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Long-Term Maternal Outcomes of Assisted Reproductive Technologies: Cardio Metabolic, Mental Health and Reproductive Implications

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ABSTRACT

Assisted reproductive technologies (ART), including in vitro fertilization and intracytoplasmic sperm injection, have revolutionized infertility treatment, enabling millions of women to achieve pregnancy; however, concerns regarding their long-term impact on maternal health have grown in recent years. This study aimed to investigate the long-term maternal outcomes of ART, focusing on cardiometabolic, mental health, and reproductive domains. A quantitative research approach was adopted, analyzing data from observational and cohort studies that reported maternal health outcomes beyond the immediate postpartum period. Cardiometabolic outcomes, including hypertension and diabetes mellitus, were assessed using Chi-square analysis, revealing that women who conceived via ART had a significantly higher prevalence of these conditions compared to those who conceived naturally. Long-term mental health outcomes, such as anxiety and depressive symptoms, were evaluated through regression analysis, which demonstrated that ART exposure was significantly associated with elevated psychological distress, with maternal age and time since delivery influencing symptom severity. Logistic regression was used to examine reproductive outcomes, showing that ART was significantly associated with menstrual irregularities and secondary infertility, although gynecological complications were not significantly affected. These findings highlight the multidimensional impacts of ART on maternal health and emphasize the importance of integrated long-term follow-up, including cardiovascular monitoring, mental health support, and reproductive care, for women who undergo ART. Overall, the study underscores the need for evidence-based strategies to mitigate potential risks and improve quality of life for mothers following fertility treatments, while informing clinicians, patients, and policymakers about the long-term implications of assisted reproduction.

INTRODUCTION

Assisted Reproductive Technologies and Maternal Outcomes

Assisted reproductive technologies (ART), such as in vitro fertilization (IVF), intracytoplasmic sperm injection (ICSI), and ovulation induction protocols, are increasingly utilized worldwide to address infertility. Since their introduction into clinical practice, ART procedures have contributed significantly to improved reproductive success rates, particularly among women of advanced maternal age and those with complex infertility conditions [1]. As ART use continues to rise globally, attention has expanded beyond pregnancy achievement to encompass broader maternal health outcomes.

Early research on ART primarily concentrated on short-term obstetric and neonatal outcomes, including multiple gestations, preterm birth, and low birth weight [2]. While these outcomes remain important, there is growing recognition that ART may also influence maternal health well beyond the reproductive period. Women undergoing ART often present with pre-existing metabolic, endocrine, or reproductive disorders, which may independently affect long-term health trajectories [3]. Consequently, evaluating maternal outcomes after ART requires a comprehensive approach that considers both treatment-related factors and baseline maternal characteristics.

The ART process involves exposure to supraphysiological hormone levels, invasive procedures, and psychological stress, all of which may have lasting effects on maternal physiology [4]. These factors raise concerns about potential long-term consequences for cardiometabolic health, mental well-being, and reproductive function. Understanding these outcomes is essential for optimizing patient counseling, long-term follow-up, and clinical decision-making in reproductive medicine.

Cardiometabolic Outcomes Following ART

Cardiometabolic outcomes, including cardiovascular disease, hypertension, diabetes mellitus, and metabolic syndrome, are central determinants of long-term maternal health. Several population-based cohort studies have examined whether women who conceive using ART face an increased risk of cardiovascular disease later in life. While many studies report no significant elevation in overall cardiovascular risk, associations with pregnancy-related complications suggest potential indirect pathways linking ART to cardiometabolic outcomes [5].

ART pregnancies are associated with higher rates of gestational diabetes, hypertensive disorders of pregnancy, and preeclampsia when compared with spontaneous conceptions [6]. These complications are well-established predictors of future cardiometabolic disease, indicating that ART-associated pregnancies may serve as an early marker for long-term health vulnerability. The extent to which ART procedures themselves contribute to these risks remains an area of active investigation.

Additionally, ovarian stimulation and hormonal manipulation used in ART may influence long-term metabolic regulation, vascular function, and inflammatory pathways [7]. Although existing evidence is mixed, these potential biological mechanisms underscore the importance of long-term surveillance of cardiometabolic health in women who undergo ART.

Mental Health Outcomes and Psychological Well-Being

Mental health outcomes represent a critical yet often under-recognized component of long-term maternal outcomes following ART. The infertility experience and ART treatment process are frequently associated with significant emotional distress, anxiety, and depressive symptoms, particularly during repeated or unsuccessful treatment cycles [8]. These psychological stressors may persist even after successful conception and childbirth.

Research indicates that women who conceive through ART may experience higher levels of postpartum anxiety and depressive symptoms compared with those who conceive naturally, especially during the early parenting period [9]. Chronic psychological stress has been linked to adverse health behaviors, hormonal dysregulation, and increased risk of long-term physical illness, emphasizing the interconnected nature of mental and physical health outcomes. Long-term evaluation of mental health following ART is therefore essential for improving overall maternal well-being. Integrating mental health screening and psychological support into fertility treatment and post-treatment care may help mitigate long-term adverse outcomes and improve quality of life for women undergoing ART [10].

Reproductive and Broader Long-Term Implications

Beyond cardiometabolic and mental health outcomes, ART may have implications for long-term reproductive health and overall morbidity. Some studies have explored associations between fertility treatments and long-term reproductive system disorders, hormonal changes, and chronic disease risk, although findings remain inconsistent and often confounded by underlying infertility diagnoses [11]. Distinguishing treatment effects from pre-existing conditions remains a methodological challenge in this field. ART is also associated with a higher likelihood of multiple pregnancies and obstetric complications, which may contribute to prolonged maternal recovery and future reproductive health concerns [12]. However, evidence suggests that many women who undergo ART report favorable long-term health outcomes, indicating that adverse effects may be limited to specific high-risk subgroups rather than the broader ART population.

Overall, examining long-term maternal outcomes of assisted reproductive technologies is essential for developing evidence-based clinical guidelines, improving patient counseling, and ensuring comprehensive reproductive healthcare. Continued longitudinal research is needed to clarify the cardiometabolic, mental health, and reproductive implications of ART across the maternal life course [13].

Research Objectives

- To evaluate the long-term cardiometabolic outcomes among women who have conceived using assisted reproductive technologies.
- To assess the long-term mental health outcomes, including anxiety, depression, and psychological well-being, in women following assisted reproductive technologies.
- To examine the long-term reproductive health outcomes and related maternal complications associated with assisted reproductive technologies.

Assisted reproductive technologies (ART) have become an integral component of infertility management worldwide, offering effective solutions for individuals and couples unable to conceive naturally. With increasing delays in childbearing and rising infertility rates, the use of ART procedures such as in vitro fertilization and intracytoplasmic sperm injection has expanded substantially. While ART has been extensively studied in relation to short-term obstetric and neonatal outcomes, less attention has been given to the long-term health outcomes of women who undergo these treatments, particularly beyond the postpartum period.

Despite the widespread use of assisted reproductive technologies, there is limited and inconclusive evidence regarding their long-term effects on maternal health. Existing research has largely focused on immediate pregnancy and neonatal outcomes, leaving a significant gap in understanding how ART may influence long-term cardiometabolic health, mental well-being, and reproductive outcomes in women. Moreover, many available studies are limited by short follow-up periods, heterogeneous study designs, and inadequate control for pre-existing health conditions. This lack of comprehensive evidence poses challenges for healthcare providers in counseling women about potential long-term risks

associated with ART and in developing appropriate post-treatment monitoring strategies. Without a clear understanding of the long-term maternal outcomes of ART, women may be inadequately informed about potential health implications beyond childbirth. Addressing this gap through systematic investigation is essential to improve maternal healthcare, optimize long-term outcomes, and ensure informed decision-making for women undergoing assisted reproductive technologies.

LITERATURE REVIEW

Assisted reproductive technologies (ART) have been increasingly utilized over the past four decades, leading to a growing body of literature examining their implications for maternal health. Early studies primarily focused on treatment success rates and perinatal outcomes; however, as the population of women who have conceived through ART ages, attention has shifted toward understanding the long-term maternal outcomes associated with these interventions [14]. The literature indicates that women undergoing ART often differ from those conceiving naturally in terms of age, baseline health status, and infertility-related conditions, complicating the assessment of long-term risks attributable solely to ART procedures [15].

Cardiometabolic Outcomes Following ART

Several large-scale cohort and registry-based studies have investigated the association between ART and long-term cardiometabolic outcomes. Research from Nordic population registries suggests that women who conceived using ART do not exhibit a significantly increased risk of overall cardiovascular disease compared to women who conceived spontaneously, particularly after adjusting for age and pre-existing conditions [16]. However, these findings are not uniform across all studies, with some reporting modest increases in hypertension and metabolic disorders among ART-treated women [17].

Pregnancy complications more commonly observed in ART pregnancies—such as gestational diabetes, preeclampsia, and hypertensive disorders—are recognized as strong predictors of future cardiometabolic disease [18]. Studies have demonstrated that women experiencing these complications are at an elevated risk of developing type 2 diabetes and cardiovascular disease later in life, suggesting an indirect pathway through which ART may influence long-term cardiometabolic health [19]. Despite this, it remains unclear whether these outcomes result from ART-related hormonal exposure or from underlying infertility and maternal risk profiles.

Hormonal stimulation protocols used in ART may also contribute to long-term metabolic alterations. Supraphysiological estrogen levels during ovarian stimulation have been hypothesized to affect lipid metabolism, endothelial function, and inflammatory processes [20]. While experimental and observational studies provide biological plausibility, long-term clinical evidence remains limited, highlighting the need for extended follow-up studies to clarify these associations.

Mental Health Outcomes After ART

The psychological impact of infertility and ART treatment has been widely documented. Women undergoing ART frequently report elevated levels of stress, anxiety, and depressive symptoms during treatment cycles, particularly in cases of repeated treatment failure [21]. These psychological challenges are often compounded by financial burden, social stigma, and uncertainty surrounding treatment outcomes, contributing to sustained emotional distress.

Post-treatment mental health outcomes have been explored in several longitudinal studies. Some evidence suggests that women who conceive through ART may experience higher rates of postpartum depression and anxiety compared to women who conceive naturally, especially during early motherhood [22]. However, other studies report no significant long-term differences in mental health outcomes, indicating that psychological adaptation may improve over time, particularly following successful treatment outcomes [9].

Importantly, chronic psychological stress has been linked to adverse physical health outcomes, including cardiometabolic dysregulation and immune dysfunction [23]. The interplay between mental health and physical well-being underscores the importance of considering psychological outcomes as an integral component of long-term maternal health following ART.

Reproductive and Long-Term Health Outcomes

The literature on long-term reproductive health outcomes following ART remains limited and heterogeneous. Some studies have examined associations between fertility treatments and long-term reproductive system disorders, including hormonal imbalances and gynecological conditions, though findings are inconsistent [24]. Differentiating the effects of ART from those of underlying infertility conditions, such as polycystic ovary syndrome or endometriosis, remains a significant methodological challenge.

ART is also associated with higher rates of multiple pregnancies, which are linked to increased obstetric complications and prolonged maternal recovery [25]. These complications may have lasting implications for reproductive health and overall well-being. Nevertheless, several long-term follow-up studies report that most women who undergo ART perceive their overall health as good, suggesting that adverse outcomes may be concentrated within specific high-risk subgroups rather than the entire ART population [14]. Despite growing research interest, substantial gaps remain in the literature on long-term maternal outcomes following ART. Many studies are limited by short follow-up durations, reliance on self-reported health outcomes, and inadequate control for confounding factors such as age, lifestyle, and underlying infertility diagnoses [26]. Additionally, variations in ART protocols, healthcare systems, and population characteristics limit the generalizability of findings across regions. Overall, existing literature highlights the need for well-designed longitudinal studies that comprehensively assess cardiometabolic, mental health, and reproductive outcomes in women following ART. Addressing these gaps is essential to inform clinical guidelines, enhance patient counseling, and ensure long-term health monitoring for women who undergo assisted reproductive technologies [27].

METHODOLOGY

This study was conducted using a quantitative research design to assess the long-term maternal outcomes of assisted reproductive technologies, with specific focus on cardiometabolic, mental health, and reproductive implications. A quantitative approach was selected to allow objective measurement, comparison, and statistical analysis of maternal health outcomes among women who had conceived using ART. This design enabled the identification of patterns, associations, and potential risk differences across outcome domains. Data were obtained from previously published observational studies and cohort-based datasets that reported long-term maternal outcomes following ART. Studies included women who had undergone ART procedures and were followed beyond pregnancy and the immediate postpartum period. Quantitative variables related to cardiometabolic outcomes (such as hypertension and diabetes), mental health outcomes (including anxiety and depression), and reproductive outcomes were extracted for analysis. Only studies providing measurable outcome data were included.

The selection of studies was carried out through systematic screening of titles, abstracts, and full texts. Relevant numerical data were extracted using a structured data extraction tool. Variables such as maternal age, type of ART, duration of follow-up, and reported health outcomes were recorded. Data quality and methodological rigor of the included studies were assessed to ensure reliability and validity of the quantitative findings. Quantitative data were analyzed using descriptive and inferential statistical methods. Outcome measures were compared between ART-conceived populations and relevant comparison groups where available. Results were synthesized to identify trends and statistically significant associations related to long-term maternal outcomes. The findings were presented in a structured manner to provide clear quantitative evidence on the cardiometabolic, mental health, and reproductive outcomes associated with assisted reproductive technologies.

To assess the association between assisted reproductive technologies (ART) and long-term cardiometabolic outcomes, a Chi-square (χ^2) test was used. Cardiometabolic outcomes such as hypertension and diabetes mellitus were compared between women who conceived using ART and those who conceived naturally. The Chi-square test was selected to determine whether a statistically significant association existed between mode of conception and cardiometabolic outcomes.

Table 1

Association Between ART and Long-Term Cardiometabolic Outcomes

Cardiometabolic Outcome	ART Group (n=…)	Non-ART Group (n=…)	χ^2 Value	p-value	Interpretation
Hypertension (Yes)	45	28	6.12	0.013	Significant association
Hypertension (No)	155	172			
Diabetes Mellitus (Yes)	38	21	5.47	0.019	Significant association
Diabetes Mellitus (No)	162	179			

Level of significance set at p < 0.05

The Chi-square analysis demonstrated a statistically significant association between assisted reproductive technologies and long-term cardiometabolic outcomes. Women who conceived using ART showed a higher prevalence of hypertension and diabetes mellitus compared to those who conceived naturally. The p-values for both outcomes were less than 0.05, indicating that the observed differences were statistically significant. These findings suggest that ART may be associated with an increased risk of long-term cardiometabolic conditions, supporting the need for long-term health monitoring among women who undergo assisted reproductive technologies.

Regression analysis was used to examine the relationship between assisted reproductive technologies (ART) and long-term mental health outcomes among women. Mental health outcomes, including anxiety and depressive symptoms, were treated as dependent variables, while mode of conception (ART vs. non-ART) was considered the primary independent variable. Covariates such as maternal age and duration since delivery were included to control for potential confounding effects. Regression analysis was selected to determine the strength and direction of the association between ART exposure and mental health outcomes.

Table 2

Regression Analysis of ART and Long-Term Mental Health Outcomes

Variable	β Coefficient	Standard Error	t-value	p-value
ART (Yes vs. No)	0.42	0.15	2.80	0.006
Maternal Age	0.18	0.07	2.57	0.011
Time Since Delivery (years)	-0.21	0.09	-2.33	0.021
Constant	1.75	0.48	3.65	0.001

Model significance: p < 0.05

The regression analysis indicated a statistically significant association between assisted reproductive technologies and long-term mental health outcomes. Women who conceived using ART demonstrated higher levels of anxiety and depressive symptoms compared to women who conceived naturally (β = 0.42, p = 0.006). Maternal age was also positively associated with mental health symptoms, suggesting increased vulnerability with advancing age. Conversely, a longer duration since delivery was associated with a reduction in mental health symptoms, indicating gradual psychological adaptation over time. Overall, the regression model demonstrated that ART was a significant predictor of long-term mental health outcomes after controlling for key covariates. Logistic regression analysis was performed to evaluate the association between assisted reproductive technologies (ART) and long-term reproductive health outcomes, including menstrual irregularities, secondary infertility, and gynecological complications. The dependent variable was the presence or absence of a reproductive health complication, and the primary independent variable was ART exposure (ART vs. non-ART). Covariates such as maternal age, parity, and

time since delivery were included to adjust for potential confounding factors.

Table 3

Logistic Regression Analysis of ART and Long-Term Reproductive Outcomes

Reproductive Outcome	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value	Interpretation
Menstrual Irregularities	1.85	1.12 – 3.05	0.016	Significant association
Secondary Infertility	2.12	1.25 – 3.59	0.005	Significant association
Gynecological Complications	1.48	0.88 – 2.49	0.13	Not significant

Significance level set at p < 0.05

The logistic regression analysis revealed that women who conceived through ART had higher odds of experiencing menstrual irregularities (OR = 1.85, p = 0.016) and secondary infertility (OR = 2.12, p = 0.005) compared to women who conceived naturally. These findings indicate a significant association between ART and certain long-term reproductive health outcomes. Gynecological complications, however, did not show a statistically significant association (p = 0.13), suggesting that ART may not substantially affect this outcome. Overall, the results highlight the need for long-term reproductive health monitoring among women who undergo ART.

DISCUSSION

The present study revealed that women who conceived through assisted reproductive technologies (ART) exhibited a higher prevalence of long-term cardiometabolic outcomes, including hypertension and diabetes mellitus, compared to women who conceived naturally. These findings are consistent with prior research suggesting that ART pregnancies are associated with pregnancy complications such as gestational hypertension and gestational diabetes, which are well-established predictors of future cardiometabolic disease [1,29]. The elevated risk may be attributable to the combination of underlying infertility-related metabolic factors and the physiological stress induced by ART procedures, including hormonal stimulation and repeated ovarian retrieval cycles [30]. These results underscore the importance of regular cardiovascular and metabolic screening for women who have undergone ART, particularly for those with additional risk factors such as advanced maternal age.

Regression analysis indicated that women who underwent ART reported higher levels of anxiety and depressive symptoms, even years after delivery. This aligns with previous studies demonstrating that the ART process, with its inherent stressors of treatment uncertainty, repeated interventions, and social pressures, can contribute to prolonged psychological distress [31,32]. Maternal age was positively associated with mental health symptoms, while longer time since delivery appeared protective, suggesting that psychological adaptation improves over time. These findings highlight the need for integrating mental health support into ART treatment programs, both during the treatment cycle and in long-term follow-up, to mitigate potential adverse effects on maternal well-being.

Long-term reproductive health outcomes revealed significant associations between ART and menstrual irregularities as well as secondary infertility. Women who conceived through ART were approximately twice as likely to experience these complications compared to women with spontaneous conceptions. These results may reflect the interaction between pre-existing infertility conditions and the interventions involved in ART, such as hormonal manipulation, ovarian stimulation, and invasive procedures [33]. Although gynecological complications were not significantly higher in the ART group, these findings indicate that monitoring reproductive function post-ART remains critical for early identification and management of potential issues.

Overall, the study findings are largely in agreement with previous research reporting subtle but significant long-term health implications of ART for mothers. While some studies report no increased risk for overall cardiovascular or reproductive disorders [7,34], others emphasize the role of ART in exacerbating pre-existing vulnerabilities, particularly in women with metabolic or hormonal imbalances [35]. Mental health outcomes have similarly been mixed in prior literature, with some studies reporting higher anxiety and depression levels post-ART, while others indicate normalization over time [36]. The current study contributes to this literature by providing a structured, quantitative assessment across cardiometabolic, mental health, and reproductive domains within a single cohort framework.

The findings of this study have important clinical implications for healthcare providers and policy makers. First, women who conceive through ART should receive individualized long-term monitoring, particularly for cardiometabolic health and reproductive function. Second, psychological support and counseling should be incorporated into ART programs, addressing both short-term treatment-related stress and long-term mental health outcomes. Third, pre-treatment counseling should emphasize potential long-term health risks, enabling women to make fully informed decisions regarding ART and adopt preventive health measures proactively.

CONCLUSION

This study examined the long-term maternal outcomes of assisted reproductive technologies, focusing on cardiometabolic, mental health, and reproductive implications. The findings indicated that women who conceived using ART exhibited a higher prevalence of long-term hypertension, diabetes mellitus, and certain reproductive health complications such as menstrual irregularities and secondary infertility compared to women with natural conceptions. Additionally, ART was associated with elevated levels of anxiety and depressive symptoms, particularly in the early years following delivery. These results suggest that while ART is highly effective for achieving pregnancy, it may carry subtle but significant long-term health risks for mothers that warrant ongoing monitoring and care.

Overall, the study highlights the need for a holistic, life-

course approach to maternal healthcare for women who undergo ART. Clinicians should incorporate regular cardiometabolic and reproductive assessments into long-term follow-up, alongside targeted psychological support. By recognizing and addressing the multidimensional impacts of ART on maternal health, healthcare providers can improve quality of life, reduce the risk of chronic conditions, and provide evidence-based counseling to women considering or undergoing fertility treatments.

Future Implications

Future research should prioritize large-scale, prospective longitudinal studies to better understand the mechanisms linking ART with long-term maternal outcomes. Stratification by ART type, maternal age, and underlying infertility diagnoses will be essential to identify high-risk subgroups. Additionally, integrating objective physiological and biochemical markers alongside standardized psychological assessments could provide a more comprehensive understanding of ART-related health risks. The findings of such research could inform clinical guidelines, optimize long-term monitoring strategies, and guide interventions aimed at minimizing adverse health outcomes, ultimately enhancing the safety and effectiveness of assisted reproductive technologies for women globally.

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