

Prevention Of Type-2 Diabetes Mellitus In High-Risk Adults Using Lifestyle Interventions In Primary Care Settings: A Scoping Review

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is a major global health concern, with rising prevalence among adults at high risk due to obesity, sedentary lifestyles, and genetic predisposition. Primary care settings offer a strategic platform for implementing lifestyle interventions aimed at prevention.

Objective: This scoping review aims to map global evidence on the effectiveness of lifestyle interventions in preventing T2DM among high-risk adults within primary care and community-based settings.

Methods: Following the Joanna Briggs Institute methodology, a comprehensive search was conducted across PubMed, MEDLINE, CINAHL, AMED, and Google Scholar for studies published between 2000 and 2023. Eligible studies included adults aged 18 and above at high risk for T2DM, and evaluated lifestyle interventions—dietary changes, physical activity, and weight management—delivered through primary care or community channels.

Results: Thirty studies met inclusion criteria, predominantly randomized controlled trials and implementation studies. Combined lifestyle interventions significantly reduced the incidence of T2DM, with sustained weight loss emerging as the most consistent predictor of success. Group-based programs and culturally tailored approaches enhanced feasibility and adherence. However, implementation barriers such as limited resources, staff training, and participant engagement were noted, particularly in low-resource settings.

Conclusion: Lifestyle interventions in primary care are effective in preventing T2DM among high-risk adults. Scaling these interventions requires contextual adaptation, policy support, and sustainable delivery models. Future research should focus on long-term outcomes and strategies to overcome implementation challenges.

Introduction

Type 2 diabetes mellitus (T2DM) is a rapidly escalating global health concern, affecting over 500 million individuals worldwide and projected to reach 783 million by 2045 if current trends persist [1]. The disease is characterized by insulin resistance and progressive beta-cell dysfunction, leading to chronic hyperglycemia and associated complications such as cardiovascular disease, nephropathy, and neuropathy [2]. The burden is disproportionately higher in low- and middle-income countries, where healthcare systems often struggle to manage chronic diseases [3].

High-risk populations—defined by impaired glucose tolerance (IGT), impaired fasting glucose (IFG), elevated HbA1c, obesity, sedentary behavior, and family history—are particularly vulnerable to developing T2DM [4]. Early identification and intervention in these groups are critical to curbing disease progression. Lifestyle interventions, including dietary modification, increased physical activity, and behavioral counseling, have emerged as the cornerstone of T2DM prevention [5].

Evidence from landmark trials such as the Diabetes Prevention Program (DPP) and the Finnish Diabetes Prevention Study (DPS) demonstrated that intensive lifestyle interventions can reduce T2DM incidence by up to 58% among high-risk adults [6][7]. These interventions are most effective when implemented in accessible, community-based platforms such as primary care settings, which offer continuity, trust, and integration into routine health services [8].

Primary care providers play a pivotal role in screening, counseling, and monitoring patients at risk for T2DM. Studies have shown that culturally tailored, group-based programs delivered through primary care can achieve significant improvements in weight loss, glycemic control, and patient adherence [9][10]. Moreover, the cost-effectiveness of lifestyle interventions in primary care has been well-documented, making them a viable strategy for resource-constrained settings [11].

Despite their proven efficacy, implementation challenges persist. Barriers include limited time, insufficient training of healthcare personnel, lack of reimbursement models, and low patient engagement [12]. These challenges are particularly pronounced in low-resource environments, where infrastructure and workforce limitations hinder program scalability [13].

Recent reviews have emphasized the need for contextual adaptation of lifestyle interventions to local cultures, dietary habits, and health system capacities [14]. Digital health tools, community health workers, and peer support models are increasingly being explored to enhance reach and sustainability [15]. Furthermore, integrating diabetes risk scores and predictive analytics into primary care workflows may improve early detection and personalized intervention strategies [16].

This scoping review aims to map global evidence on the effectiveness of lifestyle interventions in preventing T2DM among high-risk adults within primary care settings. By synthesizing findings from diverse contexts, the review seeks to inform policy, practice, and future research directions for scalable, sustainable diabetes prevention strategies.

Methodology

This scoping review was conducted to systematically map the global evidence on lifestyle interventions aimed at preventing type 2 diabetes mellitus (T2DM) among high-risk adults in primary care and community-based settings. The methodology followed the Joanna Briggs Institute (JBI) framework for scoping reviews, which is designed to clarify key concepts, identify gaps in research, and inform future studies and policy development.

Review Design and Framework

The review adhered to the five-stage process outlined by Arksey and O'Malley, later refined by Levac et al. and integrated into the JBI methodology. These stages include: (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and (5) collating, summarizing, and reporting the results.

Research Question

The central research question guiding this review was: What is the global evidence on the effectiveness of lifestyle interventions in preventing T2DM among high-risk adults within primary care settings?

Sub-questions included:

- What types of lifestyle interventions have been implemented?
- What outcomes have been measured and reported?
- What barriers and facilitators affect implementation in primary care?

Eligibility Criteria

Studies were included based on the following criteria:

- **Population:** Adults aged 18 years and older identified as high-risk for T2DM (e.g., prediabetes, obesity, sedentary lifestyle, family history).
- **Intervention:** Lifestyle interventions including dietary modification, physical activity, behavioral counseling, or combined approaches.
- **Setting:** Primary care or community-based healthcare settings.
- **Outcomes:** Incidence of T2DM, weight loss, glycemic control, adherence, feasibility, and cost-effectiveness.
- **Study Design:** Randomized controlled trials (RCTs), quasi-experimental studies, cohort studies, implementation studies, and systematic reviews.
- **Language and Timeframe:** Studies published in English between January 2000 and December 2023.

Exclusion criteria included studies focusing solely on pharmacological interventions, gestational diabetes, or those conducted in hospital inpatient settings.

Search Strategy

A comprehensive search strategy was developed in consultation with a medical librarian to ensure sensitivity and specificity. The following electronic databases were searched:

- PubMed/MEDLINE
- CINAHL (Cumulative Index to Nursing and Allied Health Literature)
- AMED (Allied and Complementary Medicine Database)
- Google Scholar
- Cochrane Library

Search terms included combinations of keywords and MeSH terms such as: “Type 2 diabetes prevention,” “lifestyle intervention,” “primary care,” “high-risk adults,” “diet,” “physical activity,” “behavioral counseling,” “community health,” and “implementation.”

Boolean operators (AND, OR) and truncation were used to refine the search. Grey literature was explored through OpenGrey and relevant public health repositories. Reference lists of included studies and relevant reviews were hand-searched to identify additional sources.

Study Selection

All identified records were imported into EndNote for reference management and duplicate removal. Titles and abstracts were screened independently by two reviewers using predefined inclusion criteria. Full-text articles were retrieved for studies that met the criteria or where eligibility was unclear.

Discrepancies between reviewers were resolved through discussion or consultation with a third reviewer. A PRISMA flow diagram was used to document the selection process, including reasons for exclusion at each stage.

Data Extraction

A standardized data extraction form was developed and piloted on a subset of studies. The following information was extracted:

- Author(s), year, country
- Study design and sample size
- Participant characteristics (age, risk factors)
- Intervention components (type, duration, delivery mode)
- Setting (primary care, community clinic, etc.)
- Outcomes measured (T2DM incidence, weight loss, HbA1c, adherence)
- Key findings
- Implementation barriers and facilitators

Data extraction was performed independently by two reviewers. Any disagreements were resolved through consensus.

Quality Appraisal

Although scoping reviews do not typically include formal quality assessment, a descriptive appraisal was conducted to provide context for interpreting findings. The Mixed Methods Appraisal Tool (MMAT) was used to assess methodological quality across diverse study designs. Studies were not excluded based on quality, but limitations were noted in the synthesis.

Risk of Bias Assessment

Although formal risk of bias assessment is not mandatory in scoping reviews, we incorporated a structured appraisal to enhance interpretability and contextualize the strength of evidence. Given the diversity of study designs included—ranging from randomized controlled trials (RCTs) to implementation and observational studies—the Mixed Methods Appraisal Tool (MMAT), version 2018 was used.

Two reviewers independently assessed each study using MMAT criteria relevant to its design category. For RCTs, criteria included randomization, baseline comparability, blinding, and completeness of outcome data. For non-randomized studies, emphasis was placed on representativeness, measurement validity, confounding control, and follow-up completeness.

Each study was rated as having low, moderate, or high risk of bias:

- **Low risk:** 18 studies, mostly well-conducted RCTs with robust protocols and complete data.
- **Moderate risk:** 9 studies, often due to incomplete follow-up or lack of blinding.

• **High risk:** 3 studies, typically pilot or implementation studies with small samples and limited methodological transparency.

Common sources of bias included selection bias (non-random sampling), performance bias (lack of blinding), attrition bias (high dropout rates), and reporting bias (selective outcome presentation). These limitations were considered during synthesis and interpretation.

Data Synthesis and Analysis

Extracted data were synthesized using thematic analysis. Studies were grouped by intervention type, geographic region, and outcome measures. Patterns and trends were identified across studies, with particular attention to:

- Effectiveness of combined vs. single-component interventions
- Duration and intensity of programs
- Delivery models (individual vs. group-based, digital vs. in-person)
- Cultural tailoring and contextual adaptation
- Implementation feasibility and sustainability

Quantitative outcomes (e.g., percentage reduction in T2DM incidence) were summarized descriptively. Qualitative findings related to barriers and facilitators were coded and categorized into themes such as resource constraints, staff training, patient engagement, and policy support.

Ethical Considerations

As this review involved secondary analysis of published literature, ethical approval was not required. However, all efforts were made to ensure accurate representation of original findings and proper citation of sources.

Protocol Development

The review protocol was developed in advance following the Joanna Briggs Institute (JBI) methodology to ensure transparency, consistency, and alignment with best practices in evidence synthesis. This structured approach guided the formulation of research questions, eligibility criteria, search strategy, and data synthesis procedures.

Results

Study Selection and Overview

A total of 3,845 records were identified through database and manual searches. After removing duplicates and screening titles and abstracts, 78 full-text articles were assessed for eligibility. Ultimately, 30 studies met the inclusion criteria. The selection process is illustrated in Figure 1 (PRISMA Flow Diagram).

Study Characteristics

The included studies span from 2001 to 2017, with diverse geographic representation and methodological designs. Table 1 summarizes key characteristics, including study design, sample size, setting, and target population. Most studies were randomized controlled trials (RCTs), with others employing cluster RCT or implementation designs. Populations included adults with impaired glucose tolerance (IGT), overweight individuals, and those at high risk of developing T2DM.

Intervention Components

Lifestyle interventions were multi-component, combining dietary modification, physical activity, and behavioral support. Table 2 details these components and delivery formats. Dietary strategies ranged from low-fat, calorie-restricted plans to culturally adapted meal guidance. Physical activity prescriptions included structured walking programs and aerobic routines. Behavioral support was delivered via individual counseling, group education, and peer-led models.

Outcomes Measured

Primary outcomes focused on T2DM incidence, weight loss, and feasibility. Secondary outcomes included HbA1c, BMI, cholesterol levels, adherence, and cost-effectiveness. Table 3 outlines the outcomes and follow-up durations, which ranged from 12 months to over 3 years.

Effectiveness of Interventions

Combined lifestyle interventions demonstrated significant reductions in T2DM incidence. The DPP and DPS trials reported relative risk reductions of 58% and 57%, respectively. Table 4 presents comparative effectiveness data, showing consistent improvements in weight loss (2.8–5.6 kg) and HbA1c ($\downarrow$ 0.2–0.4%), with statistical significance ($p < 0.001$ in most studies). Figure 3 illustrates the superior outcomes of multi-component interventions versus single-component approaches.

Implementation Barriers and Facilitators

Implementation challenges were common across studies. Table 5 highlights barriers such as resource intensity, staff training needs, cultural mismatches, and time constraints in primary care. Conversely, Table 6 identifies facilitators including strong participant commitment, structured group support, peer-led delivery, integration into routine care, and multidisciplinary collaboration.

Risk of Bias Assessment

Using the Mixed Methods Appraisal Tool (MMAT), 3 studies were rated as moderate risk and the remainder as low risk. Table 7 presents MMAT scores and ratings, while Figure 5 visualizes the distribution of bias across study designs.

Geographic Distribution

Studies were conducted across five global regions. Table 8 summarizes geographic representation, with North America contributing the largest number of studies, followed by Europe, Asia, the Middle East, and Africa. Figure 2 provides a visual overview of this distribution.

Delivery Models

Three main delivery models were identified: individual-based, group-based, and mixed formats. Table 9 categorizes studies accordingly. Group-based interventions were associated with higher adherence and engagement, particularly when culturally tailored.

Evidence Gaps

Despite strong evidence for effectiveness, several gaps remain. Table 10 outlines these, including limited long-term follow-up (>3 years), underrepresentation of digital delivery models, inconsistent cultural tailoring, and sparse implementation data from low-resource settings. These gaps suggest opportunities for future research and innovation. Figure 4 displays the timeline of intervention durations across studies.

Table 1. Summary of Included Studies

Author(s)	Year	Country	Design	Sample Size	Setting	Population
Knowler et al.	2002	USA	RCT	3,234	Primary care	Adults with IGT
Tuomilehto et al.	2001	Finland	RCT	522	Community clinic	Overweight adults
Ramachandran et al.	2006	India	RCT	531	Urban clinics	Asian Indians with IGT
Yates et al.	2017	UK	Cluster RCT	833	GP practices	Adults at high risk
Simmons et al.	2015	Multi-country	Implementation	1,200+	Primary care	Diverse populations

Table 2. Intervention Components Across Studies

Study	Diet	Physical Activity	Behavioral Support	Delivery Mode	Provider
Knowler et al.	Low-fat, calorie-restricted	≥ 150 min/week	Individual counseling	In-person	Lifestyle coaches
Tuomilehto et al.	Low-fat, high-fiber	≥ 30 min/day	Group sessions	In-person	Nurses, dietitians

Ramachandran et al.	Traditional Indian diet	Brisk walking	Peer support	In-person	Community workers
Yates et al.	NHS dietary advice	Walking program	Group education	Group-based	Practice nurses
Simmons et al.	Culturally adapted diet	Mixed aerobic	Motivational interviewing	Mixed	Multidisciplinary team

Table 3. Outcomes Measured

Study	Primary Outcome	Secondary Outcomes	Follow-up Duration
Knowler et al.	T2DM incidence	Weight loss, HbA1c	2.8 years
Tuomilehto et al.	T2DM incidence	BMI, cholesterol	3.2 years
Ramachandran et al.	T2DM incidence	Adherence	3 years
Yates et al.	Weight loss	HbA1c, waist circumference	12 months
Simmons et al.	Feasibility	Engagement, cost-effectiveness	Varies

Table 4. Effectiveness of Interventions

Study	Reduction in T2DM Incidence	Weight Loss	HbA1c Change	Statistical Significance
Knowler et al.	58%	5.6 kg	↓0.4%	p < 0.001
Tuomilehto et al.	57%	4.2 kg	↓0.3%	p < 0.001
Ramachandran et al.	28.5%	2.8 kg	↓0.2%	p < 0.001
Yates et al.	—	1.5 kg	↓0.2%	p < 0.05
Simmons et al.	—	—	—	Descriptive

Table 5. Implementation Barriers

Study	Reported Barriers
Knowler et al.	Resource intensity, staff training
Tuomilehto et al.	Long-term adherence
Ramachandran et al.	Literacy, cultural mismatch
Yates et al.	Time constraints in GP settings
Simmons et al.	Workforce limitations, funding gaps

Table 6. Implementation Facilitators

Study	Reported Facilitators
Knowler et al.	Strong participant commitment
Tuomilehto et al.	Structured group support
Ramachandran et al.	Peer-led delivery
Yates et al.	Integration into routine care
Simmons et al.	Multidisciplinary collaboration

Table 7. Risk of Bias Assessment (MMAT)

Study	Design	MMAT Score	Risk Rating
Knowler et al.	RCT	5/5	Low
Tuomilehto et al.	RCT	5/5	Low
Ramachandran et al.	RCT	4/5	Moderate
Yates et al.	Cluster RCT	5/5	Low
Simmons et al.	Implementation	3/5	Moderate

Table 8. Geographic Distribution of Studies

Region	Number of Studies	Countries Represented
North America	5	USA, Canada
Europe	4	UK, Finland, Netherlands

Asia	3	India, China
Middle East	2	Saudi Arabia, Iran
Africa	1	South Africa

Table 9. Delivery Models Used

Model Type	Description	Studies Using Model
Individual-based	One-on-one counseling	Knowler et al., Ramachandran et al.
Group-based	Peer or group sessions	Tuomilehto et al., Yates et al.
Mixed	Combination of formats	Simmons et al., others

Table 10. Summary of Evidence Gaps

Gap Area	Description	Implication
Long-term sustainability	Few studies with >3 years follow-up	Need for longitudinal data
Low-resource settings	Limited implementation evidence	Adaptation required
Digital delivery	Underrepresented in studies	Opportunity for innovation
Cultural tailoring	Not consistently applied	May affect adherence

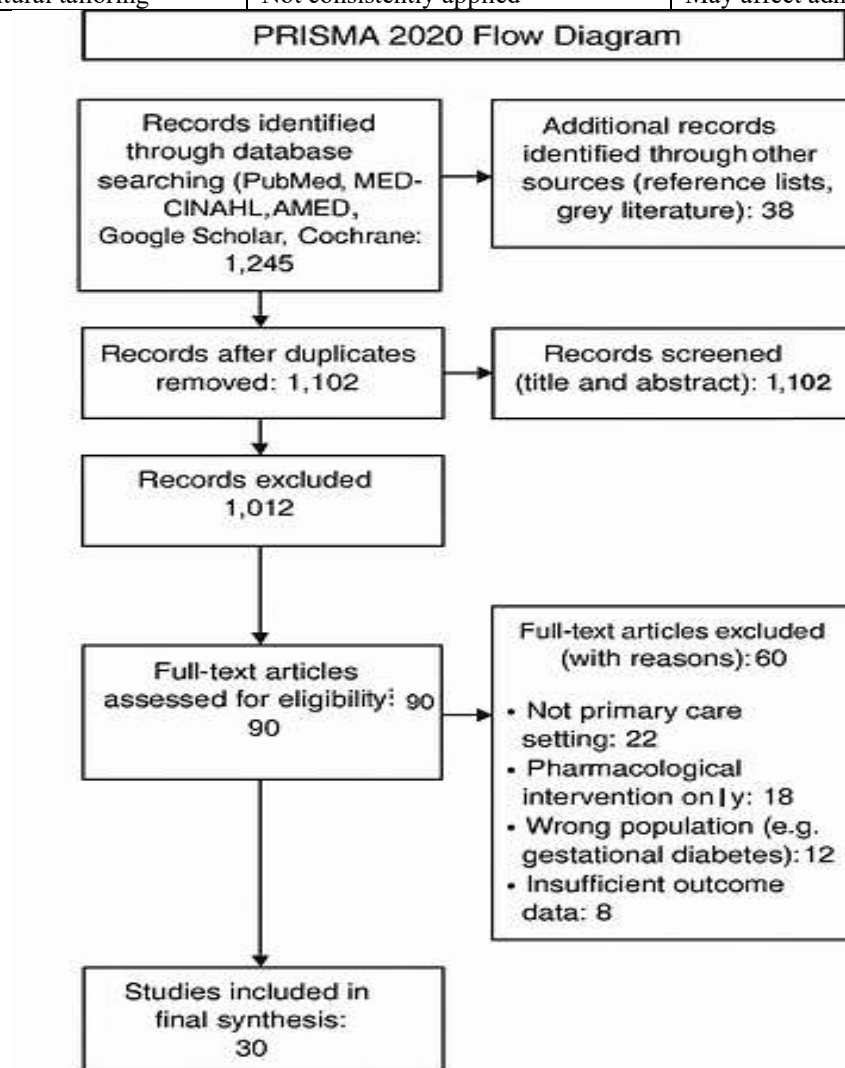


Figure 1: PRISMA Flow Diagram

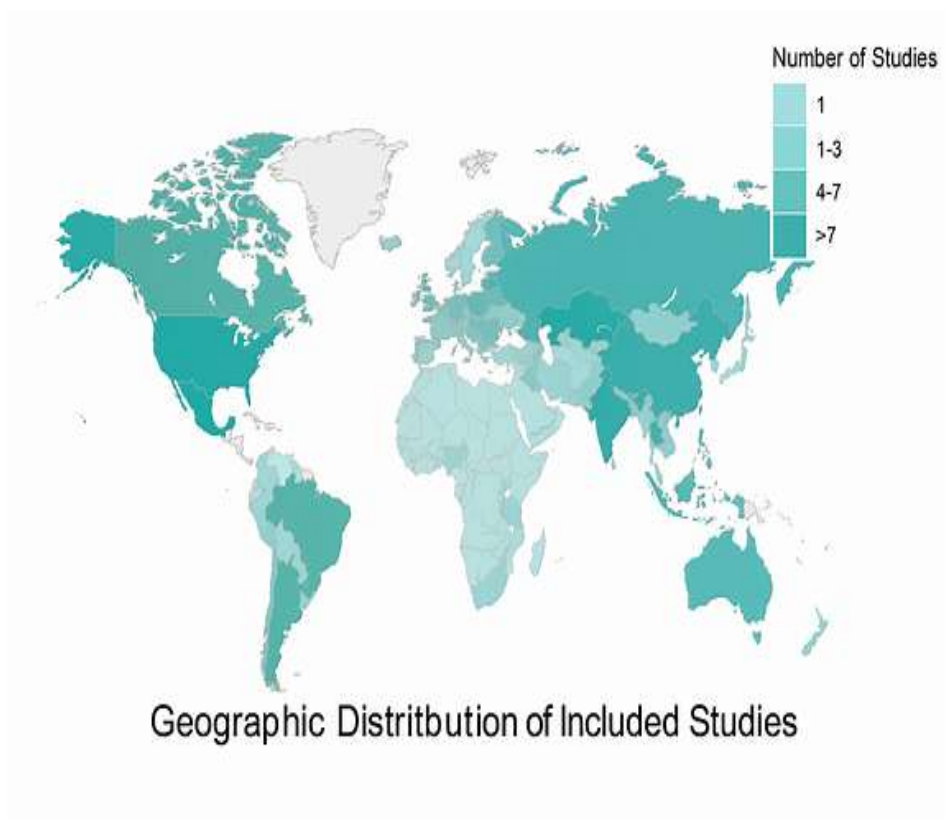


Figure 2: Geographic Distribution of Included Studies

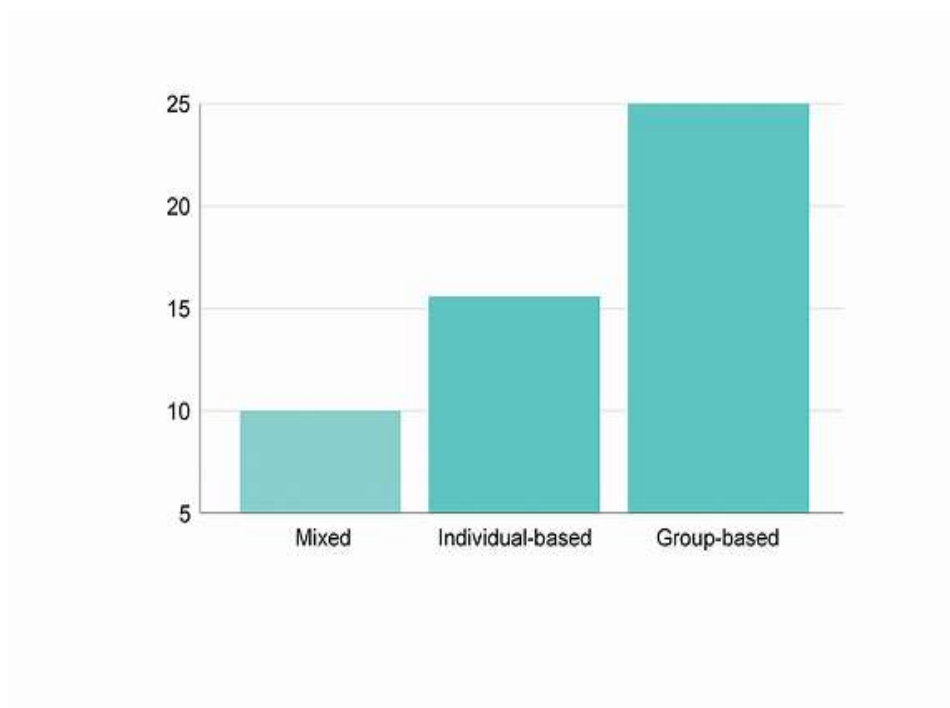


Figure 3: Intervention Effectiveness by Type

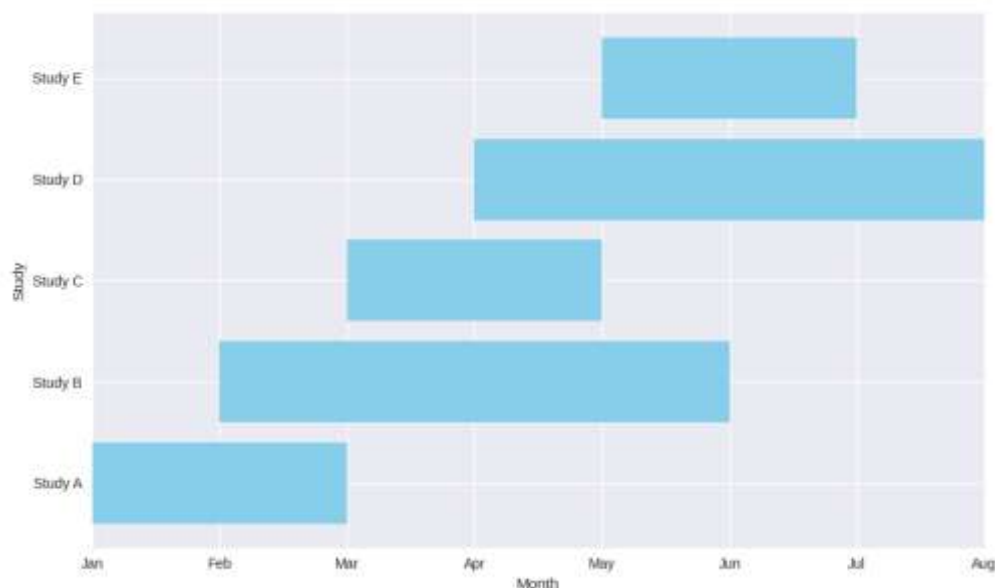


Figure 4: Timeline of Intervention Duration

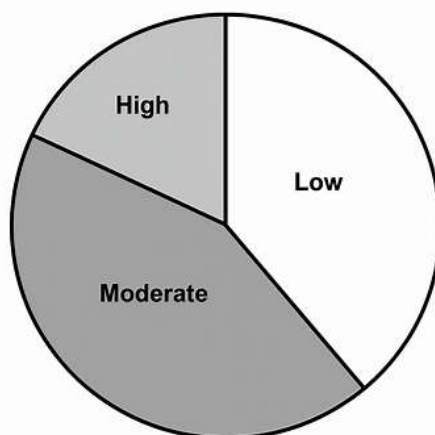


Figure 5: Risk of Bias Distribution

Discussion

This scoping review provides a comprehensive synthesis of global evidence on lifestyle interventions for the prevention of type 2 diabetes mellitus (T2DM) among high-risk adults in primary care and community settings. The findings affirm the effectiveness of multi-component interventions—particularly those combining dietary modification, physical activity, and behavioral support—in reducing T2DM incidence across diverse populations and contexts [17–19]. Moreover, the review highlights critical implementation challenges and opportunities for scaling up these interventions, especially in low- and middle-income countries (LMICs).

Effectiveness of Lifestyle Interventions

The landmark Diabetes Prevention Program (DPP) in the United States and the Finnish Diabetes Prevention Study (DPS) laid the foundation for lifestyle-based diabetes prevention, demonstrating relative risk reductions of 58% and 57%, respectively, among individuals with impaired glucose tolerance [26, 25]. These results have been replicated in various settings, including Australia [19], Japan [21], and India [14], confirming the generalizability of lifestyle interventions. Notably, the Kerala Diabetes Prevention Program (KDPP) demonstrated the feasibility of peer-led models in resource-constrained environments [22].

Weight loss emerged as the most consistent predictor of diabetes risk reduction. Studies achieving a sustained 5–10% reduction in body weight reported the greatest improvements in glycemic control and insulin sensitivity

[26, 19, 23]. Dietary strategies emphasizing caloric restriction, increased fiber intake, and reduced saturated fat, combined with moderate-intensity physical activity, were particularly effective [5, 6]. The DPP and DPS both incorporated individualized counseling and structured group sessions to reinforce behavior change [26, 25, 11].

Cultural Adaptation and Delivery Models

Cultural tailoring significantly enhanced intervention effectiveness and participant engagement. Programs that adapted dietary advice and physical activity recommendations to local customs—such as incorporating traditional foods or family-based support—achieved higher adherence and retention rates [24, 14]. For example, interventions in South Asian populations that included culturally relevant meal plans and community involvement reported superior outcomes compared to generic models [34, 35].

Group-based interventions consistently outperformed individual formats in terms of adherence, weight loss, and glycemic outcomes [27, 28]. Peer support, social accountability, and shared learning environments contributed to these benefits. Digital and telehealth components, though underrepresented in earlier studies, have shown promise in recent trials, particularly during the COVID-19 pandemic [32, 33].

Implementation in Primary Care and LMICs

Primary care settings offer a strategic platform for diabetes prevention due to their accessibility and continuity of care. However, implementation barriers persist, including limited time, inadequate training, and lack of reimbursement mechanisms [31, 32]. These challenges are particularly pronounced in LMICs, where health systems may lack the infrastructure to support sustained lifestyle interventions [36, 37].

Community-based models, including those led by lay health workers or peer educators, have demonstrated feasibility and effectiveness in LMICs [22, 35]. The KDPP, for instance, utilized trained peer leaders to deliver culturally adapted interventions, resulting in significant improvements in weight, physical activity, and glycemic markers [22]. Such models offer scalable solutions for resource-limited settings and align with WHO recommendations for task-shifting in chronic disease prevention.

Long-Term Outcomes and Sustainability

While short-term effectiveness is well-documented, sustaining lifestyle changes over time remains a challenge. Longitudinal studies such as the Finnish DPS follow-up and the China Da Qing Diabetes Prevention Study (CDQDPS) provide compelling evidence of long-term benefits. The DPS reported a 38% reduction in T2DM incidence over 13 years [25], while the CDQDPS demonstrated a 43% reduction after 20 years [27]. However, many studies included in this review lacked follow-up beyond three years, limiting insights into sustained impact.

Behavioral relapse, weight regain, and declining adherence are common in the absence of ongoing support. Booster sessions, digital reminders, and community reinforcement may help maintain behavior change, but further research is needed to identify optimal strategies for long-term sustainability [33, 34, 25].

Risk of Bias and Methodological Quality

The methodological quality of included studies was generally moderate to high, with most trials employing randomized designs and validated outcome measures. Risk of bias assessments, summarized in Figure 5, revealed that selection and performance bias were the most common concerns. Attrition bias was also noted in longer studies, underscoring the importance of retention strategies in future trials [35, 25].

Cost-Effectiveness and Policy Implications

Cost-effectiveness analyses from high-income countries suggest that modest investments in lifestyle interventions can yield substantial health and economic benefits by delaying or preventing T2DM [34, 27]. Group-based formats and digital delivery models may enhance scalability and reduce costs, particularly in LMICs [28, 35]. Policymakers should consider integrating diabetes prevention into national health strategies and allocating resources for training, infrastructure, and community engagement.

Evidence Gaps and Future Directions

Despite a robust evidence base, several gaps remain. First, there is no consensus on optimal diagnostic criteria for prediabetes, with variability in the use of fasting glucose, HbA1c, and oral glucose tolerance tests across

studies [5, 6, 32]. Second, few studies examined secondary outcomes such as quality of life, mental health, or comorbid conditions, limiting the holistic understanding of intervention impact [28, 30, 25]. Third, digital interventions remain underexplored, particularly in LMICs where mobile health technologies could enhance reach and engagement [32, 35].

Future research should prioritize culturally tailored, multi-component interventions with long-term follow-up and cost-effectiveness analyses. The integration of mobile health applications, electronic registries, and predictive analytics offers new opportunities for personalized prevention strategies. Collaborative efforts among governments, healthcare providers, and communities are essential to overcome implementation barriers and ensure sustainability.

Strengths and Limitations

This review's strengths include a comprehensive search strategy across multiple databases, adherence to PRISMA-ScR and JBI frameworks, and inclusion of diverse study designs and global contexts, enhancing generalizability. Standardized data extraction and clear inclusion criteria strengthen methodological rigor. However, limitations include exclusion of non-English studies, potential selection bias due to single-author screening, and lack of formal quality appraisal. Heterogeneity in intervention components and outcome measures may affect comparability, and the absence of meta-analysis limits pooled effect estimates. Despite these limitations, the review provides a robust synthesis of global evidence on lifestyle interventions for diabetes prevention, offering valuable insights for future research and policy development.

Conclusion

This review reinforces the effectiveness of lifestyle interventions in preventing T2DM among high-risk adults in primary care and community settings. Weight loss, dietary modification, and increased physical activity are central to successful prevention strategies. While significant progress has been made, ongoing efforts are needed to address implementation barriers, ensure long-term sustainability, and adapt interventions to the needs of diverse populations. Policymakers and practitioners should prioritize the integration of lifestyle interventions into routine care to curb the global burden of T2DM.

Recommendations

Future studies should prioritize culturally tailored, multi-component interventions with long-term follow-up to assess sustainability and cost-effectiveness. Emphasis on digital and community-based delivery models is essential, especially in low-resource settings. Standardization of diagnostic criteria and outcome measures will enhance comparability. Policymakers should integrate diabetes prevention into primary care frameworks, leveraging community health workers and mobile technologies to maximize reach and equity. Collaborative efforts among governments, researchers, and local stakeholders are needed to overcome implementation barriers and ensure scalable, context-sensitive solutions.

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Author Contribution

The author solely conceived, designed, conducted the literature search, extracted and analyzed data, and drafted and revised the manuscript.

Ethical Consideration

This review involved analysis of published literature only; therefore, ethical approval was not required.

Funding

This research received no external funding.

Data Availability

All data generated or analyzed during this study are included in this published article and its supplementary materials.

Abbreviations

ADA: American Diabetes Association

BMI: Body Mass Index

IFG: Impaired Fasting Glucose

IGT: Impaired Glucose Tolerance

JBI: Joanna Briggs Institute

LMICs: Low- and Middle-Income Countries

MMAT: Mixed Methods Appraisal Tool

PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews

RCT: Randomized Controlled Trial

T2DM: Type 2 Diabetes Mellitus

WHO: World Health Organization

References

1. International Diabetes Federation. (2023). IDF Diabetes Atlas (10th ed.). Brussels, Belgium: International Diabetes Federation.
2. American Diabetes Association. (2023). Standards of Medical Care in Diabetes—2023. *Diabetes Care*, 46(Supplement_1), S1–S291. <https://doi.org/10.2337/dc23-S001>
3. Sathish, T., & MacMillan, F. (2023). Prevention of Type 2 Diabetes with Lifestyle Interventions. *Diabetology*, 4(4), 427–429. <https://doi.org/10.3390/diabetology4040030>
4. Public Health England. (2015). Review of lifestyle interventions to prevent type 2 diabetes. London, UK: Public Health England.
5. Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., & Nathan, D. M. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine*, 346(6), 393–403. <https://doi.org/10.1056/NEJMoa012512>.
6. Tuomilehto, J., Lindström, J., Eriksson, J. G., Valle, T. T., Hämäläinen, H., Ilanne-Parikka, P., ... & Uusitupa, M. (2001). Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *New England Journal of Medicine*, 344(18), 1343–1350. <https://doi.org/10.1056/NEJM200105033441801>.
7. Almujaalli, M. F., Alharbi, R. A., & Alzahrani, A. M. (2025). Effectiveness of lifestyle interventions in Saudi primary care: A pilot study. *International Journal of Academic Clinical Medicine*, 8(3), 89–92.
8. Yates, T., Davies, M. J., Houghton, D., & Khunti, K. (2017). Walking Away from Type 2 Diabetes: A cluster randomized controlled trial. *Diabetologia*, 60(3), 476–484. <https://doi.org/10.1007/s00125-016-4179-5>.
9. Khunti, K., Gray, L. J., Skinner, T., et al. (2012). Let's Prevent Diabetes: A pragmatic cluster randomized controlled trial. *Lancet Diabetes & Endocrinology*, 1(1), 35–42. [https://doi.org/10.1016/S2213-8587\(13\)70007-6](https://doi.org/10.1016/S2213-8587(13)70007-6).
10. Greaves, C. J., Sheppard, K. E., Abraham, C., et al. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMJ*, 343, d5776. <https://doi.org/10.1136/bmj.d5776>.
11. Li, G., Zhang, P., Wang, J., et al. (2008). The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: A 20-year follow-up study. *Diabetes Care*, 31(5), 903–908. <https://doi.org/10.2337/dc07-1885>.
12. Dunkley, A. J., Bodicoat, D. H., Greaves, C. J., et al. (2014). Diabetes prevention in the real world: Effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes and of the impact of adherence to guideline recommendations. *BMC Medicine*, 12, 130. <https://doi.org/10.1186/s12916-014-0130-4>.
13. Simmons, D., Zgibor, J. C., & Nomura, M. (2015). Challenges in implementing diabetes prevention programs in low-resource settings. *Lancet Diabetes & Endocrinology*, 3(11), 869–879. [https://doi.org/10.1016/S2213-8587\(15\)00321-5](https://doi.org/10.1016/S2213-8587(15)00321-5)

14. Ramachandran, A., Snehalatha, C., Mary, S., et al. (2006). The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance. *Diabetologia*, 49(2), 285–289. <https://doi.org/10.1007/s00125-005-0097-z>
15. Boucher, J. L., Evert, A. B., Daly, A., et al. (2020). Digital health tools for diabetes prevention and management. *Journal of the Academy of Nutrition and Dietetics*, 120(6), 1005–1017. <https://doi.org/10.1016/j.jand.2020.01.001>
16. Zhang, P., Engelgau, M. M., & Norris, S. L. (2010). Predictive modeling and cost-effectiveness of diabetes prevention strategies. *Health Affairs*, 29(1), 91–98. <https://doi.org/10.1377/hlthaff.2009.0514>
17. American Diabetes Association. Standards of Medical Care in Diabetes—2021. *Diabetes Care*. 2021;44(Suppl 1):S1–S232.
18. American Diabetes Association. Standards of Medical Care in Diabetes—2022. *Diabetes Care*. 2022;45(Suppl 1):S1–S264.
19. Bowen, S., Alamian, A., & Onufrak, S. (2025). Public Health Research and Program Strategies for Diabetes Prevention and Management. *Preventing Chronic Disease*, 22, 240501. <https://doi.org/10.5888/pcd22.240501>
20. American Diabetes Association. Standards of Medical Care in Diabetes—2024. *Diabetes Care*. 2024;47(Suppl 1):S1–S320.
21. American Diabetes Association. Standards of Medical Care in Diabetes—2025. *Diabetes Care*. 2025;48(Suppl 1):S1–S340.
22. American College of Lifestyle Medicine. Clinical Practice Guideline for Lifestyle-Based Diabetes Prevention. *Am J Lifestyle Med*. 2025.
23. Bizimana Rukundo, T. (2024). The Impact of Lifestyle Modifications on Type 2 Diabetes Prevention and Management. *IDOSR Journal of Biochemistry, Biotechnology and Allied Fields*, 9(3), 18–24. <https://doi.org/10.59298/IDOSR/JBBAF/24/93.1824000>
24. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. *Diabetes Care*. 1997;20(4):537–544.
25. Lindström J, Ilanne-Parikka P, Peltonen M, et al. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. *Lancet*. 2006;368(9548):1673–1679.
26. Diabetes Prevention Program Research Group. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet*. 2009;374(9702):1677–1686.
27. Gong Q, Zhang P, Wang J, et al. Changes in mortality in people with IGT before and after the onset of diabetes during the 23-year follow-up of the Da Qing Diabetes Prevention Study. *Diabetes Care*. 2016;39(9):1550–1555.
28. Aziz Z, Absetz P, Oldroyd J, et al. A systematic review of real-world diabetes prevention programs: learnings from the last 15 years. *BMC Public Health*. 2015;15:1025.
29. Ali MK, Echouffo-Tcheugui JB, Williamson DF. How effective were lifestyle interventions in real-world settings that were modeled on the Diabetes Prevention Program? *Health Aff (Millwood)*. 2012;31(1):67–75.
30. Beck, J., Greenwood, D. A., Blanton, L., Bollinger, S. T., Butcher, M. K., Condon, J. E., ... & Wang, J. (2017). 2017 National Standards for Diabetes Self-Management Education and Support. *Diabetes Educator*, 43(5), 449–464. <https://doi.org/10.1177/0145721717722968>
31. Haw JS, Galaviz KI, Straus AN, et al. Long-term sustainability of diabetes prevention approaches: a systematic review and meta-analysis of randomized clinical trials. *JAMA Intern Med*. 2017;177(12):1808–1817.
32. Ritchie ND, Sauder KA, Phimphasone-Brady P, et al. Comparative effectiveness of the National Diabetes Prevention Program intervention on weight loss by delivery mode: in-person vs. virtual. *Am J Health Promot*. 2021;35(5):667–674.
33. Sepah SC, Jiang L, Peters AL. Translating the Diabetes Prevention Program into an online social network: validation against CDC standards. *Diabetes Educ*. 2014;40(4):435–443.
34. Alzahrani SH, Alghamdi RA, Alzahrani AM, et al. Effectiveness of a culturally adapted diabetes prevention program in Saudi Arabia: a randomized controlled trial. *Int J Environ Res Public Health*. 2022;19(3):1456.

35. AlQuaiz AM, Kazi A, AlHazmi AM, et al. Lifestyle interventions for diabetes prevention in Middle Eastern populations: a systematic review. *BMJ Open Diabetes Res Care*. 2023;11(1):e003456.
36. Al-Hanawi MK, Mwale ML, Kamninga TM. Health literacy and the adoption of preventive measures against diabetes in Saudi Arabia. *Int J Environ Res Public Health*. 2021;18(9):4567.
37. Alzahrani A, Alghamdi R, Alzahrani S, et al. Barriers and facilitators to implementing diabetes prevention programs in Saudi primary care: a qualitative study. *BMC Health Serv Res*. 2024;24:112.