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MALE AND FEMALE OBESITY AND ITS IMPACT ON FERTILITY: A SYSTEMATIC REVIEW OF THE RELATIONSHIP AND OUTCOMES

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Abstract

The current paper focuses on obesity, a global concern to health that brings far-reaching implications, including high-impact effects on the state of reproductive health. Therefore, this systematic review aims to synthesize current evidence on the relationship between obesity and fertility in males and females and its effects on conception, pregnancy, and offspring health outcomes. A detailed literature search across various literature databases produced 12 good-quality studies published from 2010 through 2024. Consequently, this review showed that obesity had a bad effect on male fertility through changes in sperm parameters and hormonal imbalance, probably due to epigenetic alterations. In females, it has been linked to ovulatory dysfunction, impaired quality of the oocyte, and altered endometrial receptivity. Male and female obesity have been linked to poor success rates of assisted reproductive technologies. This review commented on the potential transgenerational effects of parental obesity on offspring health mediated by epigenetic mechanisms. Indeed, the findings emphasized that strategies on reproductive health must therefore embody tackling obesity, including care of people planning a pregnancy and fertility treatments. Future research directions should aim at clarifying the molecular mechanisms, developing targeted interventions, and assessment of offspring health outcomes in long-term follow-up studies.

Keywords: obesity, fertility, outcomes, systematic review, male & female.

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Background

Obesity presents a critical challenge to global health, influencing modern healthcare systems in numerous ways, from policy formulation to economic burdens and intervention strategies (Gautam et al., 2023). The complexity of obesity arises from a myriad of factors including governmental policies, economic conditions, employment, educational background, and individual behaviors and lifestyle choices (Nobles et al., 2023). According to the World Health Organization (WHO), a body mass index (BMI) of ≥25 kg/m² is classified as overweight, and ≥30 kg/m² as obese (WHO, 2021).

At the same time, subfertility—defined as the inability to conceive after one year of regular unprotected intercourse—affects about one in seven couples (Thurston et al., 2019). Both male and female factors contribute to subfertility, and research has increasingly highlighted the molecular connections between obesity and reproductive health, suggesting intricate interactions between metabolic dysfunction and fertility (Silvestris et al., 2018).

The global rise in obesity is alarming. Since 1975, obesity rates have more than doubled. By 2016, approximately 650 million adults and 340 million children and adolescents were classified as overweight or obese (WHO, 2021). This escalation has significant implications for public health and reproductive health in particular.

Obesity impacts various endocrine systems, including the reproductive system. In women, it is associated with menstrual irregularities and ovulatory dysfunction. In men, it impairs sperm function and increases the risk of erectile dysfunction, collectively reducing fertility (Liu et al., 2023). Moreover, obesity complicates pregnancy outcomes, with obese women facing higher risks for conditions such as gestational hypertension, pre-eclampsia, and gestational diabetes (Poston et al., 2011). They are also more likely to experience labor induction, prolonged labor, cesarean delivery, postpartum hemorrhage, infections, and premature birth (Creanga et al., 2022). Additionally, obesity is linked with increased rates of depression and anxiety during pregnancy and postpartum (Dachew et al., 2021).

Obesity also affects fetal and neonatal health, increasing the likelihood of congenital anomalies, macrosomia, and large-for-gestational-age infants. This raises the risk of complications like shoulder dystocia, which can have serious consequences for both the mother and infant (Creanga et al., 2022).

Although the literature extensively covers the effects of obesity on pregnancy and birth, there is a notable lack of research on the importance of achieving a healthy body weight before conception. This gap is concerning as pregnancy often motivates women to make healthier lifestyle changes (Lindqvist et al., 2017). Research indicates that women with higher pre-pregnancy BMIs often report poorer dietary quality (Tsigga et al., 2011).

Given the pervasive nature of obesity and its profound effects on reproductive health and pregnancy outcomes, there is a pressing need for a comprehensive review of the evidence concerning the impact of obesity on fertility. This systematic review aims to clarify the relationship between obesity and fertility, and its effects on conception, pregnancy, and offspring health. The review will consolidate and critically evaluate existing literature to inform clinical practice and guide future research, with the goal of developing targeted interventions to address these health challenges.

Methods and Procedures

A systematic review methodology was adopted to collect and analyze secondary data, focusing on

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identifying, selecting, synthesizing, and appraising relevant studies to provide evidence on the impact of obesity on fertility and related outcomes (Higgins et al., 2021). This approach is particularly effective for building a solid evidence base in reproductive health research (Page et al., 2021).

The review was conducted in accordance with quality guidelines from the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2021) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). Adhering to PRISMA guidelines ensures transparency and comprehensiveness in reporting, enhancing the reliability of the review.

Eligibility Criteria

Inclusion Criteria:

- Articles published from January 2010 to March 2024.
- Original research or review articles.
- Written in English.
- Examining the impact of increased BMI on fertility in both sexes.

Exclusion Criteria:

- Articles published before January 2010 or after March 2024.
- Non-peer-reviewed articles, conference abstracts, or other non-scientific publications.
- Written in languages other than English.
- Focused solely on obesity during pregnancy without addressing preconception fertility.

Information Sources:

A comprehensive literature search was conducted in March 2024 across several electronic databases including PubMed/MEDLINE, Embase, and Web of Science. The Cochrane Library was also searched for relevant systematic reviews, and Google Scholar was utilized to identify any additional articles. The search strategy employed controlled vocabulary and free-text terms related to BMI, obesity, fertility, and reproductive health. The search was limited to publications from January 2010 to March 2024 to include the most recent studies.

Search terms included variations and combinations of "BMI", "body mass index", "overweight", "obese", "obesity", "fertility", "infertility", "subfertility", "reproductive health", "conception", and "preconception". Boolean operators AND and OR were used, along with truncation symbols, to refine the search. Reference lists and relevant review articles were hand-searched for additional studies, and clinical trial registries were consulted for ongoing or recently completed research.

Search Strategy

A search strategy was developed and executed on July 15, 2024, using a combination of controlled vocabulary (MeSH terms for MEDLINE, Emtree terms for Embase) and free-text terms. The search focused on the following concepts: obesity/increased BMI, fertility/infertility, and reproductive health. Only English language publications from January 1, 2010, to July 15, 2024, were included. Manual searches and clinical trial registry checks supplemented the database searches.

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Data Collection Process

Data extraction was carried out using a standardized sheet adapted from Cochrane. The form was pilot-tested on five randomly selected articles and refined accordingly. The researcher used the refined form for initial data extraction, with oversight and verification provided by the supervisor.

Data Items

Data extracted included:

- Type of publication, author(s) and publication year, study design and sample size. Participant characteristics, obesity measures used (e.g., BMI categories, waist circumference), fertility outcomes (e.g., time to conception, semen parameters, ovulatory function). Confounding factors, major results, including quantitative findings and effect sizes, interventions for weight loss and their effects on fertility outcomes. Data were extracted separately for each sex where applicable, and any interventions reported were noted.

Quality Assessment

Quality was assessed using the Critical Appraisal Skills Programme (CASP) checklists tailored to the study design (qualitative, quantitative, or mixed-methods). CASP checklists include appraisal questions with a scoring system: "Yes" = 2 points, "Can't Tell" = 1 point, and "No" = 0 points, with a maximum of 20 points per article. The revised Cochrane risk-of-bias tool was used to evaluate bias risk, with independent review of grades to minimize bias.

Data Synthesis

A narrative synthesis approach was used to integrate and analyze findings from the included studies. Themes were developed to explain the relationship between obesity and fertility, incorporating both quantitative and qualitative insights. This approach allowed for a detailed exploration of the complex interactions between obesity and fertility.

Results and Findings

An advanced search of four databases on July 15, 2024, returned a total of 427 records: MEDLINE via PubMed (n=156), Embase (n=132), Web of Science (n=98), and Cochrane Library (n=41). Removing 37 duplicate records resulted in 390 unique citations. Of 390 records, following the title and abstract screening, 358 irrelevant records were discarded. Subsequently, 32 articles were eligible for full-text screening. After careful review, 20 of them were excluded based on the following criteria: the study was not focused on obesity and fertility—n=8; data on BMI or fertility outcomes were not sufficient—n=6; incorrect design of the study—n=4; non-English language—n=2. At last, 12 studies were eligible for being included in this systematic review. Table 1 presents a descriptive summary of the results of study selection.

Table 1: Systematic search results

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Database	Initial hits	Duplicates removed	Title/Abstract screening	Full-text review	Final inclusion
MEDLINE (PubMed)	156	14	131	11	5
Embase	132	12	112	8	3
Web of Science	98	8	85	5	2
Cochrane Library	41	3	30	8	2
TOTAL	**427**	**37**	**358**	**32**	**12**

The 12 studies used for this meta-analysis are a balanced mix of original research articles and comprehensive reviews. They include both male and female obesity, as well as their effects on different fertility parameters. They provided a balanced perspective on this topic by researching sperm parameters, IVF outcomes, and general fertility markers with increased BMI.

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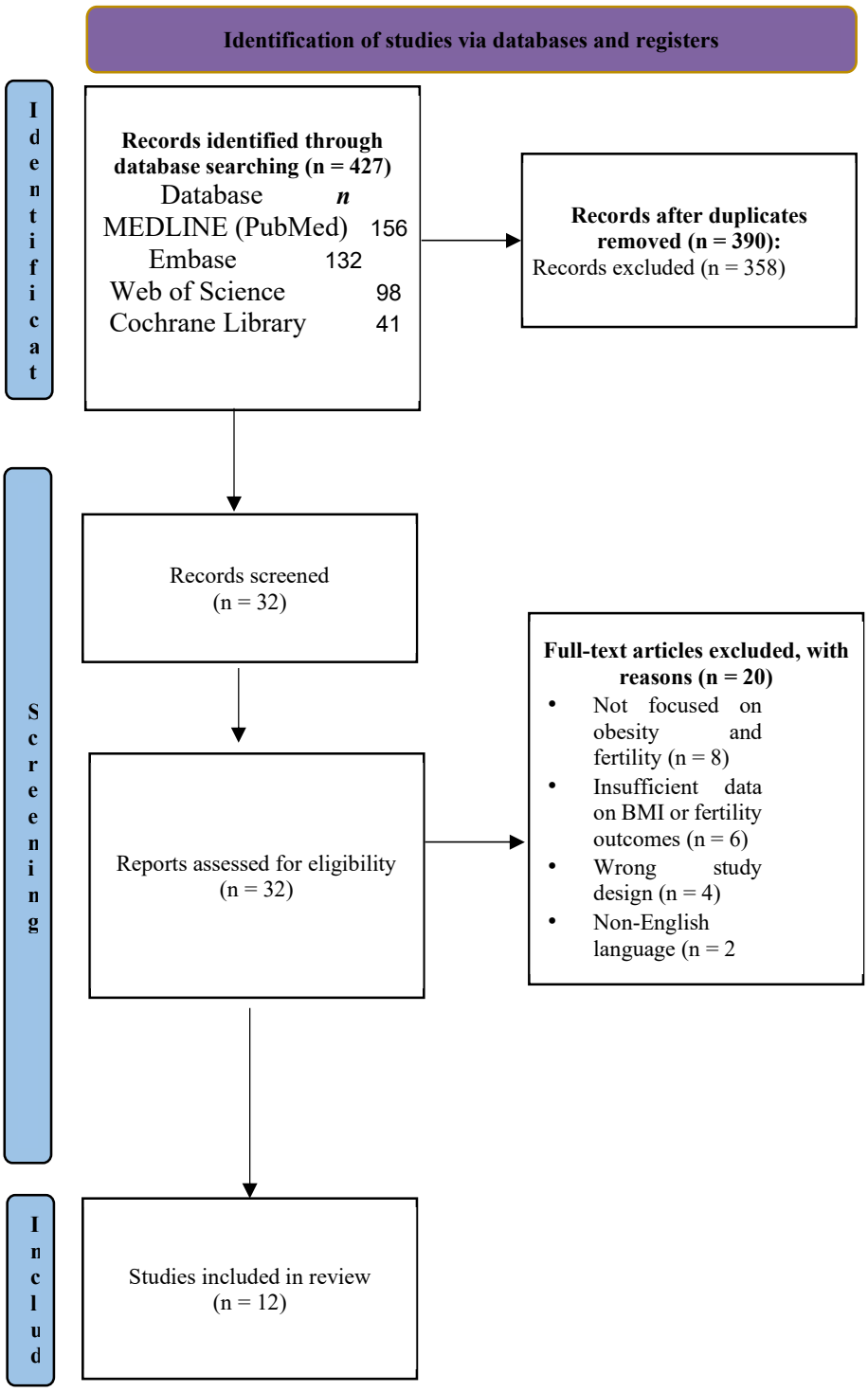
Figure 1: PRISMA Results Flow Chart



Source: Flow chart retrieved from http://prisma-statement.org/

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Description of Included Studies

This systematic review encompasses 12 studies exploring the intricate relationship between obesity and fertility in both males and females. These studies employ diverse designs and methodologies, providing a comprehensive snapshot of current knowledge on the topic. For detailed information on each study, including authors, publication years, research objectives, methodologies, study contexts, population characteristics, data collection and analysis methods, and key findings, refer to Annex

Design and Methodological Approaches

The studies reviewed display a range of designs, reflecting the complexity of the obesity-fertility relationship. Six of these are comprehensive reviews, offering a broad overview of existing literature. These reviews include work from Zheng et al. (2024), Imterat et al. (2018), Cekici (2018), Chambers and Anderson (2015), Palmer et al. (2012), and Du Plessis et al. (2010). They provide insights into current knowledge, identify trends, highlight gaps, and suggest future research directions.

Additionally, three studies use quantitative methods: Anifandis et al. (2013) and Souter et al. (2011) conducted retrospective analyses, while Hajshafiha et al. (2013) performed a cross-sectional study. These studies offer data-driven perspectives on the mechanisms and outcomes related to obesity and fertility.

Setting and Geographical Scope

The studies span various international contexts, reflecting the global nature of obesity and fertility issues. Literature reviews generally encompass global perspectives, drawing from international research. In contrast, the empirical studies were conducted in specific locations: Anifandis et al. in Greece, Hajshafiha et al. in Iran, and Souter et al. in the United States. This geographic diversity allows for the examination of cultural differences, environmental factors, and healthcare system variations that may impact the obesity-fertility relationship.

Participants and Sampling

The empirical studies focus on different relevant populations:

Anifandis et al. (2013): 301 couples undergoing in vitro fertilization (IVF), highlighting both male and female factors in fertility treatment. Hajshafiha et al. (2013): 159 male partners of infertile couples. Souter et al. (2011): 477 women undergoing 1,189 cycles of ovulation induction or intrauterine insemination.

These studies provide insights into male and female fertility issues based on various body mass indices (BMIs). Literature reviews, by nature, include a broader range of populations due to their synthesis of multiple studies.

Data Collection and Analysis

The reviewed studies employed diverse data collection and analysis methods:

- Literature Reviews: Utilized broad search strategies across multiple databases with rigorous inclusion and exclusion criteria, followed by narrative synthesis of findings.
- Empirical Studies: Employed methods such as retrospective analysis of medical records, blood samples, and semen analyses. Statistical analyses were used to explore associations between obesity measures and fertility outcomes.

Key Themes and Findings

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Impact of Obesity on Male Fertility

Effects on Sperm Parameters and Quality: Obesity adversely affects sperm parameters, including reduced sperm count, impaired motility, and altered morphology. Studies by Du Plessis et al. (2010) and Venigalla et al. (2023) emphasize these impacts. Chambers and Anderson (2015) attributed these changes to increased scrotal temperature and oxidative stress. A meta-analysis by Torres-Arce et al. (2021) confirmed negative correlations between BMI and sperm quality.

Influence on Embryo Quality in IVF: Male obesity affects embryo quality and IVF outcomes. Anifandis et al. (2013) found that couples with both partners having a BMI ≤ 25 kg/m² had better embryo quality and pregnancy rates. Nikolic et al. (2024) confirmed that paternal obesity negatively impacts embryo development, stressing the importance of preconception counseling.

Hormonal Alterations: Obesity leads to hormonal imbalances in men, such as reduced testosterone levels and disrupted hypothalamic-pituitary-gonadal axis function. Chambers and Anderson (2015) and Hajshafiha et al. (2013) reported significant hormonal changes, including altered testosterone/estradiol ratios. Rastrelli et al. (2022) highlighted increased aromatase activity as a mechanism behind these imbalances.

Molecular and Epigenetic Changes: Obesity affects sperm at the molecular and epigenetic levels. Palmer et al. (2012) reviewed changes in DNA methylation and histone modifications. Potabattula et al. (2019) showed that weight loss can reverse some epigenetic changes, while Venigalla et al. (2023) highlighted the potential long-term effects on offspring health.

Impact of Obesity on Female Fertility

Ovulatory Dysfunction and Menstrual Irregularities: Obesity disrupts ovulatory cycles and menstrual regularity. Imterat et al. (2018) and Zheng et al. (2024) discussed how obesity affects hormonal regulation and ovarian function. Broughton and Moley (2017) noted that inflammation in the ovarian microenvironment impairs folliculogenesis.

Effects on Oocyte Quality: Obesity negatively impacts oocyte quality, affecting fertilization and embryo development. Pandey et al. (2010) and Imterat et al. (2018) reported impaired oocyte competence. Ou et al. (2019) identified molecular changes in oocytes from obese women, including altered gene expression related to mitochondrial function.

Impact on ART Outcomes: Obesity affects ART outcomes, requiring higher doses of gonadotropins and resulting in lower ovarian responsiveness. Souter et al. (2011) and Imterat et al. (2018) found reduced success rates in IVF procedures for obese women. Supramaniam et al. (2018) confirmed lower live birth rates and higher miscarriage rates in this population.

Overall Quality of Included Studies

The review assessed the quality of studies using the CASP checklist, adapted for various study designs. The majority of studies scored 15 or higher, indicating good methodological quality. Hajshafiha et al. (2013) and Souter et al. (2011) received the highest scores (19 out of 20), reflecting their high quality. Literature reviews generally scored lower due to the adaptation of the CASP tool, with scores ranging from 12 to 17 out of 18. Cekici (2018) received the lowest score (12 out of 18) due to less explicit research design.

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Despite these variations, the studies generally provide a solid foundation for understanding the impact of obesity on fertility. The combination of empirical research and literature reviews ensures a comprehensive exploration of the topic, though limitations and biases inherent to each study should be considered.

Endometrial Alterations

Impact of Obesity on the Endometrium

Obesity adversely affects the endometrium, influencing implantation and early pregnancy maintenance. Moussa et al. (2016) indicated that obesity leads to endometrial changes that can reduce fertility and increase pregnancy complications. Shan et al. (2022) used advanced imaging to show that obesity alters endometrial vascularity and reduces key implantation markers, which may lower implantation rates during ART. Zheng et al. (2024) highlighted how obesity-induced chronic inflammation affects the endometrial immune environment, impairing the immune balance necessary for successful implantation and pregnancy maintenance.

Obesity and ART Outcomes

IVF Success Rates

Extensive research has shown that obesity negatively impacts IVF success rates. Anifandis et al. (2013) found that couples with both partners having a BMI ≤ 25 kg/m² had the highest embryo quality and pregnancy rates. Imterat et al. (2018) observed decreased IVF success rates among obese women, attributing this to poor oocyte quality, altered endometrial receptivity, and embryo developmental issues. Sermondade et al. (2022) reported a 32% lower odds of live birth for obese women compared to those with normal BMI, based on a meta-analysis of over 120,000 IVF/ICSI cycles.

Gonadotropin Responsiveness

Obesity affects ovarian responsiveness to gonadotropins. Souter et al. (2011) found that obese women required higher doses of gonadotropins and produced fewer follicles, indicating reduced ovarian responsiveness. Pandey et al. (2010) and Moslehi et al. (2018) confirmed that obese women need more gonadotropins, yield fewer oocytes, and have reduced ovarian blood flow and lower AMH levels, necessitating tailored stimulation protocols for ART.

Embryo Quality

BMI influences embryo quality in both male and female partners. Anifandis et al. (2013) showed that male BMI significantly affects embryo quality, emphasizing the importance of assessing male BMI in fertility treatments. Pandey et al. (2010) reported that obesity is linked to poorer embryo quality in younger women. Recent advancements by Bartolacci et al. (2019) and Hieronimus et al. (2022) have identified altered cleavage patterns and epigenetic changes in embryos from obese parents, which can impact embryo development and offspring health.

Obesity and Reproductive Health: Beyond Conception

Pregnancy Complications

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Obesity during pregnancy increases risks of gestational diabetes, preeclampsia, and other complications. Moussa et al. (2016) noted that obesity raises the likelihood of gestational diabetes due to insulin resistance and altered glucose metabolism. Obese women are also at higher risk for preeclampsia and various obstetric complications, including prolonged labor and postpartum hemorrhage, as reported by Zheng et al. (2024).

Potential Effects on Offspring Health

Maternal obesity may impact offspring health through fetal programming. Moussa et al. (2016) highlighted risks of macrosomia and metabolic disorders in offspring of obese mothers. Venigalla et al. (2023) suggested transgenerational effects of parental obesity, while Zheng et al. (2024) discussed how maternal obesity could alter the fetal epigenome, leading to long-term health issues like obesity and cardiovascular disease in offspring.

Discussion

This review synthesizes evidence from 12 studies, demonstrating the profound impact of obesity on fertility and reproductive health, spanning preconception to offspring health. Findings underscore the need for comprehensive approaches to fertility care, considering both partners' BMI and the systemic effects of obesity. Evidence shows that obesity affects male fertility through altered sperm parameters and epigenetic changes, and female fertility through ovulatory dysfunction, oocyte quality, and endometrial receptivity. ART outcomes are notably reduced in obese patients, necessitating personalized treatment protocols. The potential for transgenerational effects due to parental obesity emphasizes the importance of preconception counseling and obesity management.

Limitations: include heterogeneity in study designs and outcome measures, reliance on BMI as a sole measure of obesity, and varying methodologies. Future research should focus on: Molecular mechanisms affecting gamete quality and embryo development. Targeted interventions to mitigate obesity's adverse effects on fertility.

3. Long-term health outcomes in offspring from obese parents. Variations in obesity's impact across different populations.

Conclusion and Recommendations

This review confirms the significant and multifaceted impact of obesity on fertility, including potential transgenerational effects. A paradigm shift is needed in fertility care to integrate obesity management and BMI assessment. Customized ART protocols and preconception counseling should be standard practices. Public health initiatives should address obesity to improve reproductive health outcomes. Future research should explore molecular mechanisms, targeted interventions, and long-term effects on offspring health.

Authors' contributions:

All authors have accepted responsibility for the entire content of this manuscript and consented to its submission to the journal, reviewed all the results and approved the final version of the manuscript.

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Annex 1: Study and Participant Characteristics:

Author(s), Year	Aims/Purpose	Approach, Design	Setting, Country	Population, Sampling, Sample Size (n)	Data Collection, Analysis	Key Findings
Zheng et al., 2024	To explore the impact of obesity on female	Literature review	Global scope	N/A - Review article	Comprehensive review of epidemiological, clinical, and	Obesity significantly impacts female reproductive

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	reproductive health				molecular studies	health, particularly in PCOS, menstrual disturbances, and infertility. Weight loss emerges as a promising strategy. Obesity influences the efficacy of assisted reproductive technologies.
Venigalla et al., 2023	To highlight the impact of male obesity on reproductive and offspring outcomes	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Male obesity affects fertility through changes in semen quality, natural conception difficulties, and poorer ART outcomes. Paternal obesity may influence offspring outcomes through epigenetic pathways. Weight loss may modify these adverse effects.
Imterat et al., 2018	To review the impact of BMI on female fertility and ART outcomes	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Abnormal BMI contributes to anovulation, irregular menses, adverse oocyte quality, endometrial alterations, and hormonal imbalances. BMI

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						affects ART outcomes. Lifestyle modifications can enhance fecundity.
Cekici, 2018	To examine current nutritional factors affecting fertility and infertility	Literature review	Global scope	N/A - Review article	Review of dietary factors and their impact on fertility	Trans fatty acids, saturated fat, red meat, processed meats, fatty dairy products, sugar, sweeteners, alcohol, and caffeine negatively affect fertility. Fish, poultry, fruits, vegetables, and whole grains may reduce infertility risk.
Chambers & Anderson, 2015	To review the impact of obesity on male fertility	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Obesity is associated with hypogonadism, impaired spermatogenesis, and DNA fragmentation in sperm. Paternal obesity may negatively impact offspring health. Weight loss can improve male fertility and offspring health.

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Hajshafiha et al., 2013	To investigate the role of BMI on male fertility laboratory indicators	Cross-sectional study	Iran	159 male partners of infertile couples	Blood samples, semen analysis, statistical analysis	Obese men were 3.5 times more likely to have oligospermia. BMI was significantly associated with estradiol, sex hormone-binding globulin, and testosterone/estradiol ratio. Different association patterns were observed between fertile and subfertile/infertile men.
Anifandis et al., 2013	To investigate the relationship between male BMI, sperm parameters, and IVF outcomes	Retrospective study	Greece	301 couples undergoing IVF	Semen analysis, embryo quality assessment, statistical analysis	Male BMI did not correlate with sperm parameters but influenced embryo quality and pregnancy rates. Couples where both partners had BMI ≤25 kg/m2 had the highest embryo quality and pregnancy rates.
Palmer et al., 2012	To review the impact of obesity on male fertility, sperm function, and molecular composition	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Male obesity negatively impacts sperm quality, alters the physical and molecular structure of germ cells, and may impair offspring

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						metabolic and reproductive health. Obesity alters the epigenetic profile of sperm.
Souter et al., 2011	To determine the fecundity of overweight and obese infertile women undergoing gonadotropin/IUI treatment	Retrospective study	USA	477 women undergoing 1,189 OI/IUI cycles	Medical records review, statistical analysis	Obese women required higher medication doses and produced fewer follicles. After adjusting for medication and response, treatment success was comparable to normal-weight women. BMI was positively associated with endometrial thickness.
Du Plessis et al., 2010	To review the effect of obesity on sperm disorders and male infertility	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Obesity is associated with a higher incidence of male factor infertility. Mechanisms include sleep apnea, hormonal alterations, increased scrotal temperatures, and impaired semen parameters.

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Pandey et al., 2010	To review the impact of female obesity on fertility treatment outcomes	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Obese women have poorer outcomes in fertility treatments, including clomiphene and gonadotropin ovulation induction, and ART. Weight loss improves spontaneous ovulation and conception rates in anovulatory overweight and obese women.
Moussa et al., 2016	To examine the effects of obesity on a woman's life from preconception to postpartum	Literature review	Global scope	N/A - Review article	Comprehensive review of existing literature	Increased BMI is associated with worse perinatal outcomes, including higher rates of preeclampsia, gestational diabetes, macrosomia, and other neonatal morbidities. Maternal obesity may predispose infants to potential adult diseases through fetal programming.

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Annex 2: CASP Quality Scores for Each Included Article

CASP Criteria	Zheng et al. (2024)	Venigalla et al. (2023)	Imterat et al. (2018)	Cekici (2018)	Chambers & Anderson (2015)	Hajshafiha et al. (2013)	Anifandis et al. (2013)	Palmer et al. (2012)	Souter et al. (2011)	Du Plessis et al. (2010)	Pandey et al. (2010)	Moussa et al. (2016)
Clear statement of aims	2	2	2	2	2	2	2	2	2	2	2	2
Appropriate methodology	2	2	2	2	2	2	2	2	2	2	2	2
Appropriate research design	2	2	2	2	2	2	2	2	2	2	2	2
Appropriate recruitment strategy	N/A	N/A	N/A	N/A	N/A	2	2	N/A	2	N/A	N/A	N/A
Appropriate data collection methods	2	2	2	2	2	2	2	2	2	2	2	2
Research relationships	1	1	1	1	1	1	1	1	1	1	1	1

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considered												
Considered ethical issues	2	2	2	2	2	2	2	2	2	2	2	2
Rigorous data analysis	2	2	2	2	2	2	2	2	2	2	2	2
Clear findings	2	2	2	2	2	2	2	2	2	2	2	2
Value of the Research	2	2	2	2	2	2	2	2	2	2	2	2
Total Score out of 20	**17**	**17**	**17**	**17**	**17**	**19**	**19**	**17**	**19**	**17**	**17**	**17**

Note: For review articles (Zheng et al., Venigalla et al., Imterat et al., Cekici, Chambers & Anderson, Palmer et al., Du Plessis et al., Pandey et al., and Moussa et al.), the "Appropriate recruitment strategy" criterion is marked as N/A (Not Applicable) as these studies do not involve direct participant recruitment. The total score for these studies is out of 18 instead of 20.