The pooled estimate was close to the null (pooled AOR = 1.12; 95% CI 0.73–1.70; p = 0.604; I^2 = 80.1%).

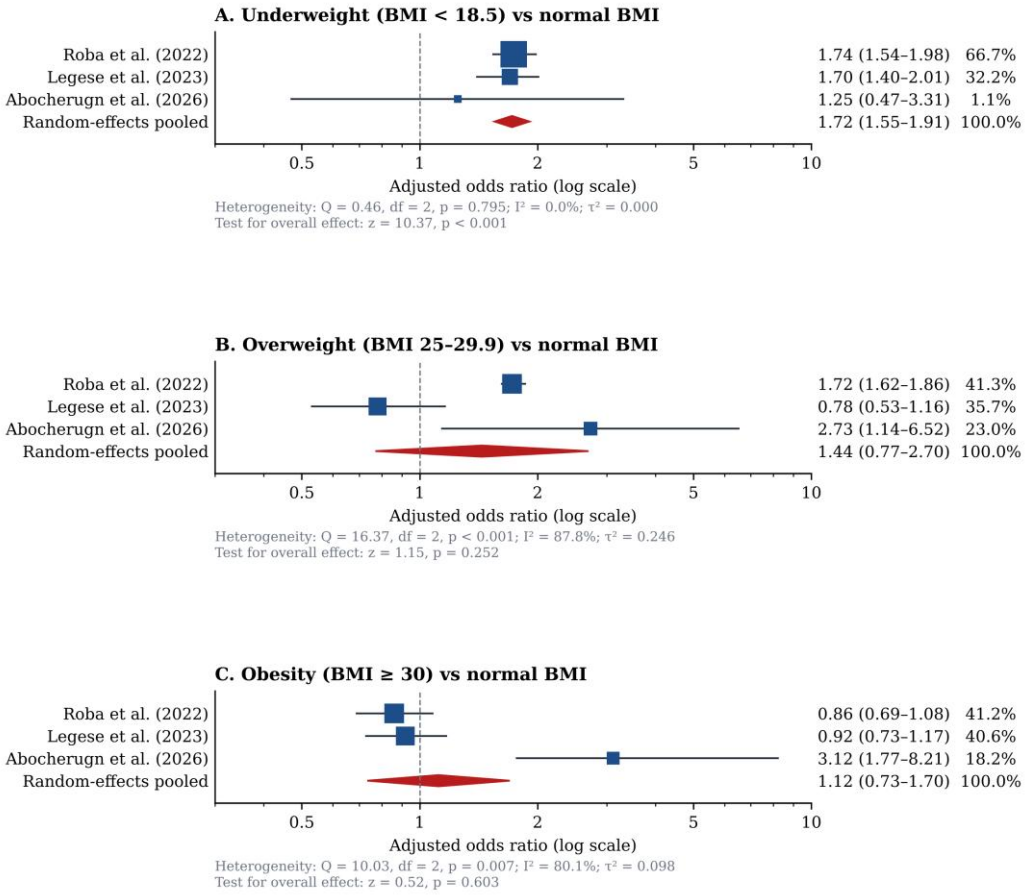

Figure 4. Forest plots of the association between body mass index categories and infertility: (A) underweight, (B) overweight and (C) obesity, each compared with normal BMI. Note: Prediction intervals are not shown because fewer than four studies contributed to each analysis.

A summary of all pooled estimates is presented in Table 4 and Figure 7.

Table 4. Summary of pooled random-effects estimates

Factor (comparison)	k	Pooled AOR (95% CI)	p	HKSJ 95% CI	I^2 (%)	τ^2	95% PI
Advanced age (oldest vs youngest)	6	2.94 (1.87–4.60)	< .001	1.32–6.55	82.6	0.237	0.66–13.09
History of STI (yes vs no)	4	3.45 (2.34–5.08)	< .001	2.21–5.38	0.0	0.000	1.47–8.08

Underweight (vs normal BMI)	3	1.72 (1.55–1.91)	< .001	1.54–1.92	0.0	0.000	—
Overweight (vs normal BMI)	3	1.44 (0.77–2.70)	.252	0.32–6.43	87.8	0.246	—
Obesity (vs normal BMI)	3	1.12 (0.73–1.70)	.604	0.26–4.89	80.1	0.098	—

Note: AOR, adjusted odds ratio; HKSJ, Hartung–Knapp–Sidik–Jonkman adjusted confidence interval; PI, prediction interval (calculated only where k ≥ 4); k, number of studies.

Subgroup and sensitivity analyses

The results of the subgroup and sensitivity analyses are summarised in Table 5 and Figure 5. For age, the pooled association was similar in DHS-based studies (AOR = 2.72; 95% CI 2.02–3.67; I^2 = 61.0%) and in facility- and community-based studies (AOR = 3.51; 95% CI 0.79–15.54; I^2 = 91.4%), and the difference between subgroups was not significant (Q-between p = 0.74). The wide interval for the primary studies reflects the opposing estimate from the Somali study. Restricting the analysis to studies whose upper age category began at 35 years or older reduced heterogeneity (I^2 = 67.4%) without changing the pooled estimate (AOR = 3.00; 95% CI 2.12–4.25). Excluding the multi-country survey analysis to remove sample overlap also left the result essentially unchanged (AOR = 2.86; 95% CI 1.55–5.26). In the leave-one-out analysis, the pooled age estimate ranged from 2.51 to 3.50 and remained significant whichever study was omitted.

For STI history, the leave-one-out estimates ranged from 3.12 to 3.60, all with I^2 = 0%, showing that no single study determined the result. For underweight, excluding the multi-country analysis gave a nearly identical estimate (AOR = 1.68; 95% CI 1.41–2.01). For overweight, the result depended on which studies were combined: excluding the Ethiopian national survey produced a significant positive association with little heterogeneity (AOR = 1.75; 95% CI 1.47–2.09; I^2 = 6.7%). For obesity, excluding the community study left a null association in the two national surveys (AOR = 0.89; 95% CI 0.75–1.04; I^2 = 0%), indicating that the community study was the source of heterogeneity.

Table 5. Subgroup and sensitivity analyses

Analysis	**k**	**Pooled AOR (95% CI)**	**I^2 (%)**	**Interpretation**
Age: main analysis	6	2.94 (1.87–4.60)	82.6	Reference
Age: DHS-based studies only	3	2.72 (2.02–3.67)	61.0	Robust
Age: facility/community studies only	3	3.51 (0.79–15.54)	91.4	Imprecise; Q-between p = .74
Age: excluding multi-country DHS (overlap)	5	2.86 (1.55–5.26)	84.5	Robust
Age: only contrasts with upper category ≥35 years	4	3.00 (2.12–4.25)	67.4	Robust; heterogeneity reduced
Age: leave-one-out range	5	2.51 to 3.50	74.4–85.9	No single study drives result
STI: leave-one-out range	3	3.12 to 3.60	0.0	Robust

Underweight: excluding multi-country DHS	2	1.68 (1.41–2.01)	0.0	Robust
Overweight: excluding Legese et al. (2023)	2	1.75 (1.47–2.09)	6.7	Direction depends on study mix
Obesity: excluding Abocherugn et al. (2026)	2	0.89 (0.75–1.04)	0.0	Null in national surveys

Note: Leave-one-out results show the range of pooled estimates obtained when each study was omitted in turn.

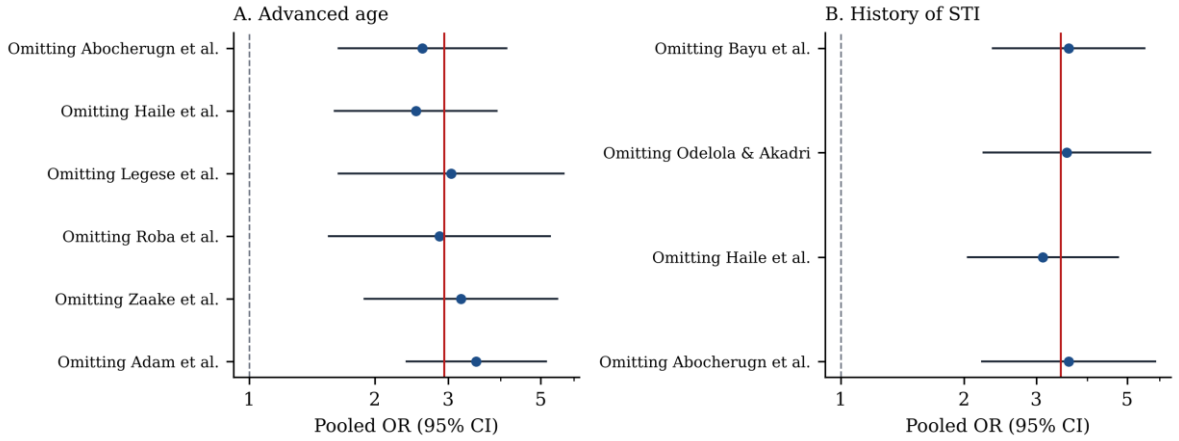

Figure 5. Leave-one-out sensitivity analysis for (A) advanced age and (B) history of sexually transmitted infection. Note: Points and lines show the pooled adjusted odds ratio and 95% confidence interval after omitting each study; the vertical red line marks the overall pooled estimate.

Publication bias

Funnel plots for age and STI history showed no clear asymmetry (Figure 6). Neither Egger's test (age p = 0.94; STI p = 0.48) nor Begg's test (age p = 1.00; STI p = 0.75) indicated small-study effects (Table 6). Because of the small number of studies, these tests have limited power, and publication bias cannot be ruled out. Tests were not performed for the BMI categories, which each included only three studies.

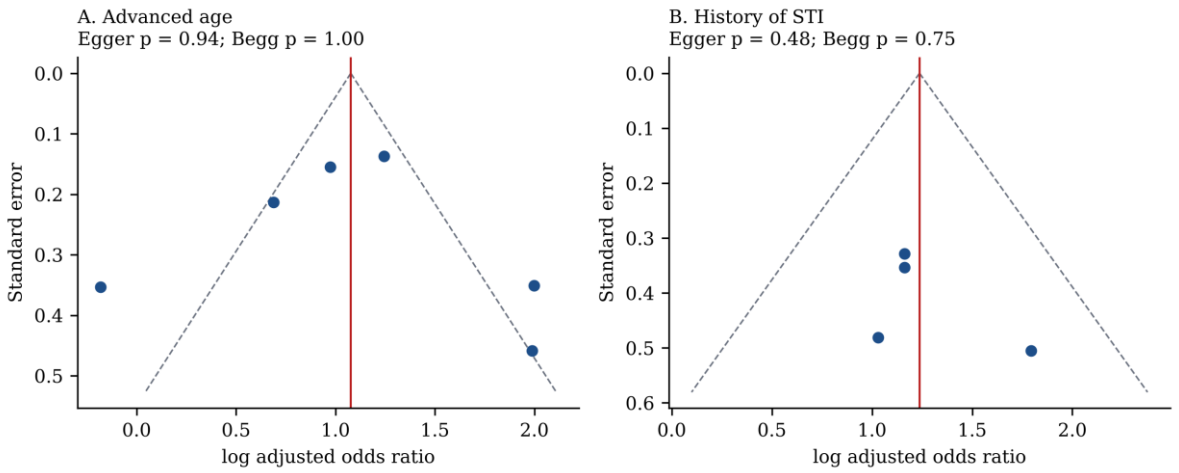

Figure 6. Funnel plots for (A) advanced age and (B) history of sexually transmitted infection. Note: Dashed lines indicate pseudo-95% confidence limits around the pooled log odds ratio (red line).

Table 6. Tests for small-study effects and publication bias

Factor	k	Egger intercept p	Begg rank correlation p	Funnel plot
Advanced age	6	.94	1.00	No clear asymmetry
History of STI	4	.48	.75	No clear asymmetry
BMI categories	3	Not tested	Not tested	Too few studies (k < 4)

Note: Tests were performed only where at least four studies were available and should be interpreted cautiously.

Certainty of the evidence

According to the GRADE assessment (Table 7), the certainty of evidence was low for advanced age, history of STI and underweight. For age, inconsistency in the magnitude of the effect was offset by the consistency of its direction in five of six studies; for STI history, the evidence was consistent and precise but based on self-reported exposures in facility samples. The certainty was very low for overweight and obesity because of serious inconsistency and imprecision.

Table 7. GRADE summary of the certainty of evidence

Factor	Studies (participants)	Pooled AOR	Downgrading considerations	Certainty
Advanced age	6 (62,648)	2.94	Observational; serious inconsistency (I^2 82.6%); heterogeneous age contrasts; consistent direction in 5 of 6 studies	Low
History of STI	4 (2,135)	3.45	Observational; self-reported exposure; small facility samples; consistent and precise	Low
Underweight	3 (44,961)	1.72	Observational; partial sample overlap between national surveys; consistent	Low
Overweight	3 (44,961)	1.44	Observational; serious inconsistency; serious imprecision	Very low
Obesity	3 (44,961)	1.12	Observational; serious inconsistency; serious imprecision	Very low

Note: Evidence from observational studies starts at low certainty in GRADE.

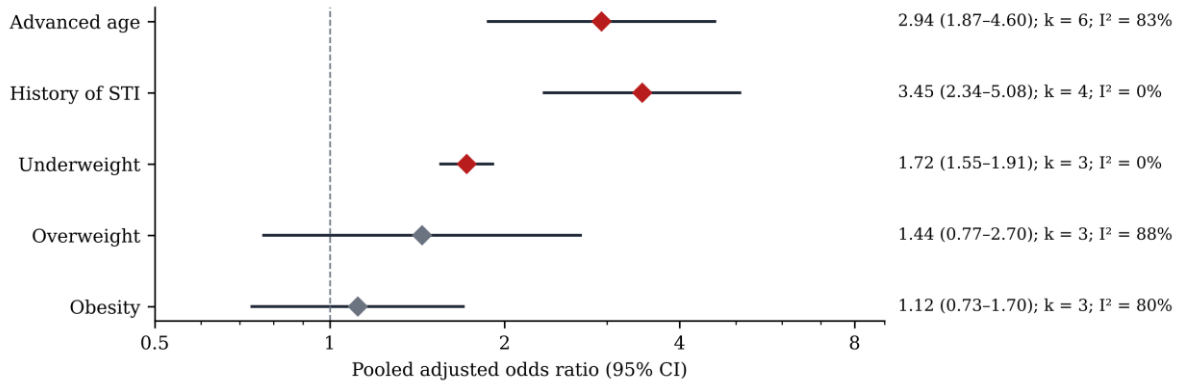

Figure 7. Summary of pooled adjusted odds ratios for the biological determinants of infertility. Note: Red diamonds denote statistically significant pooled estimates; grey diamonds denote non-significant estimates. I^2, heterogeneity; k, number of studies.

DISCUSSION

Summary of main findings

This systematic review and meta-analysis synthesised recent evidence from eight studies, comprising more than 63,000 women, on three biological determinants of infertility in sub-Saharan Africa. It found that advanced female age was associated with almost three-fold higher odds of infertility, a history of STI with more than three-fold higher odds, and underweight with about 70% higher odds, whereas the associations with overweight and obesity were inconsistent and not statistically significant. The age and STI associations were robust to every sensitivity analysis, and there was no evidence of small-study effects. Compared with the two most recent regional reviews, which reported pooled odds ratios of 2.07 and 2.19 for age and 2.76 and 3.24 for STIs (Addisu et al., 2025; Gedef et al., 2025), the present estimates are of similar or slightly greater magnitude. This convergence across reviews that used different, only partly overlapping sets of studies strengthens confidence that age and STI history are genuine and important determinants of infertility in the region. The present review adds a new and policy-relevant finding, namely that underweight rather than obesity is the BMI category most consistently associated with infertility in the available African evidence.

Female age

The finding that older women have markedly higher odds of infertility is consistent with the biology of reproductive ageing. The ovarian follicle pool established before birth declines continuously, and the quality of the remaining oocytes deteriorates with age through loss of chromosomal cohesion, telomere shortening, DNA damage, oxidative stress and mitochondrial dysfunction, which together raise the rates of aneuploidy, failed implantation and early pregnancy loss (Zhu et al., 2022). The pooled estimate of 2.94 is close to the estimates reported in recent regional reviews: Addisu et al. (2025) found an odds ratio of 2.07 for women aged over 35 years in Ethiopia, and Gedef et al. (2025) reported an odds ratio of 2.19 for women's age across sub-Saharan Africa. The present review extends these findings by including newer studies from Ethiopia, Somalia and Uganda and by showing that the association holds in both nationally representative surveys and facility-based studies. It is also consistent with the Global Burden of Disease estimate that the burden of female infertility is greatest among women aged 35–39 years (Liu et al., 2025).

The high heterogeneity in the age analysis is largely explained by differences in how age was categorised. The reference and comparison groups ranged from below 20 years to below 30 years, and from 30 years and over to 40–49 years, so that the contrasts are not strictly comparable. When the analysis was restricted to studies whose oldest category began at 35 years or above, heterogeneity fell from 82.6% to 67.4% and the pooled estimate was unchanged. The only discordant study, from Mogadishu, recruited women attending reproductive health centres by convenience sampling and was judged to be at high risk of bias (Adam et al., 2026). In clinic samples, younger women with infertility may be over-represented because they seek care

earlier, whereas older women may have stopped seeking care, which could attenuate or reverse the association. This illustrates the importance of population-based data for studying age.

In the Ugandan survey analysis, the association between age and infertility was modest for primary infertility (AOR = 1.99 for ages 40–49 years) but very large for secondary infertility (AOR = 13.15) (Zaake et al., 2024). The latter estimate was not pooled because survey-based definitions of secondary infertility are based on the time since the last birth and are therefore mechanically related to age. This distinction is important for national analyses of the Uganda Demographic and Health Survey: models of secondary infertility should interpret age effects with caution, and analyses that combine primary and secondary infertility should consider modelling them separately or including the time since the last birth.

Sexually transmitted infections

The strongest and most consistent association in this review was between a history of STI and infertility. The pooled odds ratio of 3.45, with no heterogeneity and a prediction interval that excluded the null, indicates that the association is stable across Ethiopian and Nigerian settings and across case-control and community designs. This estimate is close to that of the recent sub-Saharan African review, which reported an odds ratio of 3.24 for STI or pelvic inflammatory disease (Gedef et al., 2025), and somewhat higher than the Ethiopian estimate of 2.76 (Addisu et al., 2025).

The biological pathway is well established. *Chlamydia trachomatis* and *Neisseria gonorrhoeae* ascend from the cervix to the endometrium and fallopian tubes, where the inflammatory response, often clinically silent, damages the ciliated tubal epithelium and causes fibrosis, adhesions and occlusion (Rodrigues et al., 2025). A systematic review of the relationship between chlamydia and female infertility found a positive association in more than three-quarters of the included studies and recommended routine screening as part of infertility investigation (Passos et al., 2022). In this review, the Nigerian study found that almost two-thirds of women with tubal-factor infertility had chlamydial antibodies, compared with a quarter of pregnant controls (Odelola & Akadri, 2023), and a further Nigerian study found higher chlamydial seropositivity in tubal than in non-tubal infertility (Akabueze et al., 2024).

The null finding of the Cameroonian study of current infection (Mbah et al., 2022) is not inconsistent with these results. Tubal damage results from past infection, often years before infertility is diagnosed, so that women with infertility may no longer carry the organism. This underlines that the most effective point of intervention is early detection and treatment of STIs in young women, before tubal damage occurs, rather than testing for current infection at the time of infertility assessment. It also suggests that self-reported STI history, the measure available in DHS surveys, captures a meaningful component of risk despite its known limitations.

Body mass index

The association between BMI and infertility in sub-Saharan Africa appears to differ from that observed in high-income settings, where obesity is the principal weight-related concern. In this review, underweight was consistently associated with higher odds of infertility, with no heterogeneity across the three studies, whereas the evidence on overweight and obesity was inconsistent. The underweight finding agrees with the multi-country East African analysis, whose authors interpreted undernutrition as a risk factor for secondary infertility (Roba et al., 2022), and is biologically plausible: energy deficiency suppresses the pulsatile secretion of gonadotrophin-releasing hormone, leading to anovulation and menstrual irregularity, and undernutrition may also be a marker of chronic infection, including HIV and tuberculosis, which themselves impair fertility.

For excess weight, the two national survey analyses found no association with obesity, whereas the community-based study of couples in Ethiopia found that obese women had three times higher odds of infertility (Abocherugn et al., 2026). The mechanisms linking obesity to infertility, including insulin resistance, hyperandrogenism, altered leptin signalling, chronic inflammation and impaired oocyte quality, are well described (Yong et al., 2023), and the absence of a pooled association should not be interpreted as evidence of no effect. Several factors may explain the inconsistency. Obesity remains relatively uncommon among rural women in East Africa, which limits statistical power in national surveys; BMI measured at the time of a survey

may not reflect BMI at the time of attempted conception; and survey-based infertility definitions may misclassify women with ovulatory infertility who eventually conceive. The rising prevalence of overweight and obesity among African women means that this association deserves continued attention, particularly in urban populations.

Interpreting heterogeneity across data sources

An important feature of this review is that it combined two very different types of evidence: large national surveys that define infertility from reproductive histories, and smaller facility or community studies that compare clinically diagnosed infertile women with fertile controls. Each has strengths and weaknesses. Survey analyses are representative and measure BMI directly, but their outcome definitions can misclassify women who are using traditional contraception, who have infrequent intercourse because of partner migration, or who have conceived but lost a pregnancy. Facility studies have clinically confirmed outcomes but recruit women who have reached health services, who are likely to be more educated, more urban and more aware of their reproductive history, and they rely on recall for exposures such as STI history.

These differences help explain why the pooled estimates for STI history, based mainly on facility studies, were larger and less heterogeneous than those for BMI, which came mainly from surveys. They also explain why the estimates for age differed in magnitude but not in direction between data sources. The subgroup analysis showed that DHS-based and primary studies yielded similar pooled age estimates, which suggests that the association is not an artefact of one type of design. Future reviews with more studies should examine design, outcome definition and setting as formal sources of heterogeneity through meta-regression, which was not feasible with the small number of studies available here.

Directions for future research

Several research priorities emerge from this review. First, prospective cohort studies that measure BMI and screen for STIs before attempts at conception would allow the temporal relationship between these factors and infertility to be established and would reduce reverse causation. Second, studies should use standardised definitions of infertility, ideally the 12-month clinical definition, and should report results for standard age and BMI categories so that their findings can be pooled. Third, laboratory confirmation of past infection, for example through chlamydial serology, should be combined with self-reported STI history to reduce misclassification. Fourth, there is a need for research from West and Central Africa and from countries such as Uganda, Kenya and Tanzania, where few studies of the biological determinants of infertility have been published in recent years. Finally, analyses of male factors and of couple-level data would provide a more complete picture of infertility, since male factors contribute to a substantial proportion of infertility among couples.

Implications for research and for the Uganda Demographic and Health Survey

The findings have implications for national analyses such as multilevel studies of the Uganda Demographic and Health Surveys from 2006 to 2022. First, they provide external benchmarks: an analysis of Ugandan data would be expected to find a strong positive association with age, a positive association with self-reported STI history, and a positive association with underweight, while the role of obesity may be weaker or absent. Second, they highlight methodological issues: age should be categorised consistently (for example, using 35 years as a threshold), primary and secondary infertility should be modelled separately or the time since last birth taken into account, and BMI should be analysed as a categorical variable that distinguishes underweight from overweight and obesity rather than as a linear term. Third, the review shows how few studies from Uganda have examined BMI and STI history in relation to infertility; the only eligible Ugandan study did not include these variables (Zaake et al., 2024). Analyses of the Uganda surveys that include these biological factors would therefore fill an important gap.

Implications for policy and practice

Three practical implications follow. First, because a history of STI was the most consistent determinant, the prevention of infertility should be integrated into sexual and reproductive health programmes, with routine screening and prompt treatment of chlamydia and gonorrhoea in young women, partner notification and treatment, and education on the long-term reproductive consequences of untreated infections. Second, nutritional programmes for women of reproductive age should recognise infertility as one of the consequences of undernutrition, while also monitoring the emerging burden of obesity. Third, reproductive health counselling should provide accurate information about the decline in fertility with age, so that women and couples can make informed decisions about the timing of childbearing and seek evaluation earlier when conception is delayed.

Strengths and limitations

This review has several strengths. It focuses specifically on biological determinants, includes BMI, which previous regional reviews did not examine, and distinguishes between underweight, overweight and obesity. It is restricted to evidence published in the last five years, including the most recent national survey analyses, and it pools only adjusted estimates. The use of HKSJ intervals, prediction intervals, multiple sensitivity analyses and GRADE provides a transparent assessment of the robustness and certainty of the findings.

The review also has important limitations. The number of eligible studies was small, especially for BMI, which limits the precision of the pooled estimates and the power of the tests for heterogeneity and publication bias. Half of the studies came from Ethiopia, and there was only one study each from Nigeria, Somalia and Uganda, so the findings may not be generalisable to the whole of sub-Saharan Africa, particularly to West and Central Africa. Definitions of infertility and of exposure categories varied between studies, and the age contrasts were not uniform. The multi-country survey analysis partly overlaps with the Ethiopian and Ugandan survey analyses, although excluding it did not change the conclusions. STI history was self-reported in all pooled studies and is likely to be under-reported, which would tend to bias associations towards the null. All included studies were cross-sectional or case-control, so causal inferences cannot be drawn, and reverse causation is possible for BMI. Finally, the restriction to English-language studies published since 2020, and the inability to access the full texts of four reports, may have led to the omission of relevant evidence. The search relied on a web search engine and screened the top-ranked results of each query, so relevant studies that were not highly ranked may have been missed.

CONCLUSION

This systematic review and meta-analysis shows that advanced female age, a history of sexually transmitted infection and underweight are consistent biological determinants of infertility among women in sub-Saharan Africa, associated respectively with about three-fold, three-and-a-half-fold and 1.7-fold higher odds of infertility. The evidence for overweight and obesity is inconsistent and of very low certainty. Because STIs and undernutrition are preventable, these findings support the integration of infertility prevention into STI control and nutrition programmes, together with counselling on age-related fertility decline. Further population-based research, including multilevel analyses of national surveys such as the Uganda Demographic and Health Surveys, is needed to clarify the role of body mass index and to provide evidence from under-represented countries.

DECLARATIONS

Ethics approval and consent to participate: Not applicable. This study is a systematic review and meta-analysis of published data and did not involve human participants directly.

Availability of data and materials: The extracted data and analysis code are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: Ibrahim Abukar Mohamad conceived the review, defined the eligibility criteria, oversaw the literature search, data extraction and analysis, and reviewed and approved the final manuscript.

Use of generative AI: During the preparation of this manuscript, the author used a generative AI tool (Claude, Anthropic) to assist with the literature search, data extraction, statistical analysis, drafting and language editing. All included studies, extracted estimates and references were checked against their original sources, and the author reviewed the entire manuscript and takes full responsibility for its content.

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