SYSTEMATIC REVIEW/META ANALYSIS

Factors Related to Health Behaviors among Adults with Prediabetes: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Prediabetes is a critical stage in the progression to type 2 diabetes, where preventive lifestyle changes can be most effective. However, many adults with prediabetes do not adhere to recommended health behaviors such as physical activity, healthy dietary practices, and medication adherence. This study aimed to synthesize existing evidence on the factors influencing health behaviors among adults with prediabetes.

Methods: A systematic review and meta-analysis of observational studies was conducted using the PRISMA 2020 framework. A comprehensive search was performed across PubMed, Scopus, ScienceDirect, ProQuest, and Google Scholar. Eligible studies were published in English and focused on determinants of health behaviors in adults with prediabetes.

Results: Fourteen (14) studies met the inclusion criteria. Factors influencing health behaviors were grouped into three categories: (1) sociodemographic and health-related factors (e.g., age, gender, education, body weight), (2) cognitive and perceptual factors (e.g., self-efficacy, perceived benefits and barriers, knowledge, health literacy), and (3) motivational and social factors (e.g., types of motivation, attitudes, cues to action, social support). Meta-analysis demonstrated that higher self-efficacy and greater knowledge were significantly associated with healthier behaviors, although heterogeneity was high for self-efficacy (I^2 >75%). Limitations included the small number of eligible studies and methodological variability.

Conclusion: This review concludes that cognitive and motivational factors play a central role in shaping health behaviors. Tailored, patient-centered interventions focusing on these factors are essential for diabetes prevention. Interventions that strengthen self-efficacy, such as skills-based training and behavioral counseling are recommended to promote sustainable lifestyle change and support diabetes prevention.

Keywords: Factors, Health Behaviors, Adults, Prediabetes, Systematic review

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Introduction

Prediabetes (PreDM) is an intermediate hyperglycemia characterized by glycemic parameters above normal levels but below the diabetic threshold.[1] The global prevalence of PreDM is increasing rapidly.[2] The International Diabetes Federation (IDF) 2024 estimates indicate that approximately 635 million adults are living with impaired glucose tolerance (IGT) and 488 million with impaired fasting glucose (IFG) worldwide, underscoring the enormous and growing global burden of prediabetes.[3] PreDM is not only a risk factor for type 2 diabetes mellitus (T2DM) but is also closely related to microvascular and macrovascular complications.[4,5] PreDM is a serious health condition and was positively associated with risk of all-cause mortality and the incidence of cardiovascular outcomes, coronary heart disease, stroke, chronic kidney disease, cancer, and dementia,[6] during which effective treatment can reduce diabetes risk.[7] Treatment options for PreDM include lifestyle interventions, pharmacotherapy, and bariatric surgery, in which lifestyle intervention are first-line treatments for PreDM.[8] According to CDC, a major multicenter clinical study indicated that lifestyle changes aiming for healthy behaviors are the cornerstones of prevention or the delayed onset of T2DM. However, several recent studies demonstrated unhealthy behaviors among people with PreDM.[9]

Gochman (1997) defines health behaviors (HB) as "behavior patterns, actions and habits that relate to health maintenance, to health restoration and to health improvement". The World Health Organization (WHO) defines HB as "the actions taken by individuals that affect their health or illness".[10] Synthesizing these perspectives, health behaviors can be understood as encompassing both daily lifestyle practices and intentional actions that influence health outcomes. Several HB measurement tools with good psychometric properties have been identified in the literature. These include the Health-Related Behavior Inventory,[11] which assesses behaviors in both healthy and ill adults; the Highly Effective HB Pattern Inventory-Short Form,[12] a self-assessment tool for health-promoting habits; the Health-Related Behavior Scale,[13] which covers areas such as diet, sleep, exercise, substance use, and mental hygiene; and the Health-Promoting Lifestyle Profile. Most other tools measure specific behaviors separately, such as smoking, drinking, or sleeping.

Health behavior research is often informed by models such as the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). The HBM highlights modifying factors (e.g., sociodemographic and health-related characteristics) and cognitive constructs such as perceived benefits, barriers, and self-efficacy, while the TPB emphasizes attitudes, norms, and perceived control. Based on these frameworks, factors in this review were grouped into three categories: sociodemographic and health-related, cognitive and perceptual, and motivational and social.

Although many studies have explored predictors of health behaviors in adults with prediabetes, few have synthesized these factors into a unified framework. Understanding how various determinants influence behavior across different populations and settings is crucial for designing effective prevention strategies. This review focused exclusively on observational studies because they capture real-world associations across diverse contexts and populations; however, such designs limit causal inference due to potential confounding and bias. Future reviews could expand the scope to include interventional studies, which would provide stronger evidence on causal pathways and the effectiveness of targeted strategies. Thus, this review aims to identify common and context-specific factors to inform interventions that support healthy lifestyle changes in people with prediabetes.

Methodology

Research Design: This systematic review and meta-analysis were reported following PRISMA guidelines (Figure 1). The study was registered prospectively with PROSPERO (CRD42024612782) ensuring methodological transparency and rigor. The search term was formulated using the PECO (Population, Exposure, Comparison, and Outcome) to ensure a structured and comprehensive approach. The research question is "What factors are related to health behaviors among adults with prediabetes?"

Search strategy: Published literatures were searched in several databases including PubMed, Scopus, ScienceDirect, ProQuest and google scholar with no limited time. Several preliminary searches were conducted to refine the search terms and determine the most appropriate search strategy for each database. The search terms were combined as text word and BOOELAN operator. Search terms were used as (prediabetes OR "prediabetic state") AND "health behaviors" AND (factors OR predictors OR determinant) (Supplementary table 1) presented the search strategy and results in each database.

Inclusion and Exclusion criteria: To be included in this review, studies had to meet all the following criteria: (a) They must be cross-sectional and focus on adults with PreDM aged 18 years or older; For this review, PreDM was defined based on established diagnostic criteria from recognized organizations such as the ADA, WHO, or International Diabetes Federation. These definitions typically include impaired fasting glucose, impaired glucose tolerance, and/or elevated glycated hemoglobin (HbA1c) levels, according to respective guideline thresholds.[14] Studies using any of these standard measures to identify individuals with PreDM were eligible for inclusion. (b) Studies conducted in any setting including hospitals, clinics, or community-based settings were eligible for inclusion, as long as they focused on adults with PreDM. This approach was intended to capture a comprehensive understanding of influencing factors across different healthcare and community environments. (c) Studies had to be published in English. (d) Primarily investigate factors that predict, influence, or are associated with HB, drawing from various theoretical frameworks. HB were broadly defined to include any behavior patterns, actions, or habits undertaken by individuals with the intent to maintain health, improve well-being, or prevent health problems. To ensure rigor, influencing factors needed to be measured using standardized or validated instruments, defined as tools with documented evidence of reliability (e.g., internal consistency, test-retest stability) and validity (e.g., content, construct, or criterion-related validity) reported in the original or subsequent validation studies.

This study excluded abstracts, conference proceedings, reviews, letters, research monographs, editorials, and pooled analyses. Additionally, studies were excluded if they did not clearly define their diagnostic criteria for PreDM, used non-standardized or unvalidated tools for measuring influencing factors, or involved populations outside the scope such as pregnant women with gestational diabetes, individuals with type 1 or type 2 diabetes, or those with multiple chronic diseases. In addition, studies judged to have a high risk of bias (e.g., based on methodological limitations such as unclear sampling, inadequate adjustment for confounders, or poor reporting of measures) were excluded.

The selection of studies: Each author independently conducted their respective screening process. The search results were systematically compiled into an EndNote database. Initially, both the titles and abstracts were screened separately using predefined inclusion and exclusion criteria to refine the selection of potentially relevant studies. Articles that did not meet the relevance criteria were excluded at this stage. Subsequently, studies that passed the preliminary screening and were deemed sufficiently relevant underwent a second, more detailed evaluation, where the full texts were reviewed. Following this process, the authors compared their findings and resolved any discrepancies through discussion, ultimately reaching a consensus.

Quality assessment: Study quality was evaluated using an 8-item checklist based on Joanna Briggs Institute (JBI) guidelines,[15] covering: (1) clarity of inclusion criteria, (2) appropriateness of participants and setting, (3) valid measurement of exposure, (4) standard criteria for identifying the condition, (5) valid measurement of outcomes, (6) identification of confounders, (7) handling of confounders, and (8) appropriateness of statistical analysis. Each item was scored 1 ("YES") or 0 ("NO," "UNCLEAR," or "NOT APPLICABLE"), giving a total score of 0-8. Scores of 6-8 were deemed high quality, reflecting strong methodological rigor and low risk of bias.[15] Two reviewers independently assessed study quality, resolving disagreements through discussion and, if needed, arbitration by a third reviewer. Detailed results are provided in Supplementary table 2.

Data Extraction: The final set of included studies was systematically extracted into a structured table, summarizing key information such as title, year of publication, authors, country, population characteristics (mean age/age range), study design, sample size, theoretical framework, study outcomes, health behavior measurement tools, and main findings (Table 1). To allow comparison across studies, reported effect sizes (e.g., β coefficients) were standardized using established formulas to convert them to correlation coefficients (r) where applicable. Findings regarding factors associated with health behaviors were then organized into three categories: sociodemographic and health-related characteristics factors, cognitive and perceptual factors, and motivational and social factors. In addition to quality scoring, each study's risk of bias was assessed following JBI tool for observational studies.

Statistical Analysis: This review presents both a narrative synthesis and a meta-analysis. A meta-analysis was performed for factors that were uniformly defined and reported across studies, in order to estimate their pooled association with health behaviors. Effect sizes were extracted as standardized regression coefficients (β), correlation coefficients, or odds ratios (OR), along with their corresponding 95% confidence intervals (CI). When correlation coefficients were not available, β coefficients were converted using standard statistical methods. Fisher's r-to-z transformation was applied before pooling correlation coefficients.

A fixed-effects model was initially used to estimate the average effect size. Heterogeneity between studies was assessed using the I^2 statistic. When high heterogeneity was identified (I^2 >75%), findings were interpreted cautiously.[16] Sensitivity analyses, including leave-one-out procedures, were performed to evaluate the influence of individual studies on the pooled estimates and assess the robustness of the results. Factors reported in only a single study or those with heterogeneity too high to allow pooling were synthesized narratively.

Results

Identification and selection of studies: 2681 published publications were found. 193 of these articles were eliminated because of duplication. 2488 items were screened for titles and abstracts. 2396 of these articles were excluded. After that, sixty studies were not retrieved out of the 92 that were searched for retrieval because of inaccessible full text. Eleven papers that met the inclusion criteria were finally included. Furthermore, three papers were added to through citation searching, bringing the total number of included studies to 14 (Figure 1).

Characteristics of included articles: All included studies were cross-sectional. Six were conducted in the United States, two in Africa, two in Taiwan, and one each in Australia, Korea, Iran, and Europe. Three studies included both diabetes and prediabetes, with separate findings reported. Sample sizes ranged from 200 to 2,694 participants. Two studies specified participant ages between 30 and 75 years, and two reported ages over 40. Health behaviors were most often measured using separate tools for physical activity, diet, weight control, or other behaviors (n=10). Other instruments included the Health Promoting Lifestyle Profile (n=2), the Behavioral Risk Factor Surveillance System (n=1), and the "Alameda 7" (n=1).

In reporting the characteristics of included studies, it is important to quantify the extent to which behavioral theories were applied. Various behavioral theories were used across studies. These included Pender's Health Promotion Model, Social Learning Theory,[21] the Health Belief Model,[30] the Theory of Planned Behavior,[23,24] and Self-Determination Theory[25]. Each framework offered different perspectives on motivation, self-efficacy, and decision-making in prediabetes-related health behaviors. The remaining 7 studies did not specify a theoretical basis, often relying instead on secondary analyses of large surveillance datasets (e.g., National Health Interview Survey-NHIS, Behavioral Risk Factor Surveillance System- BRFSS, National Health and Nutrition Examination Surveys-NHANES). This imbalance has implications for synthesis: theory-based studies allow clearer interpretation of cognitive and motivational determinants, while non-theoretical studies may provide broader population-level associations but limit mechanistic insights. Future research should aim for greater integration of behavioral theory to strengthen explanatory power and intervention design.

Quality Appraisal of the included studies: Of the 14 included studies, 3 were rated medium quality (scores 5.8) and 11 were rated high quality (scores 6.8-8.8). No study fell into the low-quality range (Supplementary table 1).

Predicting factors of health behaviors: Factors related to HB among people with PreDM were categorized into three major groups based on finding factors from literature including sociodemographic and health-related factors, cognitive and perceptual factors, and motivational and social factors.

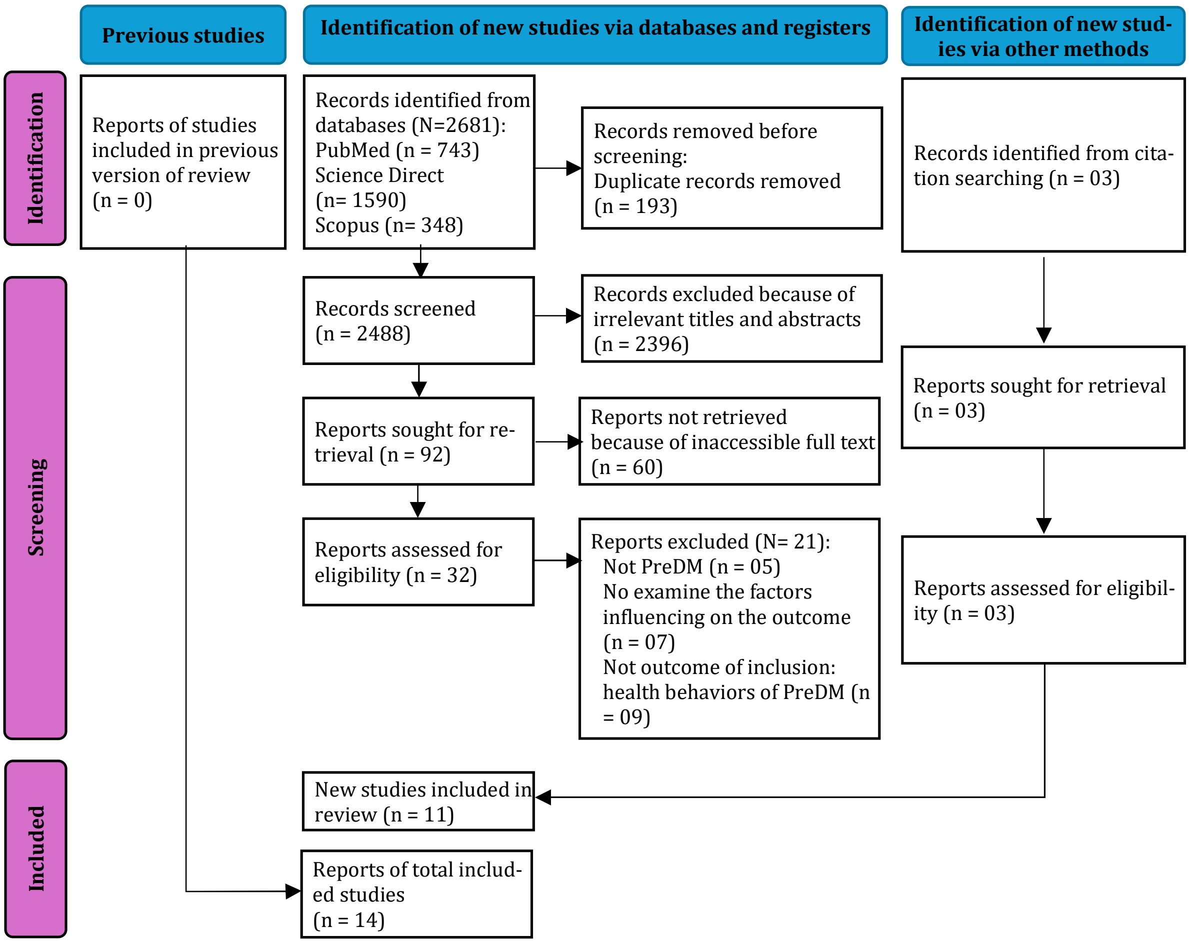

Figure 1: PRISMA 2020 flow diagram for updated systematic reviews which included searches of databases, registers, and other sources

Table 1: Systematic review of factor related to health behaviors in adults with prediabetes

Author(s), Country	Population	Study design and sample size	Theory	Health behaviors	Measurement tools	Main findings
Chen SF et al.,(2010) [17] Taiwan	work site adults with prediabetes	Cross-sectional study, N=260	Health Promotion Model	Health-promoting lifestyle 1. self-actualization, 2. health responsibility, 3. physical activity 4. nutrition, 5. interpersonal support 6. stress management.	Health -Promoting Lifestyle Profile Simple Scale (HPLP-S)	1. perceived action benefit was positively related to HB (beta = 0.129, p = 0.023) 2. perceived action barrier was negatively related to HB (beta = -0.207, p = 0.001) 3. self-efficacy was positively related to HB (beta = 0.519, p = 0<001).
Williams ED et al., (2010)[18] Australia	The Australian Diabetes Obesity and Lifestyle Study (AusDiab), adults aged ≥25 years	Cross-sectional survey	Not reported	1.Smoking, 2. Exercise, 3. Diet Quality, 4. Sedentary behavior	1. Smoking: a questionnaire on tobacco use 2. Exercise: the Active Australia questionnaire 3. Diet: the Anti-Cancer Council of Victoria food frequency questionnaire 4. Sedentary lifestyle: self-reported television viewing	1. Higher levels of education were associated with lower rates of smoking ($p < 0.001$) 2.Higher levels of education were associated with higher physical activity ($p < 0.001$) 3. Higher levels of education were associated with higher diet quality ($p< 0.001$) 4. Higher levels of education were associated with lower sedentary behaviour ($p<0.001$).
Dorsey R et al., (2011)[19] US	overweight and obese people with diabetes or prediabetes aged 40 years or older	This report is based on cross-sectional data available from the 2006 National Health Interview Survey (NHIS). n = 74 among people with diabetes; n = 29 among people with prediabetes	Not reported	1. tried to control or lose weight, 2. reduced the amount of fat or calories in their diet, 3. increased their physical activity	Respondents reported on their lifestyle behaviors, including whether they had done any of the following during the previous 12 months (yes/no): tried to control or lose weight, reduced the amount of fat or calories in their diet, or increased their physical activity	1. Men and women who received physician advice were significantly more likely to increase physical activity (OR = 3.6 and 3.0, respectively).
Zhou QP et al., (2012)[20] US	adults 20 years old or older who reported having pre-diabetes and self- identified as non-Hispanic blacks or non-Hispanic whites.	Cross-sectional survey black (n = 1156) and white (n = 9539) adults with prediabetes. This is a secondary data analysis using national data obtained from the Behavioral Risk Factor Surveillance Sys-	Not reported	1. regular physical activity 2. adequate intake of fruits 3. vegetables, and overweight/obesity.	1 participating in moderate-intensity physical activity for ≥ 150 minutes per week or engaging in vigor- ous activity for ≥ 60 minutes per week. 2. using 6 questions measuring the frequency of drinking fruit juice and eating fruit, green salad, non-fried potatoes, carrots, and other vegetables 3. Being overweight was defined as hav-	1. Blacks were more likely than whites to be overweight or obese (86% vs. 79%, $p < .001$) 2. Blacks were less likely than whites to engage in regular physical activity (29% vs. 40%, $p < .001$).

Author(s), Country	Population	Study design and sample size	Theory	Health behaviors	Measurement tools	Main findings
		tem (BRFSS).			ing a BMI of ≥ 25.0 but < 30 (1 = overweight).	
Chen MF et al., (2015)[21] Taiwan	age at least 21 years old	A descriptive cross-sectional design N =200	Bandura Social Learning Theory	Health-promoting self-care behaviors 1. self-actualization, 2. health responsibility, 3. physical activity, 4. nutrition, 5. interpersonal support 6. stress management	Health-Promoting Lifestyle Profile (Wei & Lu, 2005).	1. Self-efficacy was positively associated with health-promoting self-care behaviors (β = 0.552, p < .05). 2. Family history of DM showed a weaker positive relationship (β = 0.021, p < .05). 3. Perception of the empowerment process was positively related (β = 0.017, p < .05). 4. PreDM knowledge was positively associated but with the smallest effect (β = 0.009, p < .05)
Gopalan A et al., (2015)[22] US	Subjects aged > 20 years	A pooled cross-sectional analysis of adults from two cycles (2007-2008, 2009-2010) of the National Health and Nutrition Examination Survey N= 2,694	Not reported	Diabetes Risk-Reducing Behaviors. 1. physical activity 2. weight-related activity, and 3. the combination of weight-related and physical activity	1. any PA plus any weight-related behavior; 2. weekly moderate or vigorous PA plus BMI-appropriate weight behavior; 3. >=150 minutes/week of moderate or vigorous activity plus >=7% weight loss in past year.	1. Prediabetes-aware individuals were more likely to engage in both moderate PA with healthy weight (AOR = 1.5, 95% CI: 1.1-2.0) and meet goals of 150 min/week activity plus 7% weight loss (AOR = 2.4, 95% CI: 1.1-5.6)
Rahmati-Najarkolaei F et al., (2017)[23] Iran	age 18-75 years	N= 303	Theory of Planned Behavior (TPB)	Lifestyle behaviors 1.Physical Activity 2. Healthy eating behaviors	1. Exercise behavior was measured using a modified and validated version of Godin Leisure Time Exercise Questionnaire 2. A short self-reporting measure was used to assess the consumption of fruit and vegetable 'Over the last 2 weeks, I had (insert a number) ____ serving(s) of fruit in a typical day'' and ''Over the last 2 weeks, I had (insert a number) ____ serving(s) of vegetable in a typical day''.	1. Attitude was positively associated with PA (β = 3.31, p < .05), fruit and vegetable intake (β = 1.93, p < .05), and foods low in saturated fat (β = 1.26, p < .05), though with the smallest effect among TPB predictors for the latter. 2. Subjective norms were positively related to PA (β = 2.69, p < .05), fruit and vegetable intake (β = 4.42, p < .05), and low saturated fat food consumption (β = 2.73, p < .05). 3. Perceived behavioral control was the strongest positive predictor of all three lifestyle behaviors: PA (β = 4.21, p < .05), fruit and vegetable consumption (β = 4.72, p < .05), and consumption of foods low in saturated fat (β = 4.40, p < .05) 4. Behavioral intention was also significantly associated with PA (β = 3.25, p < .05), fruit and vegetable intake (β = 2.79, p < .05), and con-

Author(s), Country	Population	Study design and sample size	Theory	Health behaviors	Measurement tools	Main findings
						sumption of low saturated fat foods (β = 2.19, p < .05).
Hansen S et al., (2018)[24] Europe and around the world	Participants eligible for the study were over-weight (BMI > 25 kg/m2) and pre-diabetic adults between 25 to 70 years old	Experimental study N= 1973. PREVIEW study	Theory of Planned Behavior	1. Weight loss	Weight Loss	1. Male sex was positively associated with weight loss (β = 0.38, p < .05) 2. BMI was positively associated with weight loss (β = 0.41, p < .05) 3. Income was also positively associated with weight loss (β = 0.11, p < .05). 4. Expectation of disadvantages of a healthy diet was negatively associated with weight loss (β = −0.10, p < .05). 5. Education was negatively associated with weight loss (β = −0.05, p < .05).
De Man J et al., (2020)[25] Uganda. East Africa	aged 30-75 years, with a positive confirmatory test for prediabetes or diabetes	cross-sectional design, N = 712, prediabetes = 329, diabetes = 383	Self-Determination Theory	Physical activity (PA) (1) vigorous PA (2) moderate PA (3) steps counts	Physical activity was measured through: (1) self-reported frequency of vigorous PA, (2) self-reported frequency of moderate PA, and (3) pedometer counts.	**1.**Autonomous motivation was positively associated with vigorous PA (β = 0.24, p < 0.05)
De Man J et al., (2020)[26] South African	age 30-75	cross-sectional design, N = 585; prediabetes = 292, diabetes = 293,	Self-Determination Theory	Healthy dietary behavior: 1. frequency of intake of fruit, 2. vegetables 3. non-refined starch.	Healthy eating	1. Perceived competence was positively associated with healthy eating (β = 0.49, p < 0.05) 2. Perceived relatedness was also positively associated with healthy eating (β = 0.37, p < 0.05)
Luo H et al., (2020)[27] US	adults aged ≥18 residing in the United States	cross-sectional survey, used data from the 2016 Behavioral Risk Factor Surveillance System (BRFSS) (N = 54 344 adults).	Not reported	1. current smoking, 2. physical inactivity, 3. inadequate sleep,	3 HB-related variables available in the 2016 BRFSS core questionnaire as binary outcome variables	1. Low health literacy was positively associated with current smoking (ß = 0.059; P < .001) 2. Low health literacy was positively associated with physical inactivity (ß = 0.064; P < .001) 3. Low health literacy was positively associated with inadequate sleep (ß = 0.075; P < .001)
Li et al., (2021)[28] US	-	cross-sectional survey. N=389 participants in the Prediabetes-Aware group and N= 410 participants in the Predia-	Not reported	1. dietary behaviors 2. physical activity.	7 questions to evaluate dietary behaviors and 10 questions to evaluate physical activity.	1. Prediabetes awareness was not associated with any difference in dietary or physical activity behaviors

Author(s), Country	Population	Study design and sample size	Theory	Health behaviors	Measurement tools	Main findings
		betes-Unaware group				
Kwak S et al., (2022)[29] Korea	adults over 40 years of age among the data from the National Health and Nutrition Examination Survey	cross-sectional survey. This descriptive research study used a secondary analysis of the raw data from the 7th (2016-2018) and 8th (2019) Korea National Health and Nutrition Examination Surveys N= 2485.	Not reported	1. non- smoking, 2. moderate drinking, 3. adequate sleep, 4. maintaining a desirable weight, 5. exercising, 6. eating breakfast, 7. avoiding snacks	seven health-related behaviors referred to as the "Alameda 7"	1. Subjective health perception was positively associated with multiple HB. Individuals who perceived their health as good had higher rates of normal weight (33.1% vs. 21.7%), adequate sleep (32.9% vs. 20.0%), and adequate exercise (47.4% vs. 26.5%) compared to those with poor subjective health status (p < .001 for all).
McEwen LN et al., (2022)[30] US	any metformin use among the 802 individuals with prediabetes as the primary outcome of interest.	Cross-sectional study N=802.	Health Belief Model (HBM)	Metformin Use	Metformin Use	1. Younger age was negatively associated with metformin use (OR = 0.970; 95% CI = 0.950-0.991). 2. Female sex was positively associated with metformin use (OR = 1.682; 95% CI = 1.023-2.767) 3. Higher BMI was positively associated with metformin use (OR = 1.050; 95% CI = 1.020-1.081). 4. Cues to action, specifically a doctor offering metformin therapy, showed the strongest association with metformin use (OR = 65.82; 95% CI = 41.49-104.42).

(1) Sociodemographic and health-related factors

Among the 14 studies reviewed, two studies identified gender as a significant predictor. Women were more likely to use metformin (OR = 1.682, 95% CI: 1.023-2.767; positive association),[30] while men were more likely to achieve weight loss (β = 0.38, p <0.05; positive association).[24] These findings indicate that gender may differentially influence specific HB, such as pharmacologic adherence and lifestyle modification outcomes.

Among the 14 included studies, only one identified age and body mass index (BMI) as significant predictors of metformin use. Younger age was negatively associated with metformin use (OR = 0.970, 95% CI: 0.950-0.991), while higher BMI was positively associated (OR = 1.050, 95% CI: 1.020-1.081).[30]

In the study by Kwak S et al. (2022),[29] a significant association was observed between self-rated health perception and sleep behavior. Positive self-rated health was positively associated with adequate sleep and exercise (p <0.001).

Higher education was positively associated with lower smoking (p <0.001), higher physical activity (p <0.001), better diet quality (p <0.001), and lower sedentary behavior (p <0.001).[18]

Family history of diabetes had weak positive association with HB (β = 0.021, p <0.05)[21]

Socioeconomic status, especifically monthly income, was identified as a significant correlation of weight loss. In the study by Hansen et al. (2018),[24] higher income was positively associated with greater success in weight reduction efforts (*p* <0.05).

(2) Cognitive and Perceptual Factors

There is a significant positive correlation between perceived action benefit and health-promoting lifestyle (beta = 0.129, p = 0.023).[31] There is a significant negative correlation between perceived action benefit and health-promoting lifestyle (beta = -0.207, p = 0.001).[31] There were different findings on prediabetes awareness. One study found a positive association with engagement in physical activity and weight management,[22] while another found no significant association with diet or physical activity.[28]

Doctor's advice for metformin was strongly positively associated with use (OR = 65.82; 95% CI = 41.49-104.42).[30] Behavioral intention was positively associated with physical activity (β = 3.25, p <0.05), fruit and vegetable intake (β = 2.79, p <0.05), and low saturated fat food consumption (β = 2.19, p <0.05). These findings highlight the role of triggers in prompting HB.

Self-efficacy is a predictor of HB in those living with prediabetes.[21,31] Self-efficacy positively effect HB (beta = 0.519, p = 0<001).[31] Another study showed accounting for 55,2% of the variance in dependent variable and self-efficacy is a predictor of HB.[21]

According to Luo et al. (2020),[27] low health literacy was significantly and positively associated with multiple adverse HB among adults with prediabetes. Specifically, individuals with lower health literacy were more likely to report current smoking (β = 0.059, p <0.001), physical inactivity (β = 0.064, p < .001), and inadequate sleep (β = 0.075, p <0.001).

According to Chen et al. (2015),[21] positive but small association with HB (β = 0.009, p <0.05). Meta-analysis showed a pooled effect (r = 0.21, 95% CI: 0.12-0.30).

(3) Motivational and social factors

Autonomous motivation was positively associated with vigorous physical activity (β = 0.24, p < 0.05).[25] Perceived competence showed a positive association with healthy eating (β = 0.49, p < 0.05), while perceived relatedness was also positively associated with healthy eating (β = 0.37, p < 0.05).[26] Perceived behavioral control emerged as the strongest positive predictor of all three lifestyle behaviors: physical activity (β = 4.21, p < 0.05), fruit and vegetable consumption (β = 4.72, p < 0.05), and consumption of foods low in saturated fat (β = 4.40, p < 0.05).[23] Attitude was positively associated with physical activity (β = 3.31, p < 0.05), fruit and vegetable intake (β = 1.93, p < 0.05), and consumption of foods low in saturated fat (β = 1.26, p < 0.05), although it showed the smallest effect among the TPB predictors for the latter.[23]

Physician advice was positively associated with physical activity (men: OR = 3.6, 95% CI: 1.5–8.7; women: OR = 3.0, 95% CI: 1.5–5.9) and dietary change (women: OR = 2.8, 95% CI: 1.5–5.3), as reported by Dorsey et al. (2011).[19] In contrast, family and friend discouragement was negatively associated with weight loss (p < 0.05). Family and friend support also showed that disadvantages of a healthy diet and discouragement to eat healthily were negatively correlated with weight loss (p < 0.05).[24] Health care provider advice, particularly from physicians, was related to increased physical activity.[19] Subjective norms were positively related to physical activity (β = 2.69, p < 0.05), fruit and vegetable intake (β = 4.42, p < 0.05), and low saturated fat food consumption (β = 2.73, p < 0.05).[23]

Factors Eligible for Meta-Analysis

The meta-analysis of self-efficacy included two studies with a combined sample size of 460 participants (N = 260 and N = 200). Both studies reported a moderate positive association between self-efficacy and health-promoting lifestyle behaviors (r ≈ 0.52). The pooled effect size was r = 0.52 (95% CI: 0.45-0.58), indicating a consistent moderate positive relationship. A forest plot shows the individual study effect sizes, confidence intervals, and their contribution to the pooled estimate.

A total of 2 studies reported the association between self-efficacy and HB were included in the analysis.

The observed Fisher r-to-z transformed correlation coefficients ranged from 0.0993 to 0.2986. Fix-effects model was used to access the estimated average Fisher r-to-z transformed correlation coefficient with pooled correlation = 0.2121 (95% CI: 0.1201 to 0.3041), p = 0.0354, I^2 = 77.4109%.[17, 21] The pooled analysis using a fixed-effects model yielded a moderate positive correlation between self-efficacy and engagement in health-related behaviors (r = 0.59, 95% CI: 0.53-0.65, p = 0.042). The observed heterogeneity was substantial (I^2 = 75.79%), suggesting variation between studies, likely due to differences in sample characteristics and study settings.

A fixed-effects meta-analysis of two studies examined the link between prediabetes knowledge and HB. Chen et al. (2010)[17] found a significant positive association (effect size = 0.30, 95% CI: 0.18-0.42), while Chen et al. (2015)[21] reported a smaller, non-significant effect (effect size = 0.10, 95% CI: -0.04-0.24). The pooled effect size revealed a significant positive correlation (r = 0.21, 95%CI [0.13, 0.3], p<.001) (Figure 3) with heterogeneity (I^2 = 77.69%).

A Meta-Analysis: The probability of publication bias was assessed by Egger's test and Begg's test. For the association between self-efficacy, knowledge and HB, there are publication bias due to Egger's test < 0.05 (Egger's test = 0.04 for self-efficacy, and Egger's test = 0.03 for knowledge). However, the Trim & Fill analysis was not performed for publication bias due to only 2 articles. Similarity, with 2 articles, it is unsuitable to conduct sensitivity analysis to solve problem of heterogeneity.

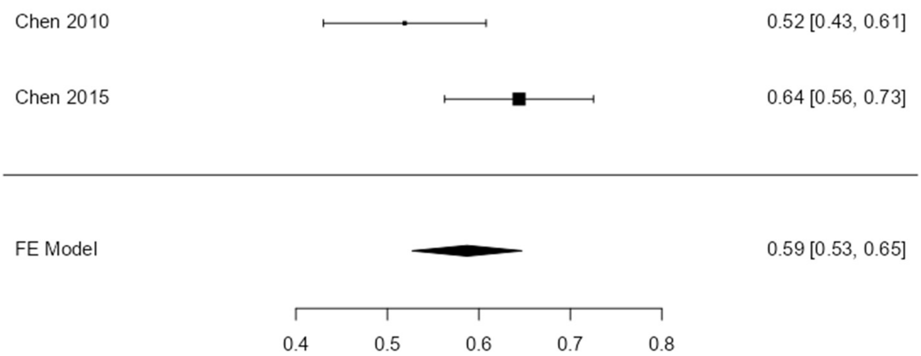

Figure 2: Association Between Self-efficacy and Health Behaviors: A Meta-Analysis

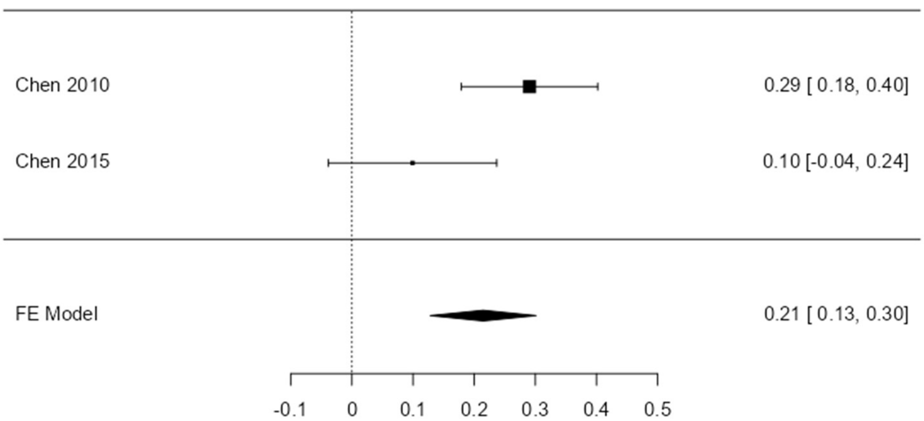

Figure 3: Association Between Prediabetes Knowledge and Health Behaviors

Discussion

This systematic review and meta-analysis synthesized evidence on factors influencing HB among adults with PreDM. Findings were grouped into sociodemographic and health-related factors, cognitive and perceptual factors, and motivational and social factors, offering a multidimensional perspective on behavior change in this population.

Sociodemographic and health-related factors: Several demographic and health-related predictors were identified. Gender differences were notable: women were more likely to use metformin, while men had greater success with weight loss interventions.[24,30] These differences may reflect gendered health perceptions and behaviors, with women typically more engaged with healthcare and preventive services, and men more responsive to structured physical interventions. Prior studies show that women report more adverse reactions to metformin, while men tend to lose more weight on anti-obesity medications, supporting the need for gender-tailored approaches.[32,33]

Higher BMI and younger age were also associated with greater engagement in HB such as medication uptake (metformin use). This may reflect greater perceived vulnerability and willingness to adopt preventive behaviors among younger individuals with higher health risks.[30,34] However, societal norms and body image perceptions, especially among men, may complicate these associations, warranting more nuanced research into these sociocultural dynamics.

Socioeconomic status (SES) and education were positively linked to healthier behaviors, including increased physical activity, better diet quality, and reduced smoking-consistent with the well-established social gradient in health.[18,35]Higher SES typically enables better access to health information and resources, although it may not fully offset risks like obesity linked to lower education.[36]

Finally, subjective health perception influenced behaviors such as sleep and exercise. Individuals with a positive view of their health were more likely to adopt preventive actions, likely due to higher motivation and self-efficacy.[29,37] Understanding the interplay between subjective health and behaviors can inform targeted health promotion initiatives, particularly in vulnerable populations.[38]

Cognitive and Perceptual Factors: Perceived benefits and barriers were significantly associated with health behaviors. Individuals who recognized more benefits and fewer barriers were more likely to engage in healthy behaviors, especially diet and physical activity.[31] Similar patterns are seen in other populations, such as cardiac patients, where perceived advantages increased participation and lower barriers improved adherence.[39] While the Health Belief Model explains much of this, external factors like socioeconomic status and healthcare access also influence behavior, highlighting a more complex interaction.[40]

Findings on prediabetes awareness were inconsistent. While some studies showed it promoted healthier behaviors,[22] others found no significant effect.[28] This suggests that awareness alone may not be enough without accompanying motivation, support, and self-efficacy, as environmental and psychological barriers often impede behavior change.[41] These inconsistencies may reflect important contextual moderators. For example, cultural differences in health literacy, the availability of national screening programs, and variations in healthcare access could shape awareness levels differently across populations.[42] In high-income countries, systematic screening and public health campaigns may contribute to higher awareness,[43] whereas in low- and middle-income settings, limited resources and differing cultural perceptions of risk may result in lower recognition of prediabetes. Future research should explicitly examine such moderators to better explain the variability in awareness across studies.

Delay discounting, or the preference for immediate rewards over long-term health benefits, was examined in only one study, revealing a gap in the literature. This trait may explain why some individuals struggle with diet and exercise adherence. Epstein LH et al. (2019)[43] similarly found that higher delay discounting was linked to increased HbA1c, reinforcing its relevance in chronic disease progression.

The exploration of health literacy reveals significant associations with various health behaviors, including smoking, physical inactivity, and sleep quality. A study by Luo H et al. (2020)[27] indicated that lower health literacy correlates with increased smoking and inactivity, which is consistent with broader research showing that low health literacy hinders preventive behaviors and effective self-management of health conditions.[44,45] This highlights a critical gap in research, particularly in non-Western populations, where such associations remain underexplored. A meta-analysis by Guo XM et al. (2020)[46] found a positive correlation between HL and self-care behaviors, with a pooled effect size indicating a small-to-moderate association ($r = 0.24$).

A meta-analysis showed that prediabetes knowledge had a small but significant effect on health behaviors ($r = 0.21$). While knowledge raises awareness, it may not translate into action without motivation or support. This is consistent with research suggesting that information alone is insufficient for sustained behavior change and may even create a false sense of confidence.[47] In this review, knowledge showed a small but significant positive association with health behaviors in prediabetes, suggesting that greater awareness may facilitate lifestyle changes. This aligns with evidence from type 2 diabetes (T2DM) populations, where meta-analyses of diabetes knowledge and self-management also report small-to-moderate associations. Improved diabetes knowledge is linked to better self-management behaviors, including diet and exercise.[48]

In contrast, self-efficacy was a stronger and more consistent predictor of health behaviors. Higher self-efficacy was linked to better engagement in physical activity, diet, and self-care. This aligns with Bandura's Social Cognitive Theory and Pender's Health Promotion Model, both of which identify self-efficacy as a core predictor of behavioral change. The pooled analysis of two studies showed a moderate, significant positive association between self-efficacy and health behaviors ($r = 0.59$, 95% CI: 0.53-0.65, $p = 0.042$), despite heterogeneity between samples. This confirms self-efficacy as a core determinant of behavior in PreDM. Despite this heterogeneity, both studies demonstrated consistent positive associations between higher self-efficacy and greater adherence to health behaviors. These findings quantitatively support the narrative synthesis, emphasizing self-efficacy as a key determinant of health behavior in adults with prediabetes. Although it is on the lower end of the spectrum, its size is generally consistent with findings from type 2 diabetes (T2DM) populations, where reviews regularly show positive relationships between self-efficacy and self-management (medication adherence, physical activity, and nutrition). For example, a narrative review reports that most T2DM studies find significant associations between self-efficacy and at least one self-management behavior, aligning with small-to-moderate correlations overall.[49] Complementary meta-analyses of diabetes self-management education (DSME) show that interventions frequently increase self-efficacy (typically small-to-moderate standardized gains), which is consistent with efficacy's role as a determinant of behavior even if the cross-sectional association is modest.[50,51]

Motivational and Social Factors: Motivational and social factors also significantly shaped health behaviors. Drawing on Self-Determination Theory[25] found that autonomous motivation, perceived competence, and relatedness were all positively associated with physical activity and healthy eating. These findings suggest that individuals who feel personally invested in their goals and supported by others are more likely to sustain behavior change. In addition, studies based on the Theory of Planned Behavior further emphasized the role of attitudes, subjective norms, and perceived behavioral control. For example, Rahmati-Najarkolaei F et al. (2017)[23] found that perceived behavioral control was the strongest predictor of healthy behaviors, followed by behavioral intention, subjective norms, and attitudes. This reinforces the importance of targeting motivation and perceived control in behavior change interventions social support from family, friends, and healthcare providers plays a crucial role in shaping HB. Positive encouragement from these social networks has been consistently associated with improved dietary habits and increased physical activity among individuals with prediabetes.[21,24] In contrast, lack of support or discouragement often serves as a barrier to behavior change. Physician advice, functioning as a cue to action, has been shown to significantly influence attempts to increase physical activity and manage weight,[19,30] underscoring the important role of healthcare providers in motivating patients. Similar patterns have been observed in other populations, such as college students, where family encouragement is linked to greater physical activity engagement. However, support dynamics are not uniformly positive. For example, single mothers relying solely on family support may experience increased psychological distress when friend support is lacking.[52] In collectivist societies, family expectations may lead to pressure rather than empowerment, creating stress and potentially undermining autonomy.[53] Therefore, while family support is often beneficial, it is important to consider its potential negative impact, particularly in cultural contexts where familial obligations and expectations are strong.

Subjective norms were positively related to healthier behaviors, including dietary practices and physical activity, confirming the role of social expectations in influencing individual choices.[23] Research consistently finds that stronger subjective norms correlate with increased intentions to engage in physical activity and healthier dietary choices.[54]

Motivational factors emerged as significant predictors of health behaviors. However, it is important to consider the cultural context in which motivation operates. Most of the included studies were conducted in high-income, predominantly individualist societies, where motivation is often framed in terms of personal agency and autonomy. In collectivist cultures, which are more common in low- and middle-income countries, health behaviors may be influenced more strongly by family expectations, community norms, or social harmony than by individual motivation alone. For instance, dietary changes or physical activity may be pursued not only for personal benefit but also to align with familial responsibilities or collective well-being. These cultural dimensions could partly explain variability in motivational effects across settings and highlight the need for culturally tailored interventions to enhance motivation in prediabetes populations. Future studies in collectivist contexts are essential to clarify how motivational processes differ across cultural orientations.

The fact that most of the included studies used cross-sectional or other observational designs is a further disadvantage. Although these offer useful glimpses into the relationships between factors and HB, they do not allow for inferences regarding causality or directionality. Higher self-efficacy, for instance, might encourage people to adopt healthier habits, but it's also feasible that successful behaviour modification gradually raises self-efficacy (reverse causality). In a same way, people's health behaviours may both influence and be influenced by their knowledge and awareness. Future studies should use prospective and longitudinal cohort designs, or intervention studies, to more thoroughly define causal pathways. These designs can shed light on temporal correlations and offer more convincing evidence for behavioural targets that are helpful in prediabetes.

Limitations

In terms of methodology, the exclusion of keywords such as "health lifestyle behavior" or "lifestyle behaviors" may have led to missing relevant studies, resulting in a potentially incomplete synthesis of determinants. Most included studies were from high-income countries predominantly the United States with only two from Africa, limiting generalizability to low- and middle-income countries (LMICs) where healthcare access, cultural norms, and socioeconomic conditions may shape behaviors differently; future reviews should incorporate LMIC-focused search strategies to ensure broader representation. Another limitation is that most included studies were cross-sectional, which precludes causal inference and raises the possibility of reverse causality. Finally, the meta-analysis did not include funnel plots or formal tests for publication bias, restricting the ability to assess small-study effects and selective reporting; these should be added in future analyses to enhance robustness.

Conclusion

This systematic review and meta-analysis provide strong evidence that self-efficacy is a major determinant of health behavior in adults with prediabetes, with a pooled correlation of r = 0.59. While demographic, cognitive, and social factors also influence behavior adoption, interventions that enhance self-efficacy and intrinsic motivation are likely to be most effective. Practical applications include integrating structured self-efficacy training into prediabetes programs, such as the Diabetes Prevention Program (DPP), to improve adherence to lifestyle changes. Future research should expand to more diverse populations and settings, using rigorous, theory-informed designs to clarify the mechanisms driving health behaviors and support tailored diabetes prevention strategies globally.

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Declaration on Use of Generative AI: The authors affirm that no generative artificial intelligence tools were utilized in the design, analysis, interpretation of data, or preparation of this manuscript. All content is the result of the authors' original work

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