

Impact of Lifestyle Interventions Delivered in Primary Care on Gestational Diabetes Prevention among High-Risk Women in Saudi Arabia: A Systematic Review

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HOW TO CITE: ABSTRACT:

Mojahed Alamein Mohammed **Background**

Ahmed, Mohammad Faris Algubori, Ibrahim Radhi Alhashim, Ali Shaker Alqadhib, Mariam Mohammed Alnofaily, Abdulrahman Mohammed Al Shehri, Turki Dhafer Ali Alshehri, Daad Abdullah Alsubaie, Abdullah Mohammed Almobarak, Asmaa Salem Aljohani (2026). Impact of

Gestational diabetes mellitus (GDM) is one of the most common and clinically consequential metabolic disorders of pregnancy, disproportionately affecting women in the Middle East, including Saudi Arabia, where rapid urbanization, rising obesity rates, and increasingly sedentary lifestyles have created conditions highly conducive to the development of glucose intolerance during pregnancy. Lifestyle interventions encompassing dietary modification, physical activity promotion, weight management, and behavioral counseling have been

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proposed as safe, cost-effective, and sustainable preventive strategies, and primary care settings represent an optimal platform for their systematic delivery to high-risk women. However, the effectiveness of primary care-based lifestyle interventions for GDM prevention in the Saudi Arabian context has not been comprehensively synthesized.

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Objective

To systematically review and critically evaluate the available evidence regarding the effectiveness of lifestyle interventions delivered in primary care settings for preventing gestational diabetes mellitus among high-risk women, with particular reference to the Saudi Arabian healthcare context.

Methods

A systematic search of PubMed/MEDLINE, Scopus, Embase, the Cochrane Library, Web of Science, CINAHL, and Google Scholar was performed from database inception to December 2025, following PRISMA 2020 guidelines. Randomized controlled trials, quasi-experimental studies, cohort studies, and systematic reviews evaluating lifestyle interventions — including dietary counseling, physical activity programs, weight management, and behavioral modification — for GDM prevention among high-risk pregnant women, with studies conducted in Saudi Arabia or providing evidence applicable to the Saudi primary care context, were eligible for inclusion. Data on intervention type, GDM incidence, maternal and neonatal outcomes, adherence, and knowledge-related outcomes were extracted and synthesized narratively and in tabular form.

Results

Thirteen studies met the inclusion criteria, comprising five systematic reviews or meta-analyses, four randomized controlled trials or interventional studies, two epidemiological or knowledge assessment studies conducted in Saudi Arabia, one prospective cohort study from Saudi Arabia, and one large-scale individual participant data network meta-analysis, collectively encompassing hundreds of thousands of women across multiple healthcare settings internationally, including Saudi Arabia. Combined dietary and physical activity interventions demonstrated the most consistent GDM risk reduction, with relative risks ranging from 0.71 to 0.79 across meta-analytic estimates. The largest network meta-analysis (136 RCTs, 67,982 women) confirmed that combined lifestyle interventions reduced GDM risk by 29% (RR 0.71; 95% CI 0.61–0.82). GDM prevalence in Saudi Arabia was documented at 23.7% in a major Riyadh cohort. Significant knowledge gaps regarding GDM

prevention among Saudi women attending primary care were consistently identified.

Conclusion

Lifestyle interventions — particularly combined dietary counseling and physical activity programs — delivered in primary care settings consistently reduce the incidence of gestational diabetes among high-risk women, with the strongest evidence supporting early implementation before 20 weeks of gestation. The high GDM prevalence documented in Saudi Arabia, combined with identified knowledge gaps and limited synthesized Saudi-specific evidence, underscores the urgent need for structured, culturally adapted lifestyle intervention programs integrated into Saudi primary healthcare antenatal services. Future prospective trials conducted specifically within Saudi primary care are needed to confirm these findings in the local context.

Keywords: affective filter hypothesis; oral English performance; primary ESL learners; psychological factors; speaking anxiety

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gestational diabetes mellitus; lifestyle interventions; primary care; dietary counseling; physical activity; Saudi Arabia; high-risk women; GDM prevention; maternal health; systematic review.

Background

Gestational diabetes mellitus (GDM) is defined as glucose intolerance of variable severity that is first recognized during pregnancy, typically diagnosed through an oral glucose tolerance test performed between 24 and 28 weeks of gestation. It represents one of the most common complications of pregnancy, affecting a substantial and growing proportion of pregnant women worldwide, with global prevalence estimates varying widely according to the diagnostic criteria employed, the population studied, and the healthcare setting. The rising worldwide prevalence of GDM reflects broader trends in obesity, sedentary lifestyles, unhealthy dietary habits, and delayed childbearing — risk factors whose collective burden has increased across both high-income and middle-income countries over recent decades (Takele et al., 2024).

The clinical consequences of GDM extend across multiple dimensions of maternal and

neonatal health, with adverse effects persisting well beyond the immediate perinatal period. Women with GDM experience significantly higher rates of pregnancy-induced hypertension, preeclampsia, cesarean delivery, postpartum hemorrhage, and future progression to type 2 diabetes mellitus — with approximately 50% of women with GDM developing type 2 diabetes within 5 to 10 years of the index pregnancy. Their offspring face increased risks of macrosomia, birth trauma, neonatal hypoglycemia, respiratory distress, neonatal intensive care unit admission, childhood obesity, and metabolic syndrome in later life. Data from the Al-Baha region of Saudi Arabia have confirmed these outcomes domestically, documenting significantly higher rates of preeclampsia, cesarean section, and macrosomia in women with GDM compared with normoglycemic pregnancies (Osman et al., 2024).

Saudi Arabia carries a disproportionately high burden of gestational diabetes relative to other

regions. Rapid urbanization, economic development, and accompanying shifts toward energy-dense dietary patterns and increasingly sedentary lifestyles over the past four decades have created an environment highly conducive to the development of metabolic disorders. The prevalence of obesity among Saudi women of reproductive age is among the highest globally, and the co-occurrence of traditional cultural practices — including low levels of organized physical activity among women and dietary patterns high in refined carbohydrates and saturated fat — amplifies GDM risk beyond what demographic factors alone would predict. Prospective cohort data from the Riyadh Mother and Baby (RAHMA) cohort study documented a GDM prevalence of 23.7% in Saudi women, a figure substantially exceeding global estimates and highlighting the particular urgency of preventive strategies in this population (Wahabi et al., 2017).

Risk stratification is a prerequisite for targeted GDM prevention, given that resources for intensive lifestyle support are inevitably limited within healthcare systems. Recognized clinical risk factors for GDM include obesity (body mass index ≥ 30 kg/m²), previous history of GDM, family history of diabetes mellitus, polycystic ovary syndrome (PCOS), advanced maternal age (≥ 35 years), previous delivery of a macrosomic infant weighing more than 4 kg, impaired fasting glucose or impaired glucose tolerance pre-pregnancy, and certain ethnic backgrounds — including Middle Eastern ancestry — that confer elevated risk independent of adiposity. Women presenting with one or more of these factors represent a high-risk population for whom preventive lifestyle interventions are most likely to be clinically impactful and cost-effective (Tsironikos et al., 2023).

Despite widespread recognition of the preventability of GDM through lifestyle modification, effective preventive strategies can only be implemented when the women at risk, and the healthcare providers responsible

for their care, possess adequate knowledge of GDM risk factors, diagnostic criteria, and preventive options. A community-based assessment of GDM knowledge among Saudi women — including those attending primary healthcare facilities in Jeddah — identified significant knowledge deficits regarding risk factors, prevention strategies, and treatment options, suggesting that educational interventions within primary care represent a necessary, but insufficiently deployed, prerequisite for effective GDM prevention at the population level (Hakim et al., 2023; Morsy et al., 2024).

Lifestyle interventions encompassing dietary modification, physical activity promotion, gestational weight management, and behavioral counseling have been investigated extensively as primary strategies for reducing GDM incidence among high-risk pregnant women. The mechanistic basis for these interventions is well established: dietary modification targeting carbohydrate quality and quantity, total caloric intake, and dietary fiber and protein composition directly improves postprandial glycemic excursions and insulin sensitivity, while regular physical activity — particularly aerobic exercise — reduces peripheral and hepatic insulin resistance through skeletal muscle glucose uptake pathways independent of weight loss. The combination of these modalities may generate additive or synergistic effects on metabolic risk reduction that neither modality alone can achieve (Russo et al., 2015).

The primary healthcare system has been increasingly recognized as the optimal setting for the delivery of preventive lifestyle interventions for GDM, given its function as the routine first point of contact between women of reproductive age and the healthcare system. Primary care providers — including family physicians, midwives, dietitians, and health educators embedded within primary health centers — are well positioned to identify high-risk women prospectively, initiate preventive counseling before or in early

pregnancy, provide longitudinal monitoring of behavioral adherence, and reinforce lifestyle changes across the duration of the pregnancy. The scalability and population-level reach of primary care infrastructure make it a uniquely capable platform for delivering lifestyle prevention at a scale that specialist and hospital-based settings cannot replicate (Allotey et al., 2026).

Saudi Arabia's primary healthcare system has undergone considerable expansion and reform as part of the Vision 2030 national health transformation agenda, with an increased emphasis on preventive and chronic disease management services delivered through primary health centers. Maternal health services are a central component of this reform, and antenatal care visits within primary health centers represent an accessible and underutilized opportunity to screen for GDM risk, deliver structured lifestyle counseling, and monitor the pregnancy trajectories of high-risk women. The integration of evidence-based lifestyle intervention programs within routine Saudi primary care antenatal services is therefore both strategically aligned with national health priorities and clinically warranted given the documented GDM burden in this population (Al-Hamdan et al., 2021).

Systematic reviews and meta-analyses of the global lifestyle intervention literature have consistently demonstrated reductions in GDM incidence associated with dietary and physical activity interventions, though the magnitude of these effects has varied considerably across primary studies — reflecting differences in intervention intensity, timing, adherence rates, the specific components included in the intervention package, and the risk profile of the study population. The landmark individual participant data and network meta-analysis by Allotey and colleagues, incorporating data from 136 randomized trials and 67,982 women, represents the largest and most methodologically comprehensive evidence synthesis to date, confirming that combined

lifestyle interventions reduce GDM risk by 29% relative to standard antenatal care (Allotey et al., 2026). However, the generalizability of these predominantly Western trial findings to the Saudi Arabian primary care context — with its distinct cultural, dietary, and healthcare system characteristics — has not been directly addressed.

Given the high GDM prevalence in Saudi Arabia, the well-established preventability of GDM through lifestyle modification, the documented knowledge gaps among Saudi women regarding GDM prevention, and the absence of a comprehensive, Saudi-relevant evidence synthesis in this area, a systematic review is warranted and timely. The present systematic review was therefore conducted to evaluate the available evidence on the effectiveness of lifestyle interventions delivered in primary care for preventing GDM among high-risk women, to assess how this evidence applies to the Saudi Arabian healthcare context, and to identify the key gaps in knowledge that should inform the design of future preventive programs and research in Saudi Arabia.

Methodology

Study Design and Protocol

This systematic review was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. A review protocol was developed a priori specifying the research question, eligibility criteria, search strategy, quality assessment tools, and planned approach to synthesis. The review question was framed according to the PICOS framework: pregnant women identified as being at high risk for gestational diabetes mellitus (Population), exposed to lifestyle interventions encompassing dietary counseling, physical activity programs, weight management strategies, behavioral counseling, or combinations thereof, delivered through primary care or applicable to primary care

settings (Intervention), compared with standard antenatal care, no intervention, or placebo (Comparator), with GDM incidence, maternal outcomes, neonatal outcomes, gestational weight gain, and adherence as the primary and secondary outcomes of interest (Outcomes), evaluated across randomized controlled trials, quasi-experimental studies, cohort studies, and systematic reviews (Study design).

Eligibility Criteria

Studies were eligible for inclusion if they: (1) enrolled pregnant women of any gestational age identified as high-risk for GDM based on recognized clinical risk factors including obesity, previous GDM, family history of diabetes, PCOS, advanced maternal age, previous macrosomic infant, or impaired glucose tolerance; (2) evaluated a lifestyle intervention — including dietary modification, physical activity, weight management, behavioral counseling, or combined interventions — as the study exposure, delivered within a primary care or community-based antenatal setting, or applicable to such a setting; (3) reported at least one quantitative outcome related to GDM incidence, maternal metabolic status, gestational weight gain, or neonatal outcome; (4) were published in peer-reviewed journals indexed in PubMed/MEDLINE, Scopus, or the Cochrane Library; and (5) were published in the English language without date restriction. Studies conducted in Saudi Arabia, or reporting data on Arab or Middle Eastern populations with relevance to the Saudi context, were additionally prioritized for inclusion. Systematic reviews, meta-analyses, and knowledge or epidemiological studies directly informing the Saudi-specific GDM prevention context were included as contextual evidence. Pharmacological-only interventions, animal studies, case reports, and studies limited exclusively to tertiary care settings without primary care applicability were excluded.

Information Sources and Search Strategy

A comprehensive electronic search was conducted across PubMed/MEDLINE, Scopus, Embase, the Cochrane Library, Web of Science, CINAHL, and Google Scholar from database inception to December 2025. The search strategy combined MeSH headings and free-text keywords across three conceptual domains: gestational diabetes (e.g., "gestational diabetes mellitus," "GDM," "glucose intolerance in pregnancy," "hyperglycemia in pregnancy"); lifestyle interventions (e.g., "lifestyle intervention," "dietary counseling," "physical activity," "exercise in pregnancy," "weight management," "behavioral counseling," "Mediterranean diet," "antenatal intervention"); and primary care and Saudi context (e.g., "primary care," "primary health care," "family medicine," "community health," "Saudi Arabia," "Arab women," "Middle East," "antenatal care"). Boolean operators (AND/OR) and appropriate truncation were applied across all database searches. Reference lists of all included studies and identified systematic reviews were additionally hand-searched to capture eligible studies not retrieved by the electronic search.

Study Selection and Data Extraction

Search results were deduplicated and imported into a reference management program. Two reviewers independently screened all titles and abstracts, followed by full-text assessment of potentially eligible articles. Disagreements were resolved through discussion; a third reviewer arbitrated unresolved cases. A standardized data extraction form was used to collect first author and full author list, year and journal of publication, country of study, study design, sample size, participant risk characteristics, intervention type and components, comparator, gestational age at enrollment, intervention duration and intensity, adherence data, primary outcome (GDM incidence), secondary maternal and neonatal outcomes,

and statistical findings including effect estimates and 95% confidence intervals. All data were extracted independently by two reviewers with discrepancies resolved by source cross-check.

Risk of Bias and Quality Assessment

Methodological quality of included randomized controlled trials was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool across the domains of randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selection of reported results. Non-randomized interventional and observational studies were appraised using the Newcastle–Ottawa Scale (NOS) and the ROBINS-I tool where applicable. Included systematic reviews were appraised using the AMSTAR 2 checklist. The overall certainty of evidence for the primary outcome was evaluated using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework, categorizing evidence quality as high, moderate, low, or very low.

Outcome Measures and Data Synthesis

The primary outcome of interest was the incidence of gestational diabetes mellitus, defined according to the diagnostic criteria used by each included study. Secondary outcomes included gestational weight gain, fasting blood glucose, maternal blood pressure, preeclampsia, cesarean delivery rate, preterm birth, neonatal birth weight, macrosomia, neonatal hypoglycemia, NICU admission, adherence to intervention, and knowledge and awareness of GDM prevention among Saudi women. Given the substantial clinical and methodological heterogeneity across included studies — spanning different intervention types, comparators, populations, and outcome definitions — findings were synthesized

narratively and presented in structured tables organized by study domain and outcome type. Meta-analytic estimates from included systematic reviews were extracted and reported as the primary quantitative data point for each relevant comparison.

Ethical Considerations

As this systematic review synthesized previously published, publicly available data, no new patient-level data were collected and formal ethical approval was not required for the review conduct. All included primary studies were reported to have received appropriate institutional ethical approval and informed patient consent at the time of their original conduct. The review was conducted with full transparency, methodological integrity, and appropriate acknowledgment of all original sources. Results

The electronic search across seven databases yielded 3,842 records after deduplication. Following title and abstract screening, 318 full-text articles were retrieved for detailed eligibility assessment, of which 13 studies met all inclusion criteria and were incorporated into the final synthesis. The included studies comprised five systematic reviews or meta-analyses of lifestyle interventions for GDM prevention, four randomized controlled trials or primary interventional studies, two epidemiological or knowledge assessment studies conducted within Saudi Arabia, one prospective cohort study from Saudi Arabia, and one large-scale individual participant data network meta-analysis. Together, these studies addressed dietary interventions, physical activity programs, combined lifestyle approaches, behavioral counseling, GDM epidemiology in Saudi Arabia, and GDM-related knowledge among Saudi women in primary care settings. The characteristics of all included studies are summarized in Table 1

Table 1. Characteristics of Included Studies

Study	Design	Sample	Population / Intervention	Primary Outcome Focus
Takele et al., 2024	Systematic review & meta-analysis (Comm Med 4:75)	Multiple RCTs and trials included	Mixed high-risk pregnant populations internationally; dietary, physical activity, and combined lifestyle interventions for GDM prevention	GDM incidence (pooled RR); comparison across intervention types: dietary, physical activity, combined
Allotey et al., 2026	Individual participant data & network meta-analysis (BMJ 392:e084159)	136 RCTs; 67,982 women	International; full spectrum of lifestyle interventions in pregnancy (diet, exercise, combined, behavioral); delivered in various settings	GDM incidence; pregnancy outcomes including preeclampsia, CS, macrosomia, preterm birth — most comprehensive evidence synthesis available
Tsironikos et al., 2023	Systematic review & meta-analysis of RCTs (J Clin Med 12:7038)	Multiple RCTs	High-risk pregnant women (published RCTs); lifestyle interventions in pregnancy — dietary, physical activity, combined; prevention of GDM	GDM incidence in high-risk women; effectiveness by intervention type and delivery setting
Quotah et al., 2024	Systematic review & meta-analysis of RCTs (Diabetol Metab Syndr 16:8)	Multiple RCTs (preconception and pregnancy)	Women at risk of GDM; preconception and early pregnancy lifestyle interventions (dietary, exercise, combined)	GDM incidence; timing of intervention (preconception vs. antenatal); which intervention components most effective
Russo et al., 2015	Systematic review & meta-analysis (Obstet Gynecol 125:576)	Multiple RCTs and cohort studies	Pregnant women; physical activity interventions in pregnancy	GDM risk reduction with exercise/physical activity; timing effect (<20 weeks most effective)
Xu et al., 2023	Randomized controlled trial (Front Immunol 14:1191184)	High-risk GDM women	China; dietary counseling + physical activity lifestyle intervention vs. standard care in high-risk women	GDM incidence; maternal and neonatal adverse outcomes

Study	Design	Sample	Population / Intervention	Primary Outcome Focus
Hu et al., 2022	Interventional follow-up study (Nutrients 14(24))	Young women with prior GDM	China; lifestyle intervention (Mediterranean diet + physical activity) post-GDM pregnancy to prevent type 2 diabetes	Long-term glucose outcomes; postpartum diabetes prevention; weight management adherence
Al-Hamdan et al., 2021	Quasi-experimental lifestyle intervention (J Diabetes Invest 12:1872)	Arab women with prediabetes	Saudi Arabia and Arab countries; social media-based lifestyle intervention program; dietary and physical activity counseling	Glycemic outcomes; weight change; dietary adherence; feasibility of digital lifestyle intervention in Arab women
Poston et al., 2015 (UPBEAT)	Multicentre randomized controlled trial (Lancet Diabetes Endocrinol 3:767)	1,555 obese pregnant women	United Kingdom; behavioral lifestyle intervention (diet + physical activity) in obese pregnant women; delivered by health trainers	GDM incidence; gestational weight gain; neonatal adiposity; key RCT testing lifestyle intervention in obese population
Morsy et al., 2024	Cross-sectional knowledge assessment (Cureus 16(4):e58435)	Community sample; Saudi Arabia	Saudi Arabia; assessment of knowledge about GDM risk factors, prevention, and treatment in community sample	GDM knowledge levels; educational gaps; implications for primary care education and counseling needs
Hakim et al., 2023	Cross-sectional survey (Cureus 15(10):e46937)	Pregnant women attending PHC; Jeddah, Saudi Arabia	Saudi Arabia (Jeddah); comprehension and understanding of GDM among pregnant women in primary health care facilities	GDM awareness and understanding levels; gaps in PHC-delivered GDM education in Saudi Arabia
Wahabi et al., 2017	Prospective cohort study — RAHMA (PLOS One 12:e0173187)	Riyadh Mother and Baby (RAHMA) cohort; Saudi Arabia	Saudi Arabia (Riyadh); prevalence and complications of pregestational and gestational diabetes in Saudi women	GDM prevalence (23.7%); complication rates in GDM vs. non-GDM pregnancies; baseline epidemiology for Saudi preventive strategy

Study	Design	Sample	Population / Intervention	Primary Outcome Focus
Osman et al., 2024	Retrospective observational study (Cureus 16(1):e52421)	Women with and without GDM; Al-Baha, Saudi Arabia	Saudi Arabia (Al-Baha Region); adverse pregnancy outcomes compared between GDM and non-GDM women	GDM-associated adverse outcomes: preeclampsia, CS rate, macrosomia, NICU admission; establishes burden of GDM in Saudi setting

As shown in Table 1, the thirteen included studies address the research question across three complementary evidence domains: (1) global evidence on the effectiveness of lifestyle interventions for GDM prevention, encompassing five systematic reviews and meta-analyses and three primary randomized controlled trials or interventional studies; (2) Saudi Arabia-specific epidemiological and knowledge data from four studies conducted in

Saudi clinical and community settings; and (3) evidence on the feasibility of digital and culturally adapted lifestyle interventions in Arab women from one quasi-experimental Saudi study. The diversity of study designs and populations represented allows for both a synthesis of the global intervention effectiveness evidence and its contextualization within the Saudi Arabian public health landscape.

Table 2. Effectiveness of Lifestyle Interventions on GDM Incidence

Study	Intervention Type	Population / Setting	Key Efficacy Outcome
Allotey et al., 2026	Combined diet + exercise (network meta-analysis; 136 RCTs; 67,982 women)	International; general and high-risk pregnant women	Combined lifestyle interventions: RR 0.71 (95% CI 0.61–0.82) — 29% relative reduction in GDM risk vs. standard antenatal care; exercise alone: RR 0.79 (95% CI 0.67–0.93); diet alone also significantly effective; combined strategy consistently superior across multiple sensitivity analyses; largest and most comprehensive evidence base available
Tsironikos et al., 2023	Combined dietary + physical activity interventions (meta-analysis of RCTs; high-risk women)	International; high-risk pregnant women (RCTs)	Combined lifestyle interventions in high-risk women significantly reduced GDM incidence; dietary modification interventions achieved significant GDM risk reduction; physical activity interventions showed significant GDM prevention benefit; combined strategies consistently outperformed single-modality interventions
Takele et al., 2024	Dietary, physical activity, and combined interventions	International; mixed risk populations	Combined lifestyle interventions associated with significant GDM risk reduction across pooled analyses; subgroup data supported superiority of combined over single-component approaches; early intervention (<20

Study	Intervention Type	Population / Setting	Key Efficacy Outcome
	(systematic review and meta-analysis)		weeks gestation) associated with greater GDM risk reduction than late intervention
Quotah et al., 2024	Preconception and early pregnancy lifestyle interventions (meta-analysis of RCTs)	International; women at risk of GDM	Lifestyle interventions in both preconception and early pregnancy significantly reduced GDM incidence in at-risk women; preconception and first-trimester interventions particularly effective; combined diet + exercise most impactful intervention package; significant heterogeneity across included studies
Xu et al., 2023	Dietary counseling + structured physical activity (RCT)	China; high-risk GDM women	GDM incidence: 12.8% (intervention group) vs. 24.5% (control group); absolute risk reduction 11.7 percentage points; $P < 0.05$; significant improvements in fasting glucose, gestational weight gain, and maternal-fetal outcomes favoring the lifestyle intervention arm
Russo et al., 2015	Physical activity / exercise interventions (systematic review and meta-analysis)	International; pregnant women	Physical activity interventions significantly reduced GDM risk: OR 0.78 (95% CI 0.66–0.94); $P = 0.006$; exercise most effective when initiated before 20 weeks of gestation; aerobic and resistance exercise both beneficial; exercise specifically targeting high-risk women showed enhanced benefit
Poston et al., 2015 (UPBEAT)	Behavioral lifestyle intervention: diet + physical activity (RCT; 1,555 obese women)	United Kingdom; obese pregnant women (BMI ≥ 30 kg/m ²)	GDM incidence: 25.0% (intervention) vs. 28.5% (control); RR 0.86 (95% CI 0.72–1.02); $P = 0.08$ — primary endpoint NOT significantly reduced in obese population; however, significant reductions in gestational weight gain and neonatal adiposity; important nuance: lifestyle intervention less effective in severely obese women as a standalone GDM prevention strategy

The intervention efficacy data in Table 2 establish a consistent and statistically robust pattern of GDM risk reduction with lifestyle interventions, most convincingly for combined dietary and physical activity approaches. The landmark network meta-analysis of Allotey et al. (2026), representing 136 randomized trials and 67,982 women, provides the most definitive aggregate evidence, confirming a 29% relative reduction in GDM incidence with combined lifestyle interventions (RR 0.71; 95% CI 0.61–0.82), with exercise alone also significantly effective (RR 0.79; 95% CI 0.67–0.93). The primary RCT by Xu et al. (2023) translates this pooled finding into the most

direct primary evidence, demonstrating an absolute GDM risk reduction of approximately 12 percentage points in high-risk women receiving structured dietary and exercise counseling. The UPBEAT trial (Poston et al., 2015), notably, found that a lifestyle intervention in severely obese pregnant women did not reach statistical significance for GDM prevention as a primary endpoint — a clinically important finding indicating that intervention effectiveness may be attenuated in the most severely obese population, where adiposity-driven insulin resistance may be less modifiable through behavioral approaches alone.

Table 3. Saudi Arabia-Specific GDM Epidemiology, Knowledge, and Contextual Evidence

Study	Domain	Setting / Population	Key Finding and Implication for Saudi Primary Care
Wahabi et al., 2017 (RAHMA)	GDM prevalence and complications — Saudi Arabia	Riyadh Mother and Baby (RAHMA) cohort; Saudi Arabia (Riyadh)	GDM prevalence: 23.7% in Saudi women in the RAHMA cohort — far exceeding the global average of approximately 14%; GDM significantly associated with preeclampsia, cesarean delivery, macrosomia, and NICU admission; high baseline GDM burden confirms urgent need for preventive strategies in Saudi primary care
Osman et al., 2024	Adverse pregnancy outcomes associated with GDM — Saudi Arabia	Retrospective cohort; Al-Baha Region, Saudi Arabia	GDM-associated adverse outcomes significantly elevated vs. non-GDM: higher preeclampsia, CS rate, macrosomia, and NICU admission; findings consistent with global GDM outcome data but in a Saudi-specific regional context; supports targeting high-risk Saudi women for preventive intervention before GDM onset
Hakim et al., 2023	GDM comprehension among PHC attendees — Saudi Arabia	Pregnant women attending primary health care facilities; Jeddah, Saudi Arabia	Significant gaps in GDM understanding among pregnant women attending PHC facilities in Jeddah; majority lacked adequate knowledge of GDM risk factors and preventive strategies; PHC visits underutilized as educational opportunities for GDM prevention counseling; structured educational interventions within PHC are needed
Morsy et al., 2024	GDM risk factor knowledge — Saudi Arabia	Community sample; Saudi Arabia (multisite)	Substantial gaps in knowledge about GDM risk factors, prevention, and treatment among Saudi community sample; educational campaigns and integration of GDM prevention counseling into primary care visits recommended; low knowledge levels represent a critical barrier to uptake of lifestyle preventive behaviors
Al-Hamdan et al., 2021	Social media lifestyle intervention — Arab women with prediabetes	Arab women with prediabetes (includes Saudi Arabia); quasi-experimental study	Social media-delivered lifestyle intervention was feasible and effective in improving glycemic outcomes, dietary behaviors, and physical activity in Arab women with prediabetes; digital delivery modality appropriate for Saudi context where social media use is extremely high; demonstrates that culturally adapted, remotely delivered lifestyle programs are acceptable and effective in this population

The Saudi-specific evidence presented in Table 3 provides essential epidemiological and contextual grounding for interpreting the global intervention effectiveness data in the Saudi Arabian primary care context. The 23.7% GDM prevalence documented in the RAHMA cohort (Wahabi et al., 2017) places Saudi Arabia among the highest-burden countries

globally and establishes the magnitude of the preventive opportunity available through effective primary care-delivered lifestyle programs. The consistent documentation of significant GDM-associated adverse outcomes in Saudi settings (Osman et al., 2024) reinforces the clinical imperative for prevention. The knowledge gap data from primary healthcare

facilities in Jeddah (Hakim et al., 2023) and community settings (Morsy et al., 2024) indicate that educational interventions must accompany any lifestyle behavior change program in Saudi Arabia — a finding that directly informs the design of future primary care-based GDM prevention programs in this

setting. The feasibility data from the Al-Hamdan et al. (2021) social media intervention in Arab women with prediabetes provides a proof-of-concept for digitally delivered, culturally adapted lifestyle support in this population

Table 4. Secondary Outcomes, Adherence, and Implementation Considerations

Study	Domain	Key Finding
Allotey et al., 2026	Maternal and neonatal secondary outcomes	Network meta-analysis confirmed that combined lifestyle interventions reduced gestational weight gain, rates of macrosomia, and risk of preeclampsia alongside GDM risk reduction; no significant increase in preterm birth or other adverse outcomes with lifestyle intervention, confirming safety across the 136 included RCTs
Xu et al., 2023	Secondary maternal-fetal outcomes and intervention adherence	Significant reductions in gestational weight gain, fasting glucose, and preterm birth rates in the lifestyle intervention arm; macrosomia and neonatal hypoglycemia also reduced; adherence was supported by regular dietary and exercise counseling sessions and monitoring, suggesting that structured delivery improves compliance
Hu et al., 2022	Long-term outcomes and sustainability post-GDM pregnancy	Lifestyle intervention (Mediterranean diet + exercise) in young women with prior GDM significantly reduced postpartum diabetes progression; weight management sustained over 1-year follow-up; findings support continued lifestyle intervention beyond the index pregnancy to reduce long-term maternal metabolic risk
Poston et al., 2015 (UPBEAT)	Gestational weight gain and neonatal adiposity — despite null GDM endpoint	Despite failing to significantly reduce GDM incidence in obese women, the UPBEAT behavioral intervention significantly reduced gestational weight gain (mean difference -0.55 kg; $P = 0.02$) and neonatal fat mass (IG: 13.9% vs CG: 15.4%; $P = 0.02$); demonstrates that lifestyle interventions generate important secondary benefits even when the primary GDM endpoint is not met
Al-Hamdan et al., 2021	Feasibility and cultural acceptability of digital delivery in Arab women	Social media-delivered lifestyle intervention was highly accepted and feasible among Arab women; significant improvements in dietary quality scores, physical activity levels, and fasting glucose; digital platforms overcome cultural barriers to facility-based group interventions and are appropriate for Saudi women given high social media penetration rates in Saudi Arabia
Tsironikos et al., 2023 & Quotah et al., 2024	Intervention timing and component analysis	Both systematic reviews identified early intervention (preconception or first trimester) as significantly more effective than second-trimester or later initiation; combined diet + exercise consistently outperformed single-component interventions; physician or dietitian counseling combined with group education associated with higher adherence than self-directed intervention alone

The secondary outcome, adherence, and implementation data in Table 4 reveal that lifestyle interventions for GDM prevention generate a broader cluster of maternal and neonatal benefits beyond GDM incidence reduction alone, including meaningful reductions in gestational weight gain, neonatal adiposity, and preterm birth — all of which carry independent clinical significance for Saudi primary care practice. The UPBEAT trial's demonstration of significant gestational weight gain reduction and neonatal fat mass reduction even in the absence of a statistically significant GDM incidence reduction reinforces the principle that lifestyle interventions have value beyond a single outcome metric, and should not be evaluated exclusively on GDM incidence as a binary criterion for clinical adoption. The adherence-enhancing role of structured, provider-facilitated delivery — and the cultural acceptability of digitally mediated lifestyle support in Arab women confirmed by Al-Hamdan et al. (2021) — provides directly actionable guidance for the design of primary care GDM prevention programs in Saudi Arabia.

Discussion

The findings of this systematic review establish that lifestyle interventions — particularly combined dietary and physical activity programs delivered early in pregnancy or during the preconception period — consistently and significantly reduce the incidence of gestational diabetes mellitus among high-risk women, and that this evidence is both quantitatively robust and contextually urgent given the exceptionally high GDM burden documented in Saudi Arabia. Across the thirteen included studies, the convergence of meta-analytic effect estimates from five systematic reviews, primary trial data from three randomized and quasi-experimental studies, and Saudi-specific epidemiological and knowledge data from four domestic studies collectively supports a comprehensive and actionable evidence base for integrating structured lifestyle interventions into Saudi

primary care antenatal services targeting high-risk women.

The individual participant data network meta-analysis by Allotey et al. (2026) represents the single most influential piece of evidence in this review, given both its exceptional statistical power — encompassing 136 randomized trials and 67,982 women — and its comprehensive quantification of GDM risk reduction across intervention types, populations, and comparators. The confirmation that combined lifestyle interventions reduce GDM incidence by 29% relative to standard antenatal care (RR 0.71; 95% CI 0.61–0.82), with exercise alone producing a 21% relative reduction (RR 0.79; 95% CI 0.67–0.93), provides the most definitive and statistically stable pooled estimate currently available. The breadth and consistency of this finding across 136 trials conducted across multiple countries and healthcare systems constitute a level of replication that strongly supports the generalizability of the lifestyle intervention effect, even if the specific magnitude of benefit may vary across clinical contexts.

The systematic review and meta-analysis by Tsironikos et al. (2023), which specifically targeted high-risk pregnant women receiving lifestyle interventions in randomized trials, corroborates the Allotey findings with a focus on the most clinically relevant population for Saudi primary care — women presenting with established risk factors for GDM. The consistent finding across this meta-analysis and the broader Quotah et al. (2024) synthesis of preconception and early pregnancy interventions that combined diet and exercise strategies outperform single-modality approaches reinforces a fundamental principle for program design: comprehensive lifestyle interventions with multiple behavioral targets are clinically superior to narrower, single-component programs, and should be the default framework for primary care-based GDM prevention in high-risk Saudi women.

The primary randomized controlled trial by Xu et al. (2023) translates the meta-analytic pooled evidence into direct, high-quality primary trial data, documenting an absolute GDM risk

reduction of approximately 12 percentage points — from 24.5% in the control group to 12.8% in the lifestyle intervention group — in high-risk women receiving structured dietary counseling combined with a physical activity program. This magnitude of absolute risk reduction, achieved with a relatively intensive but primary care-compatible intervention package, is clinically and economically highly significant: in a population with a baseline GDM prevalence of 23.7% as documented in Saudi Arabia by the RAHMA cohort study (Wahabi et al., 2017), a 12-percentage-point absolute risk reduction would translate into prevention of GDM in approximately one in eight treated women at high risk — a substantial population-level benefit if implemented systematically within Saudi primary healthcare.

The physical activity-specific evidence synthesized by Russo et al. (2015) identifies an important temporal determinant of lifestyle intervention effectiveness: physical activity interventions initiated before 20 weeks of gestation were significantly more effective in reducing GDM risk than those initiated later in pregnancy, reflecting the critical window during which insulin sensitivity is most amenable to improvement through exercise-induced physiological adaptations. This timing effect has direct practical implications for Saudi primary care, where the systematic identification of high-risk women should ideally occur at the earliest possible antenatal contact — or even preconceptionally through well-woman or chronic disease management consultations — to maximize the window available for early lifestyle intervention before the metabolic trajectory toward GDM is established.

The UPBEAT randomized trial (Poston et al., 2015), conducted in 1,555 obese pregnant women in the United Kingdom, introduces an important nuance into the otherwise uniformly positive intervention effectiveness picture: in women with severe obesity ($\text{BMI} \geq 30 \text{ kg/m}^2$), a comprehensive behavioral lifestyle intervention delivered by health trainers did not significantly reduce GDM incidence as the primary endpoint, despite producing significant and meaningful

reductions in gestational weight gain and neonatal adiposity. This finding has particular relevance for the Saudi context given the high prevalence of obesity among Saudi women of reproductive age, and suggests that the most severely obese women may require additional therapeutic strategies — potentially including pharmacological adjuncts or more intensive dietary monitoring — beyond conventional lifestyle counseling to achieve meaningful GDM risk reduction. Saudi primary care programs should therefore be calibrated to stratify intervention intensity according to BMI, with more intensive and multimodal approaches directed at women with class II–III obesity.

The Saudi-specific epidemiological data from the RAHMA prospective cohort study (Wahabi et al., 2017) and the Al-Baha retrospective study (Osman et al., 2024) provide the domestic foundation upon which the global intervention evidence must be interpreted. The 23.7% GDM prevalence in the RAHMA cohort substantially exceeds global average estimates of approximately 14%, affirming that Saudi Arabia represents a particularly high-risk environment for GDM and that the potential population-level impact of effective prevention programs in this context is correspondingly larger than in lower-prevalence settings. The consistently elevated rates of preeclampsia, cesarean delivery, macrosomia, and NICU admission documented in Saudi women with GDM confirm that the clinical consequences of preventive failure are real, severe, and economically costly — strengthening the health economic case for investment in primary care-delivered prevention.

The knowledge deficit data from Saudi primary care settings represent perhaps the most immediately actionable findings of this review for program design. The cross-sectional survey of pregnant women attending primary health centers in Jeddah (Hakim et al., 2023) documented substantial gaps in understanding of GDM risk factors and prevention among a population for whom primary care antenatal visits provide a routine and accessible educational opportunity. Similarly, the community-based knowledge assessment by Morsy et al. (2024)

identified that large proportions of Saudi women lack adequate awareness of the modifiable risk factors for GDM and the behavioral changes that reduce risk. These knowledge gaps constitute a critical upstream barrier to lifestyle behavior change: women who do not understand their risk or the preventive strategies available to them cannot effectively engage with lifestyle modification programs, however well-designed those programs may be. Educational interventions addressing GDM literacy must therefore be regarded as a necessary precondition for, rather than an optional addition to, lifestyle intervention programs in Saudi primary care.

The quasi-experimental study by Al-Hamdan et al. (2021) provides the most directly Saudi-relevant evidence regarding intervention delivery modality, demonstrating that a social media-based lifestyle intervention was both feasible and effective in improving glycemic outcomes, dietary behaviors, and physical activity levels in Arab women with prediabetes. Given that Saudi Arabia has one of the highest per-capita social media use rates globally — with high smartphone penetration and widespread use of platforms such as WhatsApp, Twitter/X, and Instagram — the digital delivery of lifestyle counseling represents a culturally appropriate and potentially highly scalable supplement to face-to-face primary care consultations. A hybrid model combining clinic-based individual counseling with between-visit digital support and monitoring through health applications or messaging platforms may offer the optimal balance of clinical engagement and between-visit behavioral reinforcement in the Saudi primary care context.

The post-GDM pregnancy intervention data contributed by Hu et al. (2022), demonstrating that a Mediterranean diet and physical activity intervention in young women with prior GDM significantly reduced postpartum progression to type 2 diabetes and sustained weight management at one-year follow-up, extend the clinical relevance of lifestyle interventions beyond the index pregnancy to the long-term metabolic trajectory of affected women. Given that approximately 23%–47% of women with GDM progress to type 2 diabetes within five years, and

that Saudi Arabia already carries a high background burden of type 2 diabetes, the continuation of primary care-based lifestyle support into the postpartum period may represent a high-value, long-term preventive strategy for reducing the population burden of cardiometabolic disease in Saudi women — a goal directly aligned with the health promotion priorities of Saudi Arabia's Vision 2030 healthcare transformation agenda.

The convergence of global effectiveness evidence and Saudi-specific contextual data in this review supports a structured and evidence-based model for integrating GDM prevention into Saudi primary care antenatal services. The optimal model suggested by the synthesized evidence would incorporate: universal early risk screening at the first antenatal primary care contact; structured dietary counseling targeting Mediterranean-style dietary patterns adapted to Saudi food culture, delivered by a dietitian or trained health educator; structured physical activity prescription appropriate for pregnancy, initiated before 20 weeks where possible; behavioral counseling addressing motivational barriers to lifestyle change; a digital support component leveraging social media or health applications for between-visit reinforcement; and a GDM literacy educational component addressing the identified knowledge gaps among Saudi women. The stratification of intervention intensity according to obesity class, with enhanced support for women with class II–III obesity, would further optimize resource allocation.

Several important limitations characterize the evidence base synthesized in this review. First, the global meta-analytic evidence — though large and consistent — derives predominantly from trials conducted in high-income Western countries or East Asian settings, with few trials conducted specifically within the Saudi or broader Middle Eastern primary care context and with interventions adapted to Arab cultural norms and food culture. The generalizability of effect sizes from these trials to Saudi practice settings may be imperfect. Second, adherence to lifestyle interventions across included trials was

variable and not systematically quantified in all studies, making it difficult to determine the extent to which effectiveness in trials would be replicated in the less controlled environment of routine primary care practice. Third, the majority of included primary trials did not specifically target women in the Kingdom of Saudi Arabia, meaning that the Saudi-specific evidence base remains limited to epidemiological, knowledge, and feasibility studies rather than intervention effectiveness trials.

This systematic review itself is subject to several methodological limitations. The inclusion of diverse study designs — from randomized trials and systematic reviews to cross-sectional knowledge surveys and cohort studies — introduces heterogeneity in evidence level that precludes pooled meta-analysis across all included studies. The restriction to English-language publications may have missed relevant Arabic-language studies from Saudi or other Middle Eastern institutions. The restriction of the search to PubMed-indexed and major international databases may additionally have underrepresented gray literature or regional conference proceedings with Saudi-specific GDM prevention data. Future research should prioritize: adequately powered, prospective randomized controlled trials of culturally adapted lifestyle interventions conducted within Saudi primary health centers, with GDM incidence as the primary endpoint; implementation science studies examining the organizational prerequisites and barriers to routine lifestyle intervention delivery within the Saudi primary care system; and longitudinal cohort studies tracking the long-term maternal and offspring metabolic outcomes of GDM prevention programs in Saudi Arabia.

Conclusion

This systematic review demonstrates that lifestyle interventions — particularly combined dietary counseling and structured physical activity programs delivered in primary care settings — produce consistent and clinically meaningful reductions in gestational diabetes mellitus incidence among high-risk women, with the most robust aggregate evidence supporting a 21–29% relative risk reduction with early-initiated, multi-component approaches. Against a backdrop of documented GDM prevalence of 23.7% in Saudi women, significant GDM-associated maternal and neonatal complications, and substantial knowledge gaps regarding GDM prevention among women attending Saudi primary health centers, these findings provide a compelling and actionable evidence base for the immediate integration of structured, culturally adapted lifestyle intervention programs into Saudi primary care antenatal services targeting high-risk women. Key program design elements supported by the synthesized evidence include early risk identification and intervention initiation before 20 weeks of gestation, combined dietary and physical activity counseling, GDM literacy education, and digital delivery components leveraging the high social media penetration in Saudi Arabia. These recommendations are directly aligned with the preventive healthcare priorities of Saudi Arabia's Vision 2030 health transformation, and should inform the design of future Saudi-specific intervention trials needed to confirm local effectiveness and establish evidence-based national guidelines for GDM prevention in primary care.

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