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Review

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Preconception Health Indicators: A Comprehensive Scoping Review

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Abstract

Objectives: Preconception health significantly influences maternal and child health outcomes. Identifying and addressing preconception health indicators can facilitate healthier pregnancies and improved maternal and fetal outcomes. This scoping review examines various preconception health indicators, including biomedical and social factors, highlighting the need for comprehensive preconception care (PCC).

Methods: A comprehensive search was performed using Scopus, PubMed, Cochrane Library, and Web of Science databases. Studies on multiple preconception health indicators were included based on predefined levels of inclusion criteria. Data was extracted, charted, and synthesized to identify key indicators and their influences on reproductive health.

Results: The qualitative synthesis included 31 studies. The review identified critical biomedical indicators, such as preconception folic acid (FA) supplementation, preventing 69% of neural tube defects (NTDs) worldwide. Other indicators included managing metabolic disorders, cardiovascular diseases, autoimmune conditions, and vaccination coverage. Behavioral indicators stressed reducing tobacco use, promoting physical activity, and supporting mental health. Social indicators focused on access to health care, health literacy, education, and socioeconomic stability. Additionally, paternal PCC and genetic counseling are vital for optimizing pregnancy outcomes. Women lacking social support face significant health risks during pregnancy and implementing social support systems can reduce maternal death rates and improve reproductive health.

Conclusions: Improving maternal and child health measures requires addressing preconception health indicators using comprehensive care programs. Chronic condition interventions should focus on management, promoting healthy lifestyle behaviors, nutrition, and access to healthcare services. Paternal PCC and genetic counseling can be added as valuable measures.

Keywords: Preconception health, Biomedical indicators, Behavioral indicators, Chronic disease management, Folic acid supplementation, Paternal preconception care, Genetic counseling, Maternal health, Child health.

Introduction

Preconception care (PCC) includes interventions aimed at modifying biomedical, behavioral, and social risks affecting women's health and pregnancy outcomes (1,2). PCC within primary care enhances health knowledge and preconception behaviors. However, evidence regarding how paternal health and PCC influence pregnancy outcomes, fetal development, and long-term child health remains limited (3). Effective PCC improves pregnancy outcomes, reduces neonatal and maternal mortality, and lowers related health costs. Despite its significance, the implementation and uptake of PCC services vary widely, underscoring the need for standardized indicators to measure their effectiveness and reach (2,3).

Biomedical indicators relate to physical health and medical history (4). Key indicators include preconception folic acid (FA) intake, which is essential for preventing neural tube defects (NTDs), reducing risks of congenital heart defects, and addressing low birth weight. Another critical indicator is the percentage of women with chronic diseases who are properly diagnosed and managed before conception (5–8). Tracking vaccination coverage among women of childbearing age is also vital, as immunization prevents disease and protects maternal and fetal health (9). Early detection and treatment of infections such as HIV, syphilis, toxoplasmosis, and rubella can prevent Adverse pregnancy outcome (APO), making screening for these infections before conception essential (9). Nutrition plays a crucial role in maternal and fetal health, with indicators including body mass index (BMI), micronutrient (MM) levels, and dietary surveys (10). Research shows both underweight and overweight individuals face higher pregnancy complications, such as gestational diabetes, preeclampsia, and preterm birth (11).

Behavioral indicators assess lifestyle and behavior factors affecting reproductive health (4). Key indicators include tobacco and substance use rates among women of reproductive age, as smoking, alcohol, and illicit drugs can adversely impact fertility and pregnancy (12,13). Regular physical activity positively influences reproductive

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health, making the proportion of women meeting activity recommendations an important indicator. Psychological well-being significantly impacts reproductive health, with stress, anxiety, and depression prevalence, along with mental health service availability, as critical indicators (14,15). While diagnosed anxiety and depression are emphasized due to their prevalence and adverse reproductive health impacts, other psychiatric conditions like schizophrenia and bipolar disorder must also be considered. Research shows women with severe mental illnesses, such as schizophrenia and bipolar disorder, face higher risks of APOs, including preterm birth and low birth weight (16). Furthermore, untreated psychiatric disorders during preconception increase the likelihood of pregnancy complications (17). Comprehensive preconception mental health screenings are essential for managing psychiatric conditions and ensuring optimal maternal and fetal health outcomes.

Social indicators are socioeconomic or environmental factors affecting preconception health (4). These include healthcare service availability, measured by the percentage of women accessing these services. Health literacy and education level among women of childbearing age are crucial for health behaviors and outcomes. Socioeconomic factors—such as income, employment, and housing stability—affect preconception health, including socioeconomic status and access to care (18). Support from family, friends, and community greatly impacts well-being during preconception. Social support boosts emotional resilience, stress management, and health behaviors, improving reproductive health outcomes (19). Strong support systems in PCC promote equality and enhance maternal-child health results (20).

These indicators are essential for assessing the effectiveness of PCC and shaping policies and practices aimed at improving maternal and child health outcomes (21-23). The United Nations Sustainable Development Goals state, "By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births." Preconception policies and strategies are cornerstone tools to achieve this goal (24). The AAFP recommends tailored care plans emphasizing health promotion, risk assessment, and interventions prior to conception to improve pregnancy outcomes (25).

Despite numerous publications on this topic over the past decades, there has yet to be a standardized framework for PCC indicators. Some studies report up to 96 potential indicators (1), while others narrow this number down to around 30 (23), with reports listing 66, 50, or 32 indicators overall (2,3,26). We address these research questions: What are the critical biomedical, behavioral, and social indicators influencing preconception health, and how do these indicators impact reproductive health outcomes? This study focuses on periconceptional care, organizing findings by biomedical, behavioral, and social indicators rather than geographic levels. While economic factors and healthcare systems influence the accessibility and quality of PCC, the review primarily examines key determinants of preconception health to guide healthcare providers, researchers, and policymakers.

Material and Methods

This review was developed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension checklist (27).

Eligibility Criteria and Search

The eligibility criteria for this review were defined to encompass a wide range of PCC indicators. While this study primarily focuses on periconceptional care, certain gestational factors, such as maternal nutrition and lifestyle, are considered for their long-term effects on reproductive health. Studies were included if they covered PCC indicators, including biomedical, behavioral, social, genetic, epigenetic, and carrier screening. Both quantitative and qualitative research, as well as policy documents, were eligible. We excluded studies that did not assess or focus on PCC, were not available in full text, involved animal studies, or were case report studies.

A comprehensive search was conducted in Scopus, PubMed, Web of Science, and Cochrane Central for relevant evidence published from January 2000 to October 2024. We used keywords and Medical Subject Headings (MeSH) terms related to preconception care, biomedical, behavioral, and social indicators. The search included terms like "preconception care," "indicators," "biomedical," "behavioral," "social," "genetics," "epigenetics," and "carrier screening," along with their synonyms. A sample PubMed search string was: ("Preconception Care"[MeSH] OR "Preconception Health" OR "Reproductive Planning") AND ("Indicators" OR "Biomarkers" OR "Genetics" OR "Epigenetics" OR "Behavioral Factors" OR "Social Determinants"). Two reviewers (A.A. and S.A.) independently reviewed titles, abstracts, and full texts. Any disagreements were settled at each phase through discussions with a third independent reviewer (A.S.). In addition, reference lists of included studies and relevant policy documents were searched manually for any additional sources of evidence.

Data Processing

In considering the frameworks of our review, Arksey & O'Malley's framework, Levacs and colleagues defined data charting. Key issues and themes were sifted, sorted, extracted, and charted from the material. The primary data were charted and summarized. The results were then reviewed to identify gaps, interpret the findings, and reach a consensus on the final reporting (28).

Data Items

The extracted items for this review included authors, publication year, study design type (quantitative, qualitative, or mixed methods), and country of origin. Additionally, the study-specific PCC indicators were recorded. Assumptions and simplifications regarding the categorization of indicators and the interpretation of findings from various evidence types were meticulously documented during data extraction.

Results

Findings of Our Search

Initially, 707 studies were identified; 467 unique studies remained after removing duplicates. Of these, 267 did not meet the eligibility criteria. The remaining 200 studies were screened in full text, with 169 excluded for insufficient data on PCC indicators. Finally, we included 31 studies that met our inclusion criteria. A summary of the characteristics of the included studies is presented in Table S1 (Supplementary file 1). The PRISMA flow diagram illustrates all stages of the literature search and study selection (Figure 1).

Study Characteristics

The included studies vary in geographic regions, study designs, and types of evidence. The publication years range from 2000 to October 2024, reflecting the evolving nature of PCC research. The studies encompass quantitative research articles, qualitative studies, policy documents, and expert opinions, providing a comprehensive overview of PCC indicators.

Overview of Findings

Biopsychosocial Dimensions

The biopsychosocial model provides a holistic approach to PCC, emphasizing the interconnected roles of biological, psychological, and social factors in reproductive health. Biological factors such as chronic health conditions, directly impact fertility and pregnancy outcomes, making medical management and proper nutrition essential before conception. Psychological factors, including mental health and stress, also play a significant role, as anxiety and depression can disrupt hormonal balance and overall reproductive health. Additionally, social factors—such as socioeconomic status, cultural beliefs, family dynamics, and healthcare greatly influence a person's ability to seek and benefit from preconception counseling. Cultural traditions may shape family planning attitudes, while family support systems impact engagement with reproductive healthcare. By integrating these dimensions, healthcare providers can offer comprehensive and personalized PCC, addressing medical needs alongside psychological support and social determinants to optimize maternal and child health outcomes (29-31).

Biomedical Indicators

a. Nutritional Status and Folic Acid Supplementation

Nutritional indicators included BMI, MM levels, and dietary assessments. The prevalence of adequate nutritional status ranged from 50% to 80%, indicating

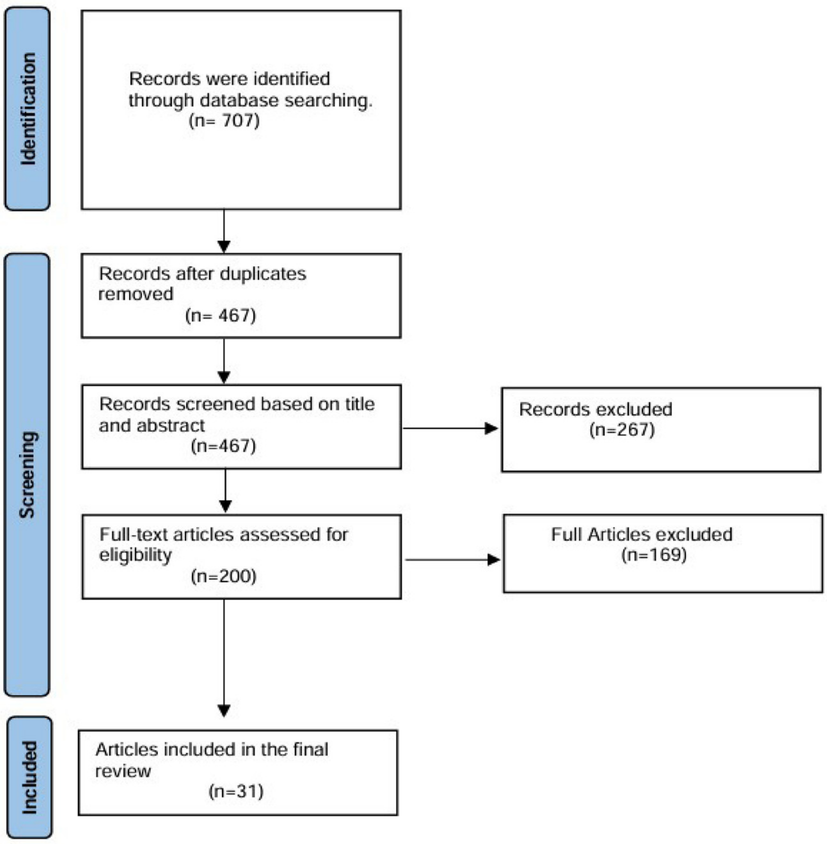

Figure 1. The PRISMA Flowchart of the Literature Search.

regional disparities. Many studies highlight the importance of FA supplementation in PCC, as it plays a critical role in preventing NTDs. Poor preconception nutrition adversely affects pregnancy outcomes, with underweight women at a 32% increased risk of preterm delivery. Similarly, maternal obesity is associated with a higher risk of pre-eclampsia, gestational diabetes, as well as an increased incidence of NTDs and congenital heart diseases in offspring. Although these effects occur during pregnancy, they originate from preconception health, underscoring the need for early nutritional interventions. Additionally, some studies link anemia during pregnancy to low birth weight; addressing iron deficiency preconception could mitigate these risks (32).

FA is one of the most essential MM in the preconception period; it can prevent 69% of NTDs (32). The daily FA requirement among women of reproductive age is 400 μg (33). Prior women who gave birth to NTD-affected babies face greater probabilities of having another NTD baby. Additional clinical guidelines prescribe an elevated FA dosage level to at-risk patients. A daily consumption of 4 mg (4000 μg) of FA becomes essential according to the Centers for Disease Control and Prevention (CDC) starting at least one month before conception through the first trimester. Research demonstrates that high FA doses effectively decrease the risk that NTDs will happen again (34) (Table 1). We reported the pooled prevalence of FA use among women in the preconception period (35) (Table 2).

FA supplementation rates among women of childbearing age vary widely, from 0% in some regions to as high as 78% in Europe, with many studies showing 30%-50%. This gap highlights the need for public health interventions to promote preconception FA intake, which is essential for preventing NTDs and other congenital anomalies. Maternal folate concentration is key for child's metabolic health and mitigating risks from maternal obesity. The Boston Medical Centre's prospective birth observational study involved 1517 mothers and children, showing an L-shaped relationship between maternal folate levels and overweight or obese children. Those of obese mothers with low folate levels faced an increased risk of developing overweight or obese, with an odds ratio of 3.05 compared to children of normal-weight mothers with higher folate levels. While focusing on pregnancy outcomes, these findings suggest optimal folate intake during preconception is vital for improving maternal metabolic health and reducing future offspring risks.

Vitamin B12 is crucial in one-carbon metabolism, affecting DNA methylation. Maternal vitamin B12 deficiency is linked to offspring overweight, obesity, and insulin resistance through differential DNA methylation, reinforcing the importance of a quality maternal diet for fetal development.

Another investigation explored the link between maternal BMI in the preconception period and nutritional risk factors of newborns. Utilizing data from The Applied Research Group for Kids (TARGet Kids!), they found that for every one-unit increase in a mother's BMI before pregnancy, the child's nutritional risk score increased by 0.09 units (10). These findings highlight the importance of preconception weight management in promoting better

Table 1. Preconception Nutrition, Dietary Supplementations, and Related Measures/Parameters (33)

Item	Background	Strength recommendation	Quality of evidence
Vitamin A	*Recommended daily allowance is 700 RAE/day. * It enhances the development of normal visual functioning, fetal growth, and immunity. *Vitamin A can have a protective effect on pregnant women with HIV/AIDS	B	III
Folic acid	*Recommended daily allowance is 400 μg in the preconception period and 600 micrograms during pregnancy. 4000 μg is recommended for women with a previous child with NTDs. *Preventive against NTDs.	A	I-a
Multivitamins	*Recommended daily allowance of folic-acid-containing multivitamins is 400 μg. *Multivitamins are reported to decrease the incidence of neural tube, cardiovascular, urinary tract, and limb defects.	A	II b
Vitamin D	*Recommended daily allowance is 400-800 IU. *Vitamin D is essential in neonatal calcium handling and adequate skeletal development.	B	I b
Calcium	*Recommended daily allowance of 1000-1300 mg/d. *Higher birth weight, decreased preterm delivery risk, and decreased infant BP.	A	I b
Iron	*Recommended daily allowance is 18-27 mg/d. *Iron deficiency anemia is associated with decreased birth weight, prematurity, and intrauterine growth restriction.	A	IB
Iodine	*Recommended daily allowance is 150-250 μg/d. *Maternal iodine deficiency can lead to abortion, mental retardation, and cretinism.	A	II-2

BP, blood pressure; RAE, Retinol activity equivalent; NTD, neural tube defect.

Table 2. Pooled Prevalence of Folic Acid Use by Women in the Preconception Period

Region	Prevalence Range
Africa	0%
Asia	21% to 46%
Australia/New Zealand	32% to 39%
Europe	9% to 78%
Middle East	4% to 34%
North America	32% to 51%

neonatal health outcomes.

The PRECONCEPT study was a double-blind, randomized controlled trial conducted on 5011 women of childbearing age in Vietnam (5). The study explored the effect of preconception MM supplementation on maternal depressive symptoms (MDS) during pregnancy and postpartum. Women were randomized to receive iron and folic acid (IFA), multiple MM, or FA alone. Overall, MDS did not significantly differ among groups; however, women who received MM or IFA demonstrated reduced depressive scores during pregnancy compared to those receiving FA alone. Results from this also point to the potential utility of MM supplementation for maternal mental health, especially for those at greater risk for depression. Although this study assessed MDS during pregnancy and postpartum, its results suggest that MM supplementation before conception may play a role in reducing the risk of perinatal depression, particularly in high-risk populations.

The relationship between dietary habits and psychosocial factors among women undergoing PCC was studied using social cognitive theory. A cross-sectional study in Isfahan, Iran, with 120 women revealed that access to healthy food and self-efficacy were essential determinants of proper dietary habits. These findings emphasize the need for interventions aimed at improving food accessibility and enhancing self-efficacy, which could significantly improve preconception nutritional status and subsequently lead to better pregnancy outcomes (38).

Literature on this theme suggests making more significant social movements to encourage better nutritional behaviors at the preconception period and enhancing strong leadership at the regional and international level to establish and implement policies and programs that could improve overall public health in this regard. Nevertheless, it is recommended that more research be conducted for a better understanding of the link and mechanisms of maternal nutrition to the health and growth of their offspring (39–41).

b. Chronic Disease Management

Managing chronic diseases such as diabetes, hypertension, and thyroid disorders is vital for reducing pregnancy complications. The SNiP study, a cross-sectional neonatal survey in Pomerania involving 5320 pregnant women, revealed that one-fifth of pregnant women present with at least one chronic illness. Additionally, 10% of women with at least one chronic disease delivered prematurely, compared to 7.5% in the healthy group (42). These findings emphasize the need for chronic disease management before conception to lower pregnancy-related risks.

Women with type 2 diabetes mellitus are particularly vulnerable to negative maternal and fetal outcomes. Achieving optimal glycemic control prior to conception reduces the risk of congenital anomalies, delivery before 39 weeks of gestation, preeclampsia, and macrosomia. However, PCC for diabetic women goes beyond managing blood glucose levels; it also includes optimizing blood pressure (BP), lipid profiles, and body weight to improve maternal and fetal health outcomes (43).

Preterm delivery, small for gestational age, and perinatal infant death are becoming increasingly associated with hypertension in women of reproductive age. Among 567 127 mother-neonate-father triads in Guangdong province, China, a population-based cohort study showed that women with elevated BP or hypertension a year before pregnancy had a higher risk of APOs compared to women who did not have elevated BP. Elevated BP and hypertension were associated with significant adverse outcomes, with an adjusted risk ratio of 1.07 for elevated BP and 1.25 for hypertension. However, these risks decreased and became statistically insignificant if hypertension was managed more than 90 days before conception. This suggests early intervention and preconception hypertension management are crucial in improving pregnancy outcomes (44).

Thyroid disease is the most prevalent endocrine disorder among women of reproductive-age. Those with thyroid dysfunction planning pregnancy should receive preconception counseling to optimize thyroid function. This includes reviewing thyroid health, using contraception until thyroid levels stabilize, and discussing thyroid disease's effects on pregnancy. Hypothyroid patients should adjust levothyroxine dosage to achieve a thyroid-stimulating hormone level of less than 2.5 mU/L (45).

Pregnant women require optimal thyroid status to reduce adverse outcomes. A retrospective study using the Clinical Practice Research Datalink database analyzed thyroid management in pregnant women with hyperthyroidism and reported that suboptimal thyroid status was prevalent, particularly in those who had prior treatments like thyroidectomy and radioiodine therapy before conception. While this study focusing on pregnancy outcomes, the findings highlight the need for optimal thyroid function before conception for better maternal health and fetal development (45). Iodine supplementation for women with thyroid disease should also be part of preconception counseling, especially in areas where iodine deficiency exists (46). Women with epilepsy require special medication management, as certain antiepileptic drugs, particularly sodium valproate, can cause birth defects and neurodevelopmental issues in children (47). The goal of preconception counseling for epilepsy patients is to manage seizures effectively and reduce teratogenic risks by considering lamotrigine and levetiracetam if suitable (48).

c. Vaccination Status

Another key focus of PCC includes immunization for diseases like rubella, hepatitis B, and human papillomavirus (HPV). Recommended vaccines are Tdap, hepatitis B, HPV, MMR, varicella, and influenza. Women of reproductive age should be screened for immunity to infections such as varicella and rubella and immunized as needed before pregnancy. Hepatitis B and MMR vaccines are highly recommended as they effectively prevent maternal disease and congenital rubella syndrome. While HPV, varicella, and Tdap vaccines are recommended, their benefits in preconception are less definitive. Influenza vaccination is advised before or during pregnancy to prevent flu-related complications (9).

Immunization rates differ significantly among pregnant women who live in urban versus rural areas due to varying Medicaid coverage. Rural women often depend on Medicaid for prenatal care but have less comprehensive coverage than urban women. In states lacking full Medicaid expansion, rural women exhibited notably lower influenza and Tdap vaccination rates, underscoring the need for better access to preconception immunization services (49).

d. Screening for Infectious Diseases

A wide range of women were screened for infections like HIV, syphilis, and toxoplasmosis, depending on both public health and access to healthcare. Because infections have the potential to impact pregnancy outcomes, screening and treatment are key components of PCC. Recommendations (“A”) are given for treatment of these infections (e.g., Chlamydia, syphilis, HIV) before pregnancy to prevent infertility, ectopic pregnancies, neonatal infections, fetal harm, and chronic infection in offspring. Infections with “B” recommendation infections are tuberculosis, gonorrheal infection, and selected HSV infections. Evidence supports the benefits of diagnosing and managing these infections during the preconception period. “C” recommendation infections encompass hepatitis C, cytomegalovirus, listeriosis, toxoplasmosis, malaria, and bacterial vaginosis in women with prior preterm birth and periodontal disease. For infections such as toxoplasmosis, preconception education is critical. Women should be counseled on avoiding high-risk foods and safe handling of cat litter to reduce maternal-fetal transmission risk (50).

Behavioral Indicators

a. Tobacco and Substance Use

The rate of tobacco and substance use among women of reproductive age is a critical indicator. In a prospective cohort study involving 259 participants, 12% were smokers, 22% were alcoholics, and 17% were binge drinkers. Upon follow-up, the data indicated a significant impact of PCC interventions on promoting healthy behaviors and reducing binge drinking (P = 0.007) (51). A review article analyzing data from the Behavioral Risk Factor Surveillance System (BRFSS) indicated significant enhancements in certain behaviors, such as decreased smoking and alcohol abuse among women of reproductive age in the 21st century, as a result of PCC efforts (52).

Bello et al analyzed drug and alcohol use using the Optum® Electronic Health Record dataset, focusing on preconception service delivery among women with substance use disorders (SUD). The study included 52,565 women aged 18 to 55, with births between 2012 and 2018. They found 6.4% had a SUD diagnosis, and 6.0% received preconception services before pregnancy. The prevalence of receiving these services was higher among women with SUD (9.6%) compared to those without (5.7%). Logistic regression analysis revealed increased odds of receiving preconception services for women with SUD, controlling for medical comorbidities (53).

b. Physical Activity

Regular physical activity is associated with improved reproductive health. However, studies indicate that only 20.4% to 47% of women engage in the recommended levels of physical activity. Several poor behaviors that could negatively impact pregnancy outcomes were discussed in the literature. In Iran, data from 480 women who participated in preconception programs in Mashhad revealed that only about 7% were engaged in regular physical activity (54). Preconception metabolic health and physical activity levels have also been linked to gestational diabetes risk and offspring birth weight. One study found that women’s preconception physical activity levels could help predict gestational diabetes risk and fetal growth outcomes, emphasizing the need for early lifestyle interventions (55).

c. Stress and Mental Health

Indicators of psychological well-being included the prevalence of stress, anxiety, and depression. Mental health issues varied, with stress levels reported between 20% and 50%, and access to mental health services remained a critical gap. Mental health-related issues reported by women during the preconception period and since adolescence can directly impact birth outcomes and child health. A prospective cohort study reported that parents who were diagnosed with depression and anxiety during adolescence or adulthood had lower emotional bonds with their children (56).

A study by Farr and Bish (57) using BRFSS found that good preconception indicators were better in women with infrequent mental distress (P < 0.001). Women's mental health before pregnancy can affect other preconception indicators such as nutrition, social surroundings, and behaviors (e.g., smoking). Those with preconception mental issues were less likely to take the recommended folate supplements, consumed fewer fruits and vegetables, and were more likely to engage in negative behaviors like tobacco use, drug abuse, and physical inactivity (58). These findings support early screening and treatment of depression, anxiety, and other mental health disorders to enhance preconception health and improve pregnancy outcomes (57,59).

Worse mental health condition during conception was also considered to be a significant determinant of infant emotional reactivity, which is also established as a risk factor for intergenerational mental disorders. A prospective study demonstrated that 37% of infants whose mothers had preconception mental illness had high emotional reactivity, establishing a clear correlation between maternal mental health before conception and children's mental health (60).

Callegari et al investigated PCC among women veterans in 2019 (61). Analysis of multivariate statistics indicates women veterans have higher rates than the general population of mental health disorders, including anxiety, depression, post-traumatic stress disorder (PTSD), and sleep disorders. Between 23% to 48% of women veterans have had depression, and 17% to 41% have PTSD and sleep disorders (62-65). In a national survey of women veterans using VA primary care services, 69% reported a history of at least one mental disorder, and over 50% had multiple mental disorders (66). Intimate partner violence is more common among veterans than nonveterans and is linked to low birth weight, preterm birth, and poor mental health. The U.S. recommends intimate partner violence screening for all women of childbearing age (67). Early identification of psychosocial stressors and access to mental health services are crucial for improving preconception health and maternal and fetal outcomes.

Social Indicators

a. Education and Health Literacy

Education and health literacy levels among women of childbearing age are crucial for health behaviors. Higher education levels correlate with better health outcomes. A community-based cross-sectional study conducted in Southwest Ethiopia included 623 pregnant women—553 from eight rural Gandas and 70 from one urban Ganda. It found that only 21.3% of pregnant women had strong awareness of PCC. This knowledge was significantly influenced by their own higher educational attainment ($\beta = 3.6$; $P < 0.001$) and their husbands' ($\beta = 2.3$; $P = 0.001$) higher educational attainment. Additional factors were planned pregnancy (β=1.2; $P = 0.005$) and regular medical follow-ups ($\beta = 1.5$; $P = 0.014$). A separate study in Adet Town, Northwestern Ethiopia, examined PCC knowledge and contributing factors, finding an overall knowledge level of 27.5%. Women aged 25 to 34 who completed secondary education had higher knowledge levels (AOR 6.52, CI: 2.55, 16.69) and (AOR 4.10, CI: 1.78, 9.44). Although focused on pregnant women, these findings highlight the role of preconception health literacy in enhancing early health behaviors and pregnancy planning.

b. Socio-economic Status

Socio-economic factors, including income, employment, and housing stability, are associated with preconception health. Studies indicate that lower socio-economic status is linked to poorer PCC indicators. Women experiencing their first pregnancy with severe preconception psychiatric conditions often come from lower socioeconomic backgrounds and exhibit multiple indicators of socioeconomic disadvantage (69). A study examining women's knowledge and behaviors related to preconception risk factors in two community health centers serving lower-income, racially diverse populations found that despite a strong awareness of preconception risk factors, high-risk behaviors and conditions remained common. The survey conducted among women aged 18 to 44 years highlighted several key findings: 63% of women were classified as overweight or obese, and 20% reported alcohol consumption. Notable differences in risk factors emerged between Black, non-Hispanic, and Hispanic respondents. Black and non-Hispanic women showed higher rates of overweight/obesity and alcohol use (18). For instance, de Jong-van den Berg et al (70) found that while awareness of the benefits of FA in the preconception period is essential, its usage relates to factors such as education level, family income, and ethnicity. Moreover, the CDC (71) reports that "forgetting" is the most common reason for not taking a vitamin supplement daily. However, in a study of Hispanic women from low-income backgrounds, researchers found that many did not regularly take vitamins due to issues such as lack of money and misunderstandings about the benefits of FA (72). These findings underscore the need for cultural ly tailored preconception education programs to enhance nutritional supplementation adherence among women from underserved communities.

Additional Indicators

a. Paternal Preconception Health

During pregnancy, 50% of the deoxyribonucleic acid (DNA) is derived from male spermatozoa. Numerous factors, including environmental influences and lifestyle choices, appear to contribute to DNA damage through oxidative stress, thereby diminishing sperm quality and reducing the likelihood of successful pregnancies. Moreover, from an ethical standpoint, men have a moral obligation to alter their preconception lifestyles and habits to foster a healthy and safe environment for child-rearing. Furthermore, fathers are positioned to positively influence maternal behaviors, such as substance use and the early adoption of prenatal care, each of which can significantly impact pregnancy outcomes. Studies indicate that men's preconception health is increasingly recognized as a vital factor in enhancing reproductive health, pregnancy, and neonatal outcomes. Male PCC encompasses actions that the male partner can undertake prior to conception to enhance his health and that of the fetus. This includes upholding high standards of personal hygiene, engaging in regular physical activity, ceasing tobacco use, and developing skills to manage stress and underlying health conditions. A study conducted by Choiriyyah et al (73) evaluated the necessity for PCC among men aged 15 to 44 years; sixty percent of study participants indicated their need for PCC. This need was particularly pronounced among younger age cohorts, individuals residing in urban areas, and recent immigrants to the United States. Additional details regarding health care risks among men requiring PCC can be found in Table 3.

Research in the last decade emphasizes the importance of paternal preconception health on pregnancy and birth outcomes. Studies from 2007 to 2017 involving 108 couples in fertility treatment showed that higher paternal folate intake predicted longer gestation and improved pregnancy outcomes. Specifically, a 400 μg/d increase in paternal folate intake correlated with a 2.6-day longer gestation period, accounting for maternal folate intake and other variables (74). In a qualitative study focused on men's need for PCC, participants highlighted the necessity of including men in reproductive health planning to improve pregnancy outcomes. Interviews and focus groups reached a consensus on the need for PCC services for men, addressing lifestyle choices, health-seeking behavior, and environmental risk exposure (75). A web-based survey conducted among fathers in Italy revealed that 35% of the participants smoked, 8% were obese, and 20% were exposed to environmental substances. It showed that interventions aimed at reducing these risk factors are required to improve pregnancy outcomes, especially among men with lower educational levels. Further research indicated that suboptimal health in men, characterized by poor lifestyle behaviors and inadequate health service utilization, adversely affects reproductive outcomes (76). NHANES data from 2013 to 2018 revealed that men with disabilities had significantly higher rates of suboptimal preconception health indicators, such as smoking, excessive alcohol use, and poor diet, compared to men without disabilities (77).

Table 3. Health Care Risks Among Men in Need of Preconception Care

Healthcare Risks	Prevalence
Poor/fair overall health status	4%
Overweight/ obesity	57%
Underweight	2%
Daily use of marijuana	7%
Binge drinking in the last year	58%
Use of cocaine, crack, crystal/meth, or IV drugs	7%
High STI risks	21%

b. Genetics and Epigenetics

Genetic and epigenetic factors are increasingly recognized as important in PCC. Studies discussed the role of genetic screening and counseling in preconception health. A study that included 832 participants from Australia revealed that 92% of the study participants support genetic testing and screening. Good genetic knowledge correlates well with participants' intention to use preconception carrier screening (78). Preconception expanded carrier screening (ECS) uses next-generation sequencing to identify at-risk carriers of recessive disorders, aiding couples facing conception challenges, particularly in populations with high consanguinity. In one of 30 couples who underwent the study, 90% carried at least one variant in 95 genes, with the HBA, HBB, CYP21A2, and G6PD genes being the most common. ECS facilitates informed decision-making regarding reproductive choices and reduces the risk of having offspring with genetic disorders (79). Genomic clinical sequencing was evaluated in a randomized controlled trial involving women and their partners considering pregnancy, comparing genomic screening to usual care. The study assessed clinical and personal utility, costs, and psychosocial impacts, providing insights into the benefits and challenges of integrating genomic screening into PCC. This research demonstrated the potential of genomic screening to enhance reproductive planning and influence healthcare decisions (80). Epigenetic modifications play a crucial role in early embryonic development, and preconception interventions aimed at optimizing parental health can significantly influence fetal outcomes.

Recent studies have evaluated the cost-effectiveness of integrating epigenetic screening and lifestyle interventions into PCC programs. For instance, preconception ECS effectively reduces Mendelian disease incidence. A study found that preconception ECS lowers the affected birth rate compared to minimal screening, estimated to be cost-effective with an incremental cost per life-year gained below $50 000 (81).

Discussion

This review evaluates the relevant literature on key local, regional, and national preconception indicators. Among reproductive-age women, there are significant regional disparities in nutritional status, with 50% to 80% having adequate nutrition. Many studies have focused on the importance of FA supplementation in preventing NTDs. FA supplementation is consistently emphasized for its critical role in preventing these defects, with supplementation rates varying widely across different regions—from as high as 85% to as low as 30%. This demonstrates that targeted public health interventions are necessary to increase FA consumption (32). The control of chronic diseases is an important biomedical PCC indicator; a study of 5320 pregnant women in Pomerania found that 20% had at least one chronic illness, with 10% giving birth prematurely, compared to 7.5% of healthy women. Additionally, factors like preterm delivery, small for gestational age, and perinatal infant death are increasingly linked to hypertension in women of reproductive age (44). Regarding vaccination status, rural women have lower vaccination rates due to limited Medicaid coverage compared to urban women, highlighting healthcare access disparities. Recommended PCC vaccinations include Tdap, hepatitis B, HPV, MMR, varicella, and influenza. Screening for HIV, syphilis, and toxoplasmosis is crucial, as infections can affect pregnancy outcomes. Treatment recommendations are provided for infections, including chlamydia and syphilis, before pregnancy to prevent complications. Conditions like hepatitis C and toxoplasmosis receive educational 'C' recommendations on preventive behaviors. The behavioral indicators show tobacco use among reproductive-age women ranges from 0% to 35%, with substance use at 5% to 20%. A secondary analysis of BRFSS data (2003-2010) among 547 177 non-pregnant U.S. women aged 18–44 revealed significant improvements in alcohol use, smoking, social support, physical activity, and influenza vaccination, underscoring the importance of PCC.

Other behavioral indicators examined in our scoping review include physical activity status and mental health among women of reproductive age. Engagement in recommended levels of physical activity among women varied from 30% to 60%, with notable regional disparities. For instance, a study in Mashhad reported that only 7% of 480 women in preconception programs were regularly active. Engaging in physical activity during the preconception period is crucial, as it reduces the risk of gestational diabetes and supports healthier birth weights (54). Mental health issues such as stress, anxiety, and depression had prevalence rates ranging from 20% to 50%, adversely impacting pregnancy outcomes and child health. PCC also enhances mental health, which is associated with improved pregnancy outcomes, underscoring the significance of early screening and treatment of mental illnesses (56). Higher education and health literacy levels were linked to better preconception health outcomes (82).

Recent research highlights the increasing importance of paternal health in PCC. Studies indicate that many men—particularly younger individuals, urban residents, and recent immigrants have a greater need for PCC to optimize reproductive and overall family health outcomes. Additionally, men are often at risk for health issues such as obesity, binge drinking, and high rates of sexually transmitted infections that can negatively impact pregnancy outcomes (73,74). Genetic screening, such as ECS, is also becoming a vital PCC tool for couples to make informed decisions and minimize genetic risks (79).

Future studies should further explore the social and psychological dimensions of PCC, as these aspects remain underrepresented in the current literature. While this review acknowledges the roles of family functioning, societal expectations, and cultural traditions, but in-depth research is needed on how these factors influence individuals' decisions to seek preconception counseling. Understanding the interplay between social structures and reproductive health could offer valuable insights for culturally sensitive interventions. Mental health also plays a crucial role in PCC, yet its impact on reproductive health outcomes is insufficiently studied. Future research should investigate the effects of stress, anxiety, depression, and other psychological conditions on preconception health-seeking behaviors, fertility, and pregnancy outcomes. Integrating mental health assessments and interventions into PCC programs could lead to more comprehensive reproductive health strategies. Despite growing recognition of paternal health in PCC, research in this area is limited compared to maternal health. Evidence suggests that men's lifestyle factors, nutritional status, and chronic disease management significantly influence sperm quality and overall pregnancy outcomes. However, PCC often overlooks male health interventions, focusing primarily on maternal factors. Additionally, the long-term impact of paternal health behaviors on reproductive success and fetal development should be studied. There is a need to develop targeted interventions that promote healthy preconception behaviors in men, including nutritional supplementation, physical activity, substance use reduction, and chronic disease management. Integrating male preconception health into routine reproductive healthcare could enhance couple-based planning and ultimately improve maternal, fetal, and child health outcomes.

Limitations

This scoping review aims to map the landscape of epidemiological evidence of PCC, rather than provide clinical recommendations. Unlike systematic reviews that synthesize clinical effectiveness data, this approach allows for broad exploration of key preconception indicators across biomedical, behavioral, and social domains. While it does not yield quantitative clinical conclusions, it provides a comprehensive overview to inform future research, policy development, and healthcare strategies. Despite efforts to encompass a wide spectrum of studies, it is imperative to acknowledge a potential bias within existing literature, particularly concerning the overrepresentation of studies from high-income countries. This overrepresentation may reflect disparities in research funding, infrastructure, and publication rates, which could distort the evidence base towards contexts endowed with greater resources and more developed healthcare systems. Consequently, the findings may not entirely encapsulate the experiences, outcomes, or contextual challenges encountered in low- and middle-income countries (LMICs).

The generalizability of the findings to low-resource settings is limited. Many of the interventions, technologies, or healthcare delivery models assessed in the reviewed studies may not be feasible or sustainable in LMICs due to financial, infrastructural, or human resource constraints. Additionally, cultural, political, and social determinants that influence health outcomes in these settings are often underexplored in studies conducted in high-income countries. Therefore, caution should be exercised when applying the conclusions of this review globally, and further research is needed to contextualize and adapt evidence-based practices to low-resource environments

A key strength of this review is its extensive, iterative search strategy, ensuring a wide-ranging and inclusive assessment of the available literature.

Conclusions

PCC aims to identify and addresses health risks before pregnancy, enabling early interventions that can enhance pregnancy outcomes and optimize interpregnancy intervals. Physical, mental, and nutritional health during this period is critical for future mothers, offspring, and male partners, whose health and lifestyle choices significantly influence reproductive success. Health education and counseling should be promoted among all reproductive-age individuals. Encouraging regular use of PCC services is essential, especially in low-income and vulnerable populations with limited access. More research is needed to develop and strengthen preconception policies, ensuring services are widely available and affordable. Given the evidence supporting men's role in reproductive success, they should also engage in PCC, as their health impacts partners and children. Addressing male-specific health indicators, such as lifestyle, chronic disease management, and reproductive screenings, is vital for improving family health and reproductive outcomes. To support these efforts, there is a critical need for the development of standardized PCC indicators, which would enable consistent evaluation, guide future research, and inform effective policy-making.

Conflict of Interests
The author declares that there are no competing interests.

Availability of data and materials
All data and materials used in this study, including all reviewed studies, are available upon request from the corresponding author

Ethical Issues
Not applicable.

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Supplementary files
Supplementary file 1 contains Table S1 (the summary characteristics of the included studies).

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