



Navigating the South Asian Diabetes Landscape: Methodologies for Intervention, Communication and Evaluation

Koning C^{1*} and Chouinor K²

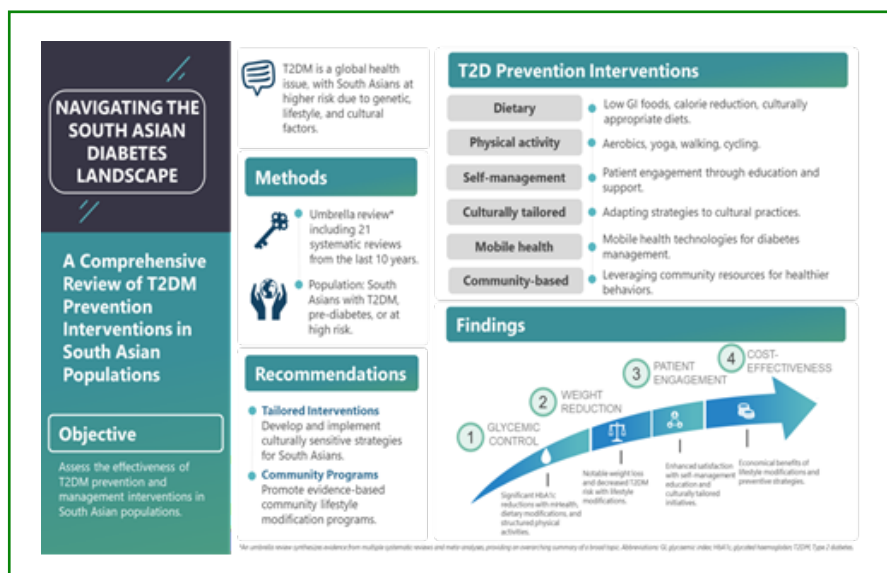
¹Cipher HCC, Spain

²IHSTS, Canada

*Corresponding author: Clare Koning, Cipher HCC, Sagra, Alicante, Spain, Email: clarekoning@cipherhcc.com

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Graphical Abstract



Abstract

Objective: Type 2 diabetes mellitus (T2DM) poses a significant global health challenge, especially for South Asian populations who have a higher risk due to genetic, lifestyle, socioeconomic, and cultural factors. This review paper assesses the effectiveness of interventions targeting T2DM prevention and management in South Asian populations.

Design: A systematic search of studies published in the last 10 years was conducted, focusing on systematic reviews with or without meta-analyses. Databases included PubMed/Medline, Cochrane Library, and others, following Joanna Briggs Institute guidelines for umbrella reviews.

Setting: The review included South Asian individuals from countries like India, Pakistan, and Bangladesh, examining various T2DM management interventions compared to usual care or control.

Participants: Out of 283 articles, 21 systematic reviews were included. These reviews covered a wide range of South Asian

populations, including those with T2DM, pre-diabetes, or high-risk, residing in diverse regions and socioeconomic contexts.

Results: The findings highlight the effectiveness of interventions targeting T2DM among South Asian populations. Interventions such as dietary modifications, physical activity programs, self-management education, culturally tailored initiatives, and mobile health interventions significantly improved glycaemic control, weight reduction, and patient satisfaction. Comprehensive education, multidisciplinary teams, and support networks were identified as crucial facilitators for promoting healthier behaviours among South Asians.

Conclusions: This review underscores the effectiveness of culturally tailored interventions in preventing and managing T2DM among South Asian populations. Collaborative, culturally sensitive approaches and partner engagement are crucial for addressing the unique challenges in diabetes care in South Asians.

Keywords: Type 2 Diabetes Mellitus; South Asian Populations; Intervention Effectiveness; Glycaemic Control; Culturally Tailored Interventions

Abbreviations

BMI: Body Mass Index; CI: Confidence Interval; DBP: Diastolic Blood Pressure; GI: Glycemic Index; Hba1c: Glycated Hemoglobin; HDL: High-Density Lipoprotein; ICER: Incremental Cost-Effectiveness Ratio; Kg: Kilogram; LDL: Low-Density Lipoprotein; Mm Hg: Millimeters of Mercury; NCD: Non-Communicable Disease; PODOSA: Pre-Diabetes Observational Study in South Asia; QALY: Quality-Adjusted Life Year; RCT: Randomized Controlled Trial; RR: Relative Risk; SBP: Systolic Blood Pressure; T2DM: Type 2 Diabetes Mellitus.

Introduction

Type 2 diabetes mellitus (T2DM) represents a significant global health challenge, with a disproportionate burden observed among South Asian populations [1]. Individuals of South Asian descent, including those from countries such as India, Pakistan, Bangladesh, and Sri Lanka, face an increased risk of developing T2DM compared to other ethnic groups [2]. This heightened susceptibility is attributed to a complex interplay of genetic predispositions, lifestyle factors, socioeconomic determinants, and cultural influences [3]. Given the escalating prevalence of T2DM and its associated complications within these populations despite rigorous pharmacological guidelines [4], there is a critical need to comprehensively evaluate the effectiveness of interventions aimed at prevention and management. Through the lens of an umbrella review, we offer a panoramic view of the landscape, shedding light on the successes, challenges, and avenues for future exploration.

Methods

In this umbrella review, we conducted a systematic search for studies published within the last 10 years, focusing on

systematic reviews with or without meta-analyses and following Joanna Briggs Institute guidelines for umbrella reviews. Included databases and registries were PubMed/Medline, Cochrane Library, Joanna Briggs Institute Systematic Review Database, Semantic Scholar, SciSpace, ScholarAI, and Consensus. The population of interest included South Asian individuals, encompassing those from countries such as India, Pakistan, Bangladesh, Sri Lanka, and those of East Indian ethnicity. The search strategy targeted review studies assessing various interventions for managing T2DM that included measured outcomes. The PICO framework delineated the population as South Asian adults with, or at risk of T2DM, the intervention as studies evaluating T2DM management interventions, and the comparison as usual care or control. Figure 1 outlines the PRISMA search strategy.

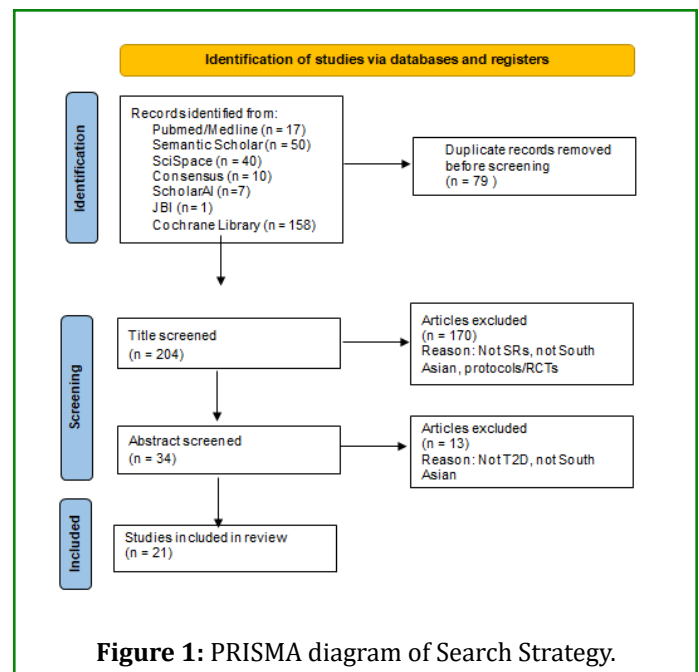


Figure 1: PRISMA diagram of Search Strategy.

Summary of Findings

A total of 283 articles were retrieved from the seven databases and registries. After the removal of duplicates and abstract screenings, 21 systematic reviews were included in

this umbrella review. The studies include systematic reviews ($n = 13$), those with meta-analyses ($n = 7$), and a systematic rapid review ($n = 1$). Figure 2 illustrates the dates, types of reviews and intervention foci.

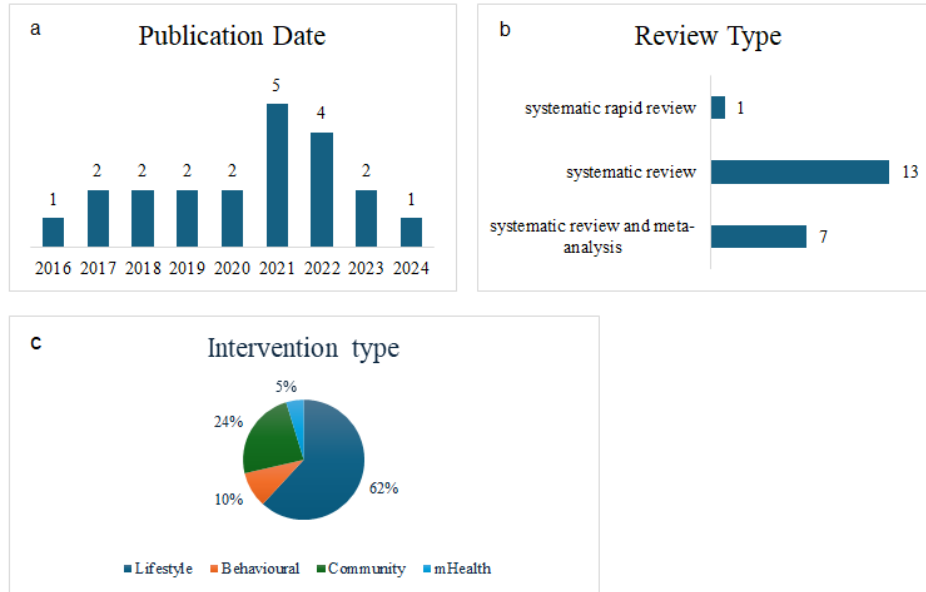


Figure 2: (a) Number of reviews by publication year, (b) Included reviews by review type, (c) Intervention type studied.

Footnotes: Lifestyle: Lifestyle modification advice with or without supervised physical activity program. Dietary modifications. Intensive lifestyle interventions over 2 years. Diet and physical activity interventions. Lifestyle interventions in the included studies promoted self-management using multiple education components, such as diet, physical activity, medication adherence, and smoking cessation. Delivered by healthcare professionals in a hospital/clinic setting. Lifestyle interventions aimed at T2DM prevention: diet, physical activity, and behavioural changes. Lifestyle intervention delivered by CHWs or peer supporters or a combination of both. Lifestyle interventions: small, group-delivered translational DPP provided by a combination of health professionals and trained lay health workers. Effect of aerobic, resistance, balance, or combined exercise programs. Behavioural: Non-pharmacological interventions for the prevention of T2DM: Peer support, nutritional supplements (Fenugreek powder). Diabetes self-management education (in person): educational booklets, audiocassettes recorded in the participants' preferred language and pictorial flashcards. Community: Community and clinic-based screening, NCD care education, NCD specialized corner or hospital, and a follow-up system. Community-based lifestyle interventions: group-class positive feedback lifestyle behaviour promotion; 12-16 weeks duration. Located: religious settings, NGO venues, fitness facilities, community spaces. Guidelines directed

dietary and physical activity interventions (walking, yoga, cycling) delivered in the community. Lifestyle modification and diabetes screening: policy, clinical and behavioural, including school smoking cessation programs, tobacco tax, food labeling, counselling, salt reduction campaign. Yoga, meditation, exercise, community-based peers, health professionals, dietary education. mHealth intervention: Voice, email, text, mobile-based bi-directional messages daily to weekly. Duration: 12-24 months.

The umbrella review encompasses a broad spectrum of populations within the South Asian demographic, including individuals with existing T2DM, pre-diabetes, or those deemed at high risk for developing the condition, with various studies focusing on different subsets of this population. These South Asian participants resided in different regions, such as India, Pakistan, and Bangladesh, and those living in high-income countries like the United States and Europe. Additionally, the review incorporated populations from low- and middle-income countries, reflecting the diverse socioeconomic backgrounds within the South Asian community, and specific populations, such as migrants with T2DM, individuals with co-morbid conditions like cancer, cardiovascular disease, or chronic respiratory diseases, and adults aged 18 years and older who may be non-diabetic but at risk for T2DM. The duration of T2DM varied from new diagnosis to long-term, as

did diagnosis, with self-reported and clinical diagnoses being included in systematic reviews. Table 1 outlines the included

studies and their characteristics.

S. No	Title	Authors	Year	Study Type	# Included articles	Population	Intervention	Outcomes	Results
1	Effectiveness of lifestyle interventions/ culturally bespoke programmes in South Asian ethnic groups targeting weight loss for prevention and/ or remission of type 2 diabetes: a systematic review and meta-analysis of intervention trials.	Farhat G, et al. [5]	2024	Systematic review and meta-analysis of intervention trials	24	South Asians at risk of or with existing T2DM with duration ≥ 12 weeks.	Lifestyle modification advice with or without supervised physical activity program.	Change in weight (kg) from baseline. Decrease in HbA1c to non-diabetic levels (HbA1c $\leq 6.5\%$) without diabetes medications.	<ul style="list-style-type: none"> Intervention group showed mean weight reduction of -0.65 kg compared to control (95% CI: -1.04, -0.26; p = 0.01). Lifestyle modification advice, including physical activity, resulted in greater weight loss (-1.13 kg; 95% CI: -2.04, -0.21; p = 0.02). Fasting blood glucose levels were slightly lower in intervention groups, with no significant changes in HbA1c or 2-hour plasma glucose levels.
2	Systematic review of the barriers and facilitators to dietary modification in people living with type 2 diabetes and pre-diabetes from South Asian ethnic populations	Rai A, et al. [6]	2023	Systematic review	7	South Asians with T2DM or pre-diabetes.	Dietary modifications.	Factors that hinder or support change.	<ul style="list-style-type: none"> Three facilitators: (1) cultural sensitivity, (2) health education and (3) support networks. Five barriers: (1) healthcare inequity, (2) cultural insensitivity, (3) social pressures, (4) misconceptions and (5) time constraints.

3	Dietary Interventions for Type 2 Diabetes in South Asian Populations-A Systematic Review	Subhan FB, et al. [7]	2023	Systematic review	18	South Asians with a diagnosis of T2DM.	Glycemic management and/or nutrition behavior and nutrition intervention.	Blood pressure, lipid panel, and body weight or body mass index (BMI).	<ul style="list-style-type: none"> · Higher session frequency and comprehensive education were associated with successful interventions. · Low-GI foods, with support from dietitians, led to compliance and BMI reduction. · Benefits on lipid or blood pressure outcomes were seen in higher-intensity interventions, typically at 3 months.
4	Long-term effect of lifestyle interventions in the cardiovascular and all-cause mortality of subjects with prediabetes and type 2 diabetes: A systematic review and meta-analysis	Zucatti KP, et al. [8]	2022	Systematic review and meta-analysis	11	Prediabetes and T2DM. Included PODOSA trial participants.	Intensive lifestyle interventions over 2 years.	Cardiovascular risk and all-cause mortality.	<ul style="list-style-type: none"> · Lifestyle interventions were not superior to usual care in reducing cardiovascular (RR, 0.99; 95% CI, 0.79 to 1.23) and all-cause mortality (RR, 0.93; 95% CI, 0.85 to 1.03)

5	Effects of lifestyle interventions on cardiovascular risk factors in South Asians: a systematic review and meta-analysis	Limbachia J, et al. [9]	2022	Systematic review	35	Self-reported T2DM. Included 2 Indian studies.	Diet and physical activity interventions.	Cardiovascular risk of myocardial infarction, stroke, blood lipids, blood pressure, adipose tissue, T2DM self-reported.	<ul style="list-style-type: none"> · No CVD reported in trials · Diet and physical activity interventions lower SBP (MD -2.72 mm Hg) and DBP (MD -1.53 mm Hg) · Diet-only interventions reduce DBP (MD -2.05 mm Hg), triglycerides (MD -0.10 mmol/L), and LDL cholesterol (MD -0.19 mmol/L) · Physical activity-only interventions decrease SBP (MD -9.7 mm Hg), DBP (MD -7.29 mm Hg), and increase HDL cholesterol (MD 0.08 mmol/L)
6	Non-pharmacological interventions for the prevention of type 2 diabetes in low-income and middle-income countries: a systematic review of randomised controlled trials	Sarker A, et al. [10]	2022	Systematic review of RCTs	5	Adult population aged over 18 years non-diabetic and pre-diabetic from countries including India.	Non-pharmacological interventions for the prevention of T2DM: Peer support, nutritional supplements (Fenugreek powder).	Change in the incidence of T2DM, changes in glycated haemoglobin (HbA1c) level, weight/body mass index (BMI), fasting glucose level and 2-hour glucose from baseline.	<ul style="list-style-type: none"> · Significant decrease in T2DM incidence post-intervention through physical training and dietary modifications. · Notable reductions in secondary outcomes including weight, BMI, fasting and 2-hour plasma glucose, and HbA1c.

7	Clinical and Patient-Centered Implementation Outcomes of mHealth Interventions for Type 2 Diabetes in Low-and-Middle Income Countries: A Systematic Review	Mokaya M, et al. [11]	2022	Systematic review	30	Adults with T2DM. 5 Indian studies.	mHealth intervention: Voice, email, text, mobile-based bi-directional messages daily to weekly. Duration: 12-24 months.	HbA1c, fasting blood glucose.	· HbA1c percentage difference was <0.3% between the mHealth intervention and the comparison group. · Studies with longer intervention periods exhibited higher effect size and percentage difference on HbA1c (1.52% to 2.92%).
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8	A systematic rapid review on quality of care among non-communicable diseases (NCDs) service delivery in South Asia	Ether S, et al. [12]	2021	Systematic rapid review	13	South Asians with cancer, diabetes, cardiovascular disease, chronic respiratory disease. 3 T2DM studies included.	Community and clinic-based screening, NCD care education, NCD specialized corner or hospital, and a follow-up system	HbA1c, blood pressure, lipids, patient satisfaction	<ul style="list-style-type: none"> · HbA1c: intervention 10.4% improvement vs. 3.4% improvement (RR, 1.93 [95% CI, 1.52 to 2.45]) control. · Blood pressure: Intervention 6% higher likelihood of reaching target BP (RR, 1.14 [CI, 1.04 to 1.26]) compared to control. · LDLc Level: Intervention 9.3% higher likelihood of achieving target LDLc (RR: 1.23 [CI, 1.13 to 1.34]). · Patients' Satisfaction Scores increased from baseline: <ul style="list-style-type: none"> - Test group 1 (educational materials): 3 months: +16; 12 months: +18. · Test group 2 (education materials and diabetic kit): 3 months: +25; 12 months: +30.
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9	Lifestyle Interventions to Improve Glycemic Control in Adults with Type 2 Diabetes Living in Low-and-Middle Income Countries: A Systematic Review and Meta-Analysis of Randomized Controlled Trials (RCTs).	O'Donoghue G, et al. [13]	2021	Systematic review of RCTs	30	Adults with T2DM living in low-and-middle income countries. 2 studies from India. 2 studies from Pakistan.	Lifestyle interventions in the included studies promoted self-management using multiple education components, such as diet, physical activity, medication adherence, and smoking cessation. Delivered by healthcare professionals in a hospital/clinic setting	HbA1c	· Significant improvements in HbA1c (mean difference -0.63), fasting blood glucose (standardized mean difference -0.35), and body mass index (mean difference -0.5)
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10	The Effect of Lifestyle Intervention on Diabetes Prevention by Ethnicity: A Systematic Review of Intervention Characteristics Using the TIDieR Framework.	Chen M, et al. [14]	2021	Systematic review and meta-analysis	45	At risk for T2DM and prediabetics. 10 South Asian studies included.	Lifestyle interventions aimed at T2DM prevention: diet, physical activity, behavioural changes.	T2DM incidence: fasting blood glucose, BMI, changes in waist circumference.	<ul style="list-style-type: none"> · High number of intervention sessions linked with a greater reduction in diabetes incidence ($P = 0.043$) and significant weight loss ($P = 0.015$). · Other intervention characteristics (provider, delivery format) had no significant impact on outcomes (all $P > 0.05$). · Long-term interventions (≥ 12 months) associated with significant diabetes risk reduction across all ethnic groups. · Short-term interventions (< 12 months) more effective for weight loss in most ethnic groups.
11	Ethnic differences in response to lifestyle intervention for the prevention of type 2 diabetes in adults: A systematic review and meta-analysis.	Chen M, et al. [15]	2022	Systematic review and meta-analysis	45	Adults at risk for T2DM. 10 South Asian studies included.	Lifestyle intervention	Fasting glucose, HbA1c, physical activity.	<ul style="list-style-type: none"> · No ethnic differences found for T2DM incidence, fasting glucose, HbA1c, and physical activity.

12	Lifestyle interventions for type 2 diabetes management among migrants and ethnic minorities living in industrialized countries: a systematic review and meta-analyses.	Rawal L, et al. [16]	2021	Systematic review and meta-analysis	17	Migrants with T2DM. 4 South Asian studies included.	Lifestyle interventions delivered by CHWs or peer supporters or combination of both	HbA1c, fasting blood glucose, weight, BMI, blood pressure, physical activity, alcohol consumption, tobacco smoking, food habits, healthcare utilization.	· Small but significant reduction in HbA1c level (-0.18%; 95% CI -0.32% to -0.04%, p=0.031).
13	Cost-effectiveness of Diabetes Prevention Interventions Targeting High-risk Individuals and Whole Populations: A Systematic Review.	Zhou X, et al. [17]	2020	Systematic review	39	High risk for T2DM. 1 South Asian study included.	Lifestyle interventions: small, group delivered translational DPP provided by a combination of health professionals and trained lay health workers.	Cost-effectiveness, ICER.	· Interventions following a Diabetic prevention program (DPP) curriculum had a median ICER of \$6,212/QALY, while those that did not follow a DPP curriculum had a median ICER of \$13,228/QALY. · Lower ICER when delivered by a combination of healthcare workers and lay health workers.

14	Preventing Type 2 Diabetes among South Asian Americans through community-based lifestyle interventions: a systematic review.	Ali SH, et al. [18]	2020	Systematic review	8	South Asians with T2DM living in the US.	Community-based lifestyle interventions: group-class positive feedback lifestyle behaviour promotion; 12-16 weeks duration. Located: religious settings, NGO venues, fitness facilities, community spaces.	HbA1c	<ul style="list-style-type: none"> · Intervention showed improvement in glucose and insulin indicators. · Statistical analysis revealed significant reductions in blood glucose and A1C post-intervention. · A1C decreased from baseline (38.96 mmol/mol) to 12-week post-intervention (37.00 mmol/mol) and to 24-week follow-up (36.54 mmol/mol), all statistically significant ($p < 0.0005$) compared to control.
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15	Effects of dietary and physical activity interventions on the risk of type 2 diabetes in South Asians: meta-analysis of individual participant data from randomised controlled trials.	Jenum AK, et al. [19]	2019	Systematic review and meta-analysis of RCTs	6	High risk for T2DM South Asian adults living in Europe.	Interventions incorporating diet and/or physical activity.	Incidence of T2D, weight, waist circumference, glucose control.	<ul style="list-style-type: none"> · Incident diabetes rate was 12.6% in intervention groups and 20.0% in control groups. · A clinically important 35% relative reduction in diabetes incidence. · Pooled hazard ratio (HR) for diabetes incidence was 0.65 (95% CI 0.51, 0.81; I2= 0%) for intervention vs control. · Absolute risk reduction was 7.4% (95% CI 4.0, 10.2) with no significant interactions for subgroups (sex, BMI, age, study duration, and region). · Mean difference for lifestyle modification vs control: 2-hour glucose: -0.34 mmol/l (95% CI -0.62, -0.07; I2= 50%); Weight: -0.75 kg (95% CI -1.34, -0.17; I2=71%); Waist: -1.16 cm (95% CI -2.16, -0.16; I2= 75%); no significant effect found for fasting glucose.
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16	Culturally Tailored Self-Management Interventions for South Asians With Type 2 Diabetes: A Systematic Review	Navodia N, et al. [20]	2019	Systematic review	4	South Asians with T2DM.	Diabetes self-management education (in person): educational booklets, audiocassettes recorded in the participants' preferred language and pictorial flashcards.	HbA1c	<ul style="list-style-type: none"> Reduction in A1C: 3 months: Mean difference (MD) -0.4% (95% CI -0.5 to -0.2) 6 months: MD -0.5% (95% CI -0.7 to -0.4) 12 months: MD -0.2% (95% CI -0.3 to -0.04) 24 months: MD -0.3% (95% CI -0.6 to -0.1)
17	Dietary and physical activity recommendations to prevent type 2 diabetes in South Asian adults: A systematic review.	Muilwijk M, et al. [21]	2018	Systematic review	18	South Asians without T2DM.	Guidelines directed dietary and physical activity interventions (walking, yoga, cycling) delivered in the community.	Identify gaps in interventional studies and guidelines that are targeted to the South Asian population.	<ul style="list-style-type: none"> Intervention studies and guidelines did not reference evidence that shows included components to be effective for South Asian populations in particular.
18	Cost-effectiveness of interventions to control cardiovascular diseases and diabetes mellitus in South Asia: a systematic review	Singh K, et al. [22]	2018	Systematic review	42	South Asians with cardiovascular disease of T2DM.	Lifestyle modification and diabetes screening: policy, clinical and behavioural, including school smoking cessation programs, tobacco tax, food labeling, counselling, salt reduction campaign.	Cost-effectiveness	<ul style="list-style-type: none"> Cost effective T2DM interventions: lifestyle modification and metformin treatment for diabetes prevention, and screening for diabetes complications every 2–5 years.
19	Lifestyle-tailored interventions for South Asians with type 2 diabetes living in high-income countries: a systematic review.	Ballotari P, et al. [23]	2017	Systematic review	9	South Asians with T2DM living in high income countries.	Lifestyle interventions.	Mortality, HbA1c, blood pressure, morbidity, self care, physical activity, awareness, knowledge.	<ul style="list-style-type: none"> Significant decrease in HbA1c, blood pressure, improvement in knowledge and self-care.

20	The effectiveness of structured exercise in the south Asian population with type 2 diabetes: a systematic review.	Albalawi H, et al. [24]	2017	Systematic review	18	South Asian adults with T2DM.	Effect of aerobic, resistance, balance, or combined exercise programs.	Glycemic control, blood pressure, waist circumference, blood lipids, muscle strength, functional mobility, quality of life or neuropathy progression.	<ul style="list-style-type: none"> · Aerobic exercise alone or resistance exercise alone were the most common types of exercise. · All types of exercise led to improvements in all measured outcomes. · Obese south Asians with T2DM with physical limitations may even benefit from lower doses of aerobic exercise e.g. light intensity walking of 5 minutes every hour.
21	Improving management of type 2 diabetes in South Asian patients: a systematic review of intervention studies	Bhurji N, et al. [25]	2016	Systematic review of interventional studies	23	Patients from Pakistan, Bangladesh or India with T2DM.	Yoga, meditation, exercise, community-based peers, health professionals, dietary education.	HbA1c, blood pressure, lipid levels, anthropometrics and knowledge.	<ul style="list-style-type: none"> · Significant improvements in glycaemic and other end points in Indian based studies. Less so in European studies.

Table 1: Umbrella review included evidence.

Diabetes Prevention Strategies

The interventions were designed to address the specific needs and contexts of South Asian populations, focusing on dietary interventions (e.g., low glycaemic index foods, culturally appropriate dietary patterns, and calorie reduction), physical activity programs (e.g., structured exercise routines like aerobic exercises, yoga, walking, and cycling), self-management education (e.g., enhancing patient engagement through education and support networks), culturally tailored interventions (e.g., adapting strategies to fit cultural practices and preferences), mobile health (mHealth) interventions (e.g., utilizing mobile health technologies like text messages and apps to support diabetes management), and community-based lifestyle interventions (e.g., leveraging community resources to promote healthier behaviours). Key outcomes used to measure the success of an intervention included glycated haemoglobin (HbA1c) levels, weight loss outcomes,

and changes in T2DM incidence rates, along with the role of lifestyle interventions and support networks.

HbA1c

The reduction of HbA1c levels through lifestyle interventions holds paramount importance in the management of T2DM, particularly within South Asian populations. Reductions in HbA1c levels, indicating improved glycemic control, were realised with lifestyle and mHealth interventions, low-impact exercise, and T2DM education. Similarly, evidence showed improved HbA1c levels in South Asians with physical activity interventions and dietary changes [26]. Interestingly, in Caucasian and Asian populations with T2DM, lifestyle weight-loss interventions resulted in significantly improved HbA1c levels, but not in Black/African or Hispanic groups [27]. These variations could be attributed to non-glycemic factors or behavioural differences, like lack of

self-monitoring. However, recent research has highlighted the potential inaccuracy of HbA1c testing in South Asian populations. A unique genetic variant has been found in 7.6% of this population that falsely lowers HbA1c levels by up to 6 mmol/mol [28]. Similarly, the genetic makeup of Western and Asian populations with advanced T2DM has been linked to variations in cardiovascular disease and mortality rates [29]. Further research is needed to better understand these differences and enhance the monitoring and treatment of individual patients by considering ethnic distinctions.

Weight Loss

The complexity of weight loss in South Asian individuals with T2DM is significant, considering cultural practices, dietary preferences, and lifestyle habits. Nevertheless, weight loss was observed in participants in our review, suggesting the effectiveness of culturally appropriate lifestyle interventions and dietary interventions in managing obesity, a significant risk factor for T2DM. Other reviews have gone further to note the effectiveness of partial meal replacement interventions in South Asian populations, which yielded the most pronounced effects on weight loss and a reduction of -2.19 kg [26]. Similarly, in a randomized control trial of South Asians living in the United Kingdom, total diet replacement techniques showed promise with >10% body weight loss, nudging participants closer to T2D remission [30]. Lifestyle interventions focusing on culturally appropriate dietary changes, increased physical activity, and behavioural interventions have succeeded in preventing and managing T2DM among South Asians, with particular attention to incorporating low GI foods and regular physical exercise [7].

Culturally Tailored Self-Management Strategies

South Asian individuals with T2DM face daily self-management challenges, including diet, weight management, medication, and complex care, influenced by cultural, language, religious, and social factors. Miscommunication and low health literacy further contribute to barriers in diabetes care for South Asians in the US [31]. Our review presents promising outcomes with lifestyle interventions tailored to the specific needs of South Asian populations, indicating the importance of culturally sensitive approaches [7,20]. Other reviews have also shown that culturally tailored education, including flashcards and group sessions, and culturally appropriate food substitutions to be effective in reducing HbA1c levels [26].

Comprehensive education, multidisciplinary teams, and support networks were identified as crucial facilitators for promoting healthier behaviours and improving diabetes management outcomes in our review. Others have also noted that teams, including pharmacists and nurses, can effectively support patients in T2DM self-management [32]. The benefits

of multidisciplinary teams extend beyond self-management and have successfully decreased T2D major amputations in 94% of cases by addressing glycemic control, local wound management, vascular disease, and infection promptly and cohesively for patients with diabetic foot ulcers [33]. Other beneficial support networks in T2DM care include family and informal diabetes self-management groups, which have enhanced adherence to self-care management practices [34]. Likewise, the use of community health workers, equipped with the necessary knowledge, skills, and medical supplies, has the potential to complement healthcare staff's efforts to ensure longevity of improved outcomes [32].

Interventions tailored to different sociocultural and cultural contexts were found to be beneficial in self-management strategies for asthma in South Asian populations [35]. These interventions include culturally and linguistically appropriate education, adaptation to learning styles, and addressing daily stressors and social support [35]. Similarly, in the context of weight reduction among obese South Asian adults, such tailored interventions have shown positive outcomes [36]. Acknowledging cultural and religious factors in dietary interventions for South Asian communities is important, including fasting practices and preferences for sweets during religious festivals. These considerations can enhance patient adherence, confidence, and self-efficacy [31].

Increasing evidence suggests that digital health interventions can enable supported self-management, aligning with the shift towards person-centred care. These digital interventions address challenges like accessibility, real-time monitoring, personalized support, education, and integration of healthcare systems, thereby enhancing their access to healthcare and improving overall health outcomes [37]. In our review, mHealth interventions were found to be effective in reducing HbA1c levels. Existing evidence supports this and reports digital health interventions to be most effective in the form of telemedicine, self-care education, and self-monitoring via smartphone functions [32]. mHealth interventions have also shown success in increasing physical activity [38], decreasing weight in those over 65 years of age [39], and are portable, wearable [40], and scalable [41]. Utilizing mHealth interventions, such as mobile applications and text message reminders, to deliver health education, reminders, and support for diabetes self-management among South Asian populations, extends the reach to diverse geographic locations [38,39,11]. However, face-to-face interactions still hold value, especially in pharmacist medication counselling [32].

Diabetes Prevention Programs

Culturally tailored diabetes prevention programs have shown positive outcomes and were feasible when

implemented in US South Asian participants [42]. Positive changes were observed in weight, waist circumference, blood pressure, plasma lipids, HbA1c, and various other cardiometabolic indicators, with 55% of participants returning to normoglycemia [42]. Importantly, T2DM interventions focused on lifestyle modification and diabetes screening as well as those at the policy level (e.g. smoking cessation programs, tobacco tax, food labelling) were found to be cost-effective, with run-off benefits to cardiovascular health in South Asian populations [22]. Both population and individual-level lifestyle interventions need to be adopted to decrease the burden of T2DM in the future [43]. However, addressing the multifaceted nature of diabetes requires a shift from focusing solely on treatment, to a more holistic approach that targets the underlying causes [44]. Consequently, there is an urgency to shift the focus from treatment-based programs to health delivery programs that embrace population-based interventions to maximize the impact of diabetes management efforts [32,45,46]. By leveraging community-based resources, such as peer support networks and community health workers, access to diabetes care, digital platforms, evidence-based education, and self-management support services, population-level initiatives can be realised for South Asian populations across geographical areas [18,47-49].

Discussion

By focusing on South Asian populations, who are known to have a higher predisposition to T2DM and its complications, this review provides targeted insights that are directly applicable to a group at higher risk. This specificity enhances the clinical applicability of the findings, allowing healthcare providers to tailor interventions more effectively to this population. According to our review findings, culturally tailored interventions are crucial for addressing the multifaceted needs of South Asian individuals with T2DM. While lifestyle interventions show promise in glycemic control and weight management, challenges persist due to cultural, genetic, and social factors. Nuanced approaches considering cultural differences and dietary preferences are essential. Additionally, comprehensive education, support networks, and multidisciplinary teams play pivotal roles in promoting healthier behaviours and improving diabetes management outcomes. Leveraging community health workers and digital health interventions can enhance access to healthcare, aligning with person-centred care principles. Thus, a culturally adapted, holistic approach is indispensable for optimizing diabetes care for the South Asian population with T2DM.

Other research has also highlighted the unique challenges that occur with migrations to Western countries. Acculturation, or the process of adapting to a new cultural environment, often

involves significant lifestyle changes that can affect health outcomes. For instance, acculturation to Western dietary patterns, typically higher in processed foods and sugars, has been linked to increased obesity, cardiovascular risk, and diabetes risk among migrants [50,51]. Access to healthcare is another critical factor, as migrants may experience barriers such as language difficulties, lack of health insurance, and unfamiliarity with the healthcare system, which can lead to delayed diagnosis and inadequate management of diabetes [52]. Additionally, the stress associated with migration and the challenges of adapting to a new environment can exacerbate mental and physical health issues [53]. Addressing these challenges requires targeted interventions that account for the specific needs and circumstances of migrant populations to effectively manage and prevent T2DM.

Our review explored population groups, intervention types and health outcomes. However, dietary variations, socioeconomic status, and differences between urban and rural populations were under-reported in the included studies. The South Asian community exhibits significant diversity that influences diabetes management and intervention outcomes. Regional dietary variations are substantial, with distinct eating habits and food availability impacting nutritional health across different South Asian groups [54]. For example, South Asians in America with strong cultural practices are more prone to consume fried snacks, sweets, high-fat dairy [54], and overall energy intake appeared to decline with longer durations of residence and subsequent generations of immigrants, who also consumed less protein and monounsaturated fat compared to Western populations [55]. Additionally, dietary practices and socioeconomic situations in urban areas often differ from those in rural settings, where access to fresh produce, health education, and healthcare resources might be more limited [56]. These constraints on healthy diets create a complex landscape of diabetes risk and management, where urban populations might have different dietary patterns and healthcare access compared to their rural counterparts [56]. Understanding these variations is crucial for developing tailored strategies that address the dietary pattern modification and the unique needs of diverse South Asian subgroups as part of a comprehensive risk reduction program.

Non-glycemic factors, such as genetic variants were briefly explored in the review literature, including the role of genetic variants in diabetes management. Other research has gone into more detail, reporting six T2DM susceptibility loci (GRB14, ST6GAL1, VPS26A, HMG20A, AP3S2, HNF4A) in South Asians from India, Pakistan, Sri Lanka, and Bangladesh [57]. Notably, SNPs in GRB14 affect insulin sensitivity, while ST6GAL1 and HNF4A influence beta-cell function. GRB14 encodes a protein that inhibits insulin receptor signalling, and ST6GAL1 impacts insulin action through glycosylation

of cell-surface components [57]. Several other genes have also been linked to glucose metabolism, insulin resistance, and reduced fasting insulin levels [57]. This means that genetic variations might lead to differences in how glucose is processed and how HbA1c is formed, and while HbA1c is a standard marker, it might not capture the full spectrum of glucose control issues in those with specific genetic backgrounds [28]. Similarly other studies have also noted that HbA1c levels in South Asians may also be influenced by other factors such as mental wellbeing and body weight [58]. This genetic diversity can complicate the interpretation of HbA1c as a biomarker, potentially leading to misestimation of glycemic control and disease risk.

The review highlights a gap in evidence relating to the sustainability of T2DM interventions in South Asian populations. While many included studies reported the immediate benefits of lifestyle modifications and dietary changes, there was less focus on long-term adherence and the persistence of these benefits. Addressing this gap is crucial to recognize that while short-term results are promising, long-term adherence to interventions is more challenging and essential for sustained health improvements [59]. Data from the MASALA study, the only longitudinal cohort of South Asians in the United States, provided valuable information into the epidemiology [60]. Adjusting to a diabetic diet and lifestyle is a significant challenge for many South Asians with T2DM, primarily due to issues such as limited health literacy, the high carbohydrate levels in traditional South Asian foods, culturally prescribed family roles, and a lack of dietary guidance that aligns with their cultural context [42,60]. This contributes to the lack of sustainability of 'standard' T2D prevention programs in South Asians [42], and minimal long-term effects of lifestyle changes on weight and glucose regulation [5]. Future research should focus on evaluating the long-term efficacy of interventions, including strategies to enhance adherence, measure sustained outcomes, and assess the reduction in diabetes-related complications over extended periods.

Another area that was not explored in detail in this review was the cultural elements that enhance adherence. While our review did uncover the value of culturally tailored interventions in managing T2DM, the included research did not explore the impact of family dynamics, religious practices, or traditional beliefs. Family involvement, such as in meal preparation, food purchasing, and support, significantly influences health behaviours [61], as does integration of religious practices and cultural beliefs [51]. South Asian children living in Canada were found to have increased metabolic risk and the acculturated Western culture was positively associated with a high intake of unhealthy food [51]. Similarly, Canadian South Asian women lacked awareness of healthy eating principles and the time

to prepare healthy meals [62]. Research shows that family-based approaches, respect for religious practices, and a multi-interventional approach can boost engagement and effectiveness in diabetes management [6,62,63]. Additionally, healthcare providers can benefit from a deeper understanding of the cultural context of South Asian diabetes management and provide culturally relevant messaging to support lifestyle changes [64,65].

The recommendation is to therefore to firstly develop and implement tailored interventions targeting South Asian populations at high risk of or already diagnosed with T2DM, considering factors such as genetic predispositions, lifestyle habits, socioeconomic status, and cultural influences, and secondly, promote innovative evidence-driven community- and population-based lifestyle modification programs.

This umbrella review is subject to several limitations. Inconsistencies in reporting intervention characteristics across the included studies hinder direct comparison and synthesis. The variability in study quality and heterogeneity of interventions and populations may affect the reliability and generalizability of the findings. Additionally, publication bias could lead to an overestimation of intervention effectiveness, and the exclusion of non-English studies may limit the comprehensiveness of the review. Temporal and contextual differences among studies further complicate applicability. As this review relies on secondary data, it lacks the nuanced insights available from primary research and may include overlapping studies, which could skew results. While the review acknowledges the inclusion of South Asians residing in high-income countries like the United States and Europe; however, it does not sufficiently differentiate the unique challenges and contextual factors faced by migrant populations. This limitation arises from the nature of the umbrella review, which relies on the scope and quality of the included systematic reviews and meta-analyses, thereby constraining the ability to address specific variables not covered by the primary studies. Future reviews should aim to more thoroughly examine these variables to better understand the nuances in intervention efficacy for South Asian populations.

Conclusion

This umbrella review comprehensively evaluates interventions aimed at preventing and managing T2DM within South Asian populations. The findings reveal a range of effective strategies, including dietary modifications, physical activity programs, self-management education, culturally tailored initiatives, mHealth interventions, and community-based lifestyle interventions. Notably, these interventions demonstrate improvements in glycaemic control, lowered the incidence of T2DM, and enhanced the overall well-

being among South Asians. The review underscores the importance of tailored, culturally sensitive interventions and collaborative efforts with partners to address the unique challenges associated with diabetes care in South Asian communities.

Authorship

Koning C: Conceptualization, investigation, methodology, project administration, writing - original draft, writing - review and editing, final approval, and accountability for all aspects of the work.

Chouinor K: Conceptualization, project administration, writing - review and editing, final approval, and accountability for all aspects of the work.

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