

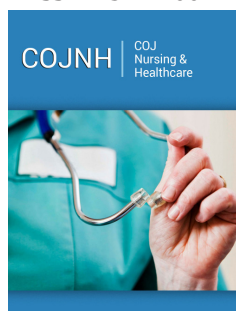
Facilitators and Barriers of Modifiable Behaviours that Reduce the Risk of Developing Type 2 Diabetes in Adulthood: An Integrative Review

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Abstract

Background: The risk of developing type 2 diabetes (T2DM) is significantly increased by various modifiable factors, such as obesity, unhealthy diet and sedentary lifestyle. This implies that T2DM can be partially prevented and its progression and complications can be minimised by altering these modifiable risk factors, particularly among the adult population.

Aim: The main aim of this review was to identify barriers and facilitators of modifiable behaviours for reducing the risk of developing T2DM.

Methods: An integrative review was undertaken. A computerised systematic search for relevant studies was performed on Cumulative Literature Index of Nursing and Allied Health Literature (CINAHL), MEDLINE and Sociological Abstracts. Thematic synthesis was performed to analyse the included studies.

Conclusion: Following critical appraisal a total of 19 studies, six quantitative and 13 qualitative, were reviewed. Three main themes concerning modifiable behaviours were identified from the studies: physical activity, diet and smoking. The review identified numerous internal and external factors affecting for these modifiable behaviours, which were classified and synthesised under two main themes: (1) barriers to and (2) facilitators of modifiable behaviours. Four subthemes were identified and discussed as barrier to modifiable behaviours, including

- A. Personal factors, such as health and emotional issues.
- B. Social factors, such as lack of social support;
- C. Informational factors, such as inadequate knowledge and awareness and
- D. Environmental factors, such as climate and individual settings. Conversely, three subthemes were identified as facilitators for modifiable behaviour, including
 - a) Personal factors, such as motivation.
 - b) Social factors, such as adequate social support and
 - c) Informational factors, such as adequate knowledge and awareness.

Conclusion: Numerous factors can facilitate or bar adult engagement in modifiable behaviours that reduce the risk of developing T2DM. Strategies to enhance modifiable behaviours should focus on education and counselling, enhancing individual self-efficacy and promoting social support.

Keywords: Modifiable behaviours; Lifestyle intervention; Physical activity; Diet; Diabetes prevention; Diabetes mellitus; Smoking

Introduction

Overview

Type 2 diabetes mellitus (T2DM) is the most common chronic metabolic disorder and affects millions of people worldwide [1]. An estimated 422 million people worldwide have diabetes, which represents 9% of the global adult population [2]. Approximately 90% of diabetes cases are T2DM. The prevalence rate of diabetes in high-income countries is around 6%, which is slightly lower than the 7% in low-income countries [2]. T2DM is associated with numerous adverse multisystemic morbidities and a significantly high risk of mortality,

especially if it is not effectively managed [3]. This means that effective strategies for T2DM management should typically target primary, secondary and tertiary prevention [4]. While genetic factors can contribute to T2DM, there is overwhelming evidence that the risk of developing T2DM is significantly increased by various modifiable factors, such as unhealthy diet and sedentary lifestyle.

Modifiable behaviours that reduce the risk of T2DM

Since various modifiable behaviours contribute to the highest proportion of T2DM cases, they must be adjusted to reduce the disease risk. Hence, modification includes minimising sedentary lifestyle factors by increasing physical activity (PA) and having a healthy dietary intake [5]. However, other considerable modifiable behaviours may include cessation of smoking, decreased alcohol intake, elimination of environmental toxins, sleep pattern and positive lifestyles with minimal stress and anxiety [6]. Increasing PA and dietary fibre intake is effective in reducing the risk of T2DM [5]. For instance, Knowler et al. [7] stated that individuals who are physically active and eat healthy diet have reduced likelihood of developing insulin resistance, impaired glucose regulation and T2DM.

Importance and relevance

Despite well-established evidence that T2DM can be partially prevented through modifiable behaviour, the prevalence and incidence rates of T2DM continue to rise [8]. Potentially, there may be factors that prevent people from adjusting their modifiable behaviours towards decreasing their risk of developing T2DM. At present, there is no identified literature that categorizes facilitators and barriers for the implementation of modifiable risk behaviour and the development of T2DM. The factors that facilitate or inhibit people's adoption of positive behaviours to prevent T2DM are not well understood. As such, it is imperative to perform an integrative review to evaluate existing studies and consolidate information about facilitators and barriers towards these factors to identify support strategies for adults at risk of T2DM. Therefore, the aim of this study is to apply an integrative review approach to identify the barriers to, and facilitators of, adopting a healthy lifestyle to prevent T2DM. Hence, the question that this integrative review seeks to answer is what the facilitators of are, and barriers to, modifiable behaviours that reduce the risk of developing T2DM in adulthood

Methods

Search strategy

To identify relevant literature concerning facilitators and barriers of modifiable behaviours, systematic and standardised searches using various search terms and phrases were performed. First, an advanced computerised search for relevant literature was performed across three databases: Cumulative Literature Index of Nursing and Allied Health Literature (CINAHL), MEDLINE and Sociological Abstracts. This approach proved efficient in rapid identification of literature, including study articles concerning the prevention of T2DM. The databases were relevant because of their renowned collections of publications and literature in the

medical field. As this review focuses on barriers to, and facilitators of, individual behaviour, the Sociological Abstracts database, which contains behaviour and social science studies, was searched to include related studies. A hand searches of physical journals was also conducted to identify further relevant literature for inclusion in this integrative review.

Inclusion criteria

To review the most relevant literature, studies had to meet the following inclusion criteria:

- peer-reviewed primary studies in the English language.
- adult population at high risk of developing T2DM
- the study had to identify barriers to, and facilitators of, modifiable behaviours for T2DM prevention and risk minimisation.

Exclusion criteria

This integrative study excluded reviews, guidelines, seminars and case studies without methodologies, procedures or scientific presentations of results. Second, the review excluded studies that focused on sample presence of diabetes or other health conditions (e.g., cancer and heart illness). This is because other conditions have different management plans and may not depend exclusively on modifiable behaviours. Third, any article that did not address clear barriers or facilitators of modifiable behaviours for T2DM risk prevention and minimisation were excluded.

Search outcome

A total of 423 studies were mined from online databases and 10 were found through the manual search (Figure 1). Of those a total of 19 studies, met the inclusion criteria and appraisal quality and were selected for inclusion in this integrative review.

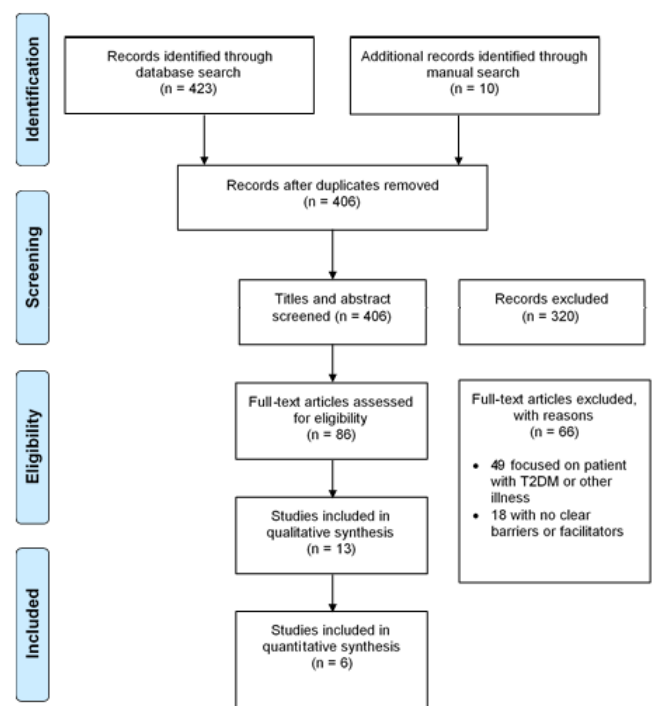


Figure 1: PRISMA flow diagram of search outcomes.

Quality appraisal

Critical appraisal is an important procedure in any integrative review to ensure the inclusion of high-quality studies [9]. For this reason, each individual study considered for this integrative review was investigated and critically appraised to ascertain its validity and reliability. This was done with a standardised critical appraisal tool based on Critical Appraisal Skills Programme (CASP) procedures. Corresponding quality assessment tools were used to account for the varying designs of the retrieved studies. These included four variants of the CASP and Centre for Evidence Based Management (CEBMA) checklists to tailor a quality appraisal to each study [9,10].

Findings

A total of 19 studies were included in this review to address the research question: what are the facilitators of, and barriers to, modifiable behaviours that reduce the risk of developing T2DM in adulthood? Included studies were undertaken in nine developed countries with a total of 1513 participants. The study characteristics of the included quantitative and qualitative studies have been identified in Tables 1 & 2 respectively.

Table 1: Description of the quantitative studies.

Author Year Country	Study Design	Aim	Methods	Population	Result
Smith et al. [40] Australia	Cross-sectional	"TO examined patterns of postpartum PA among women with recent gestational diabetes mellitus (GDM)"	Data collected: telephone surveyed Data Analysis: logistic regression	N=226 women with recent GDM	Barriers: childcare (49%), time (37%), inappropriate local neighbourhood (25%), not interest in PA (25%), tiredness (24%).
Donahue et al. [16] United States	Cross-sectional (survey)	"To identify barriers characteristics associated with increased PA"	Data collected: survey by mail Data Analysis: predictive logistic regression models	N=258 individuals at high risk attending different primary care centre. (n=157) women	Barriers: less priority for PA (odds ratio 0.45; 95%), concerned about harm (odds ratio 0.42; 95%), No time (odds ratio 0.38; 95%) Support: participant with higher education more active (P <.001)
Sawchuk et al. [15] United States	Cross-sectional	"To examined personal and built-environment barriers and facilitators to walking and PA"	Data collected: survey by mail Data Analysis: Pearson correlation coefficients	N=75 American Indian aged 50-74 n=58 women	Personal barriers: lack of self-efficacy (29%), absence of group walking (16%) Environment barriers: bad pedestrian path (12%). Personal facilitator: being health (48%)
McGuire et al. [34] Australia	Cross-sectional	"To investigate what factors, predict perceptions of barriers to exercise in midlife women"	Data collected: online questionnaire. Data Analysis: t-tests, ANOVA and Pearson's correlation	N=225 Australian women	Barriers: health literacy, lack of motivation, health and mental problems (41%) (F (8219) =20.1, p<.01)
Kaiser et al. [17] Switzerland	Prospective cohort	"To specify the determinants of postpartum PA and dietary habits after a pregnancy complicated by GDM"	Data collected: questionnaires Data Analysis: multivariate logistic regression	N=122 women	Barriers to healthy lifestyle: lack of social support (P <.001), health literacy (P = .002)
Jelsma et al. [12] Australia	RCT	"To investigate how a behavioural lifestyle intervention influences psychosocial determinants of PA and dietary behaviours in a population at risk of type 2 diabetes"	Data collected: questionnaire Data Analysis: linear regression analyses	N=59 women with history of GDM Intervention n=29 control n=30	Intervention improve social support (P < 0.001), motivation (P < 0.001).

Table 2: Description of the qualitative studies.

Author Year Country	Study design	Aim	Methods	Population	Result
Grace et al. [24] United Kingdom.	Anthropology theory	“To understand lay beliefs and attitudes, religious teachings, and professional perceptions in relation to diabetes prevention in the Bangladeshi community”	Data collected: focus groups & semi-structured interviews. Data Analysis: thematic analysis	N=137 in three phases n=80 Bangladeshi people n=29 Bangladeshi Religious leaders n= 28 Health professionals	<p>Barriers to PA:</p> <ul style="list-style-type: none"> > Lack of time, money, childcare and poor language > Social norms; exercise is shameful for elderly. <p>Barriers to healthy food:</p> <ul style="list-style-type: none"> > Traditional unhealthy food difficult to change. > The cost of healthy food affected food selections. <p>Facilitators</p> <ul style="list-style-type: none"> > To modifiable behaviour: <p>Fear of illness and complications.</p> <ul style="list-style-type: none"> > Support community by religious leader.
Jilcott et al. [21] United States.	Not stated	“To examined low- to moderate- income, midlife women’s perceptions of food sources: and related influences on food choices in the home and work environments.”	Data collected: in depth semi-structured interviews Data Analysis: inductive approach	N= 28 low- and moderate- income midlife women from rural and urban areas n N= 28 low- & moderate- income n=15 urban n= 13 rural	<p>Barriers to healthy food chose:</p> <ul style="list-style-type: none"> > Destination of food store, unavailability of produce markets, easy access to fast food, limited food option in workplace. <p>unavailability of supermarket,</p> <ul style="list-style-type: none"> > Diet taken at home was mainly influenced by health concerns & family members, > Women from urban and rural have different perceptions on food environment.
Abbott et al. [19] Australia	Not stated	“To Understand the barriers and facilitators to dietary change faced by this group of Aboriginal people”	Data collected: semi-structured interviews Data Analysis: thematic analysis	N=23 Aboriginal n=19 women	<p>Barriers to healthy food.</p> <ul style="list-style-type: none"> > Absence of social support for dietary change. > Socially isolated > Health wellbeing > Food affordability <p>Facilitators to healthy food.</p> <ul style="list-style-type: none"> > Being healthy were strong motivators.

Korkiakangas et al. [38] Finland	Not stated	"To describe the motivators and barriers to PA among individuals with high risk of type 2 diabetes"	Data collected: questionnaires with open ended questions Data Analysis: content analysis using QSR software.	The 1st Follow up n = 63 the 2nd follows up n = 71	Facilitators factors to PA: > Mental well-being > Health Physical well-being. > Social relationships. > Control weight
Ludwig et al. [25] United Kingdome	Phenomenological theory	"To elucidating the relevant barriers and motivations for dietary and lifestyle choices"	Data collected: one to one Semi-structured interviews & focus group. Data Analysis: sociological approach	N=55 first and second generation Pakistani women n=44 first generation n=11 second generation	Barriers to lose weight via & diet: > Limited awareness and health literacy of risk factor. > Influence of culture, religion and family cooking expectations. > Family responsibilities more prioritised than losing weight.
Jepson et al. [26] United Kingdome	Anthropology theory	"To explore the motivating and facilitating factors likely to increase PA for South Asian adults"	Data collected: focus groups & in-depth interviews Data Analysis: thematic analysis	N=59 South Asians n= 36 women	Facilitators to PA > Enjoyment & social activity > Weight management > Improving physical & mental health > Being role models to community.
Caperchione et al. [11] Australia	Grounded theory	"To gather information and gain insight into the PA and nutrition behaviours of these men"	Data collected: focus group Data Analysis: Inductive approach	N=30 middle aged men	Barriers to PA: > Absence of time: because of family and work commitments. > Lack of motivation Barrier to healthy diet: > Poor cooking skills. Facilitators to PA. > Being healthy >to be great role model. Facilitators to healthy diet. > Control weight > Prevent illness > Feeling active.

Normansell et al. [14] United Kingdom	Post-Trial Follow-up	"In-depth exploration of the experiences of samples of participants from both intervention groups who increased their step-count and who did not increase their step-count from the PACE-UP primary care PA trial"	Data collected: semi-structured audio-recorded telephone interviews Data Analysis: thematic analysis	N=43 purposive sample n=29 women	Barriers to walking. > Specific health problems > job commitments >Environment > Time management Facilitators to walking. >Healthy lifestyle > Enhance physical health > Enjoyment > Social support
Procter et al. [13] United Kingdom	Feasibility study	"To describe the behaviour change techniques (BCTs) used during the Walk to Work intervention"	Data collected: digitally recorded interviews Data Analysis: framework approach	N=22 engaged in 10-week walk n=14 participants n=8 promoters	Barriers to walking. > Motorised traffic > Weather Workload > Car parking facilities. Facilitators to walk. > Good weather > Absent of carpark.
Hammarstrom et al. [22] Sweden	Post-Trial Follow-up	"To explore barriers and facilitators to weight-loss experienced by participants in a diet intervention for middle-aged to older women"	Data collected: interviews, with open questions Data Analysis: content analysis	N=8 Swedish women fulfilled diet intervention project.	Barriers to health diet >Difficulties changing food habits >Health issues > Lack of self-control >Social relations. Facilitators to healthy diet > Desiring for self-determination > Receiving social support. >Overall, there was strong emphasis on obstacles than on motivators
Gele et al. [23] Norway	Grounded theory	"To explore women's knowledge of diabetes, their access to preventive health facilities, and factors impeding their reception of preventive health programs targeted for the prevention of type 2 diabetes"	Data collected: unstructured interviews Data Analysis: thematic analysis	N=30 Somali immigrant women	Barriers to PA: > Lack of access to suitable PA facilities. > lack of access to reliable health information Facilitators to PA: > Private women sport facilities > group training > overall, participants had good knowledge on T2DM.

Sari et al. [18] Denmark	Social cognitive theory	"To investigate perceived barriers to participation in an exercise intervention among alcohol use disorder patients"	Data collected: semi-structured interview Data Analysis: systematic text condensation	N=17 n=13 male	<p>Barriers to exercise:</p> <ul style="list-style-type: none"> 1-Structural factors. <ul style="list-style-type: none"> > Type and time of exercise 2-Social factors <ul style="list-style-type: none"> > Commitment > Unsupportive relations 3-Emotion factors. <ul style="list-style-type: none"> > Shame, guilt and Fear of involving in the intervention > Negative affect of the exercise
Nagelhout et al. [20] Netherlands	Not stated	"To examine barriers and facilitators for health behaviour change among adults from multi-problem households"	Data collected: semi-structured interviews Data Analysis: framework approach	N=25 adults from multi-problem households n=14 women n=11 men	<p>Barriers to PA:</p> <ul style="list-style-type: none"> > Cost of sports facilities > health issues > time consumption <p>Barriers to healthy nutrition.</p> <ul style="list-style-type: none"> > Participants with low income using food bank thought its barriers due to shortage of good food offered > incorrect knowledge >cost of healthy foods. <p>Facilitators to PA</p> <ul style="list-style-type: none"> > Paid job or voluntary job that includes PA > being healthy > owing a pet to walk <p>Facilitators to healthy nutrition</p> <ul style="list-style-type: none"> > Health wellbeing > lose weight <p>Barriers to quitting smoking :</p> <ul style="list-style-type: none"> > Stress > social environment <p>Facilitators to quitting smoking :</p> <ul style="list-style-type: none"> > Medical condition > cost

The first stage of the review involved general classification of studies based on the major modifiable behaviours for reducing the risk of T2DM that they investigated. The studies were clustered into three major groups under the three dominant behaviours: PA, diet and smoking (Table 3). The second stage involved further clustering of the studies' concepts, ideas, findings and results

as either facilitators or barriers. Since most investigated both facilitators and barriers of the modifiable risk factors, a third step was simultaneously applied. This involved classification of the facilitators or barriers into either internal or external and produced four sub-categories under each of the modifiable behaviours (Table 3).

Table 3: Summary of the themes.

Themes	Internal Barriers	External Barriers	Internal Facilitators	External Facilitators
Physical activity				
Caperchione et al. [11]	> Low priority	> Work commitments	> Being a good role model.	> Social activity
Donahue et al. [16]	> Worries about injury	> Family responsibility	> Disease prevention.	> Social relationships
Gele et al. [23]	> Lack of time & energy	> Inconsistent media messages	> Weight management.	> External monitoring
Jelsma et al. [12]	> lack of motivation	> Lack of access to facilities	> Higher education	> Provision of information
Jepson et al. [26]	> Laziness	> lack of health information	> Feelings good.	> Programs support
Korkiakangas et al. [38]	> Low healthy literacy	> weather	> Enjoyment	> Physical environment
McGuire et al. [34]	> Physical illness	> Type of exercise.	> Flexible routine	> Role model
Nagelhout et al. [20]	> Mistrust of monitoring	> Lack of social supported	> Better health	
Normansell et al. [14]	> Fear, guilt, shame	> Built environment	> Owning pet	
Procter et al. [13]	> Lack of willpower.	> Cost of Physical facilities.	> High self-efficacy	
Sari et al. [18]	> Lack of childcare	> Social norms		
Sawchuk et al. [15]	> Poor language.			
Smith et al. [40]				
Diet				
Abbott et al. [19]	> Sense of isolation	> Lack of social support	> Family concern.	> Family support
Caperchione et al. [11]	> Food habits.	> Family commitment.	> Diabetes free lives	> Religious influence
Gele et al. [23]	> Insecurity	> Food preferences	> Health problems	> Food environment
Hammarstrom et al. [22]	> Poor cooking skills	> Cost	> Self-determination	
Jelsma et al. [12]	> Lack of time	> Poor access to health information	> Clear goals.	
Jilcott et al. [21]				
Ludwig et al. [25]	> Personal health issues	> Diet implementation	> Being healthy.	
Nagelhout et al. [20]	> Lack of awareness	> Food environment		
		> Social environment		
		> Broader socio-cultural influences.		
		> Lack of healthy food.		
Smoking				
Nagelhout et al. [20]	> Stress	> Social environment	> Medical conditions	> Cost

Physical activity

Internal facilitators: The review identified various internal facilitators of PA. These included high self-efficacy weight management, the need to be a good role model, disease prevention, physical and mental health and wellbeing improvement, effective self-monitoring strategies and dog ownership [11]. The study conducted by Smith et al. [12] identified self-efficacy, contributed to sufficient PA. The study also identified that self-efficacy enables effectively planning time and engaging in exercise. Two of the reviewed studies investigated education as an internal motivator for participation in PA. The qualitative study done by Caperchione et al. [11] confirmed that better knowledge was a positive determinant

for PA [12-15]. A quantitative survey by Donahue et al. [16] found that 56% of the 258 participants, who attended 14 community centres in North Carolina, engaged in at least 150 minutes of PA weekly. Remarkably, those with higher education levels were more likely to exercise (OR 1.72; 95% CI 1.08-2.75). Therefore, it can be assumed then that education and adequate information enhanced comprehension of the health benefits of exercise.

External facilitators: The main external facilitator of PA was the enhancement of health information and social support. Jelsma et al. [12] identified that participants enhanced social support for engaging in PA after lifestyle counselling sessions with a health professional. A study by Procter et al. [13] investigated the feasibility

of a 10-week Walk to Work behaviour change technique in 22 employees. It revealed that the main promoters of engagement in the intervention included additional support and encouragement. Effective support of PA programs was also identified as an important facilitator of exercise by Normansell et al. [14]. Their study revealed that supporting the participant by supplying adequate information on health importance of PA, enhancing self-monitoring, reviewing goals, providing feedback and using rewards all facilitated their engagement in exercise. Other studies, such as Sawchuk et al. [15], reported that American Indians were more likely to engage in PA if they were near interesting locations.

Internal barriers: The review identified internal barriers to physical activities, such as low self-efficacy, limited motivation, poor physical and mental wellbeing, limited time, low perceived benefit, emotional issues, inflexible routines and a lack of energy [16]. For instance, Smith et al. [17] identified that 26.5% of their 226 study participants had sedentary lifestyles, with only 36% having sufficient exercise, according to official recommendations. One of the main barriers was insufficient time (37.6%) for engaging in PA. The study identified that women who were under time pressure or tired had low self-efficacy. Other factors that hindered participants' engagement in PA included worries about injury difficulties in allocating time [16]. Similarly, Normansell et al. [14] identified that inflexible routines and work commitments hindered proper PA. Hence, it can be surmised that interventions aimed at improving engagement in exercise should be flexible.

External barriers: External barriers were inconsistent media messages, inadequate knowledge, inaccessibility of tailored health information and training, cost implications, a lack of social support and environmental issues. A study by Caperchione et al [11] identified that middle-aged men do not exercise regularly because of inconsistent media messages about the benefits and best types of PA that they should engage in. The study also identified other external barriers such as increased work commitments and family responsibilities. In terms of social support, Kaiser et al. [18] identified that low social support was associated with low adherence to a healthy lifestyle, including physical exercise. Similarly, Sari et al. [19] revealed that the participants were impeded by social barriers in the form of as a requirement for accountability and unsupportive relatives. This illustrated that an individual's social environment is essential for facilitating engagement in PA. In relation to environmental issues, Procter et al. [13] identified that barriers to the effective exercise intervention (Walk to Work) included wider contextual issues, such as economic climate and unprecedented weather, as well as organisational factors in the form of workload and availability of parking facilities.

Diet

Internal facilitators: Internal facilitators of healthy diet and nutrition practices included improved knowledge, disease prevention and self-determination [19]. A qualitative study by Abbott et al. [20] found that Aboriginal persons who had taken a cooking course at the Aboriginal Medical Service Western Sydney (2002–2007) had improved knowledge of nutrition and better cooking skills. Their implementation of the desired dietary

changes was motivated by various internal factors, such as medical diagnoses, including both prediabetes and diabetes. Caperchione et al. [11] reinforced this idea by revealing that a need for disease prevention and remaining healthy were motivators of healthy eating. Nagelhout et al. [21] identified that having health conditions (such as diabetes) motivated the participants to eat healthily. This finding was also supported by Jilcott et al. [22], who found that health concerns motivated participants to engage in healthy eating and nutritional practices. Moreover, Abbott et al. [20] found that beyond self-concern, some study participants were motivated to implement dietary changes by their desire to influence their relatives to lead healthier lives and live without diabetes.

External facilitators: The review identified a number of external facilitators of healthy dietary practices, including proper support and religious influence [23]. For instance, Hammarstrom et al. [23] revealed that external facilitators included support from family, friends and the healthy diet project itself. Likewise, a prospective study by Kaiser et al. [18] identified low levels of social support as a barrier to adherence to healthy lifestyles and dietary habits. Thus, social support, including that of family and friends, was considered a great source of encouragement to continue engaging in healthy nutrition towards weight-loss. Program support was also important in facilitating healthy dietary practices. For instance, Jelsma et al. [12] revealed that programs-both face-to-face and telehealth-counselling sessions provided women with high BMIs and histories of GDM with enhanced self-efficacy towards healthy diets. This was also an important observation in a study by Hammarstrom et al. [23], which revealed that support from family members, friends and the intervention program enhanced healthy nutrition practices in women in Northern Sweden.

Internal barriers: The internal barriers to healthy dietary practices included a sense of isolation, family influence, personal struggles and poor cooking abilities [20] identified that Aboriginal persons were hindered by various internal barriers, such as a sense of isolation. Those who implemented the desired dietary practices were afraid to be isolated from family members who did not support the new diet. Abbott et al. [20] also identified other personal factors including poor dental care and psychological illness in the form of depression. These likely incapacitated individuals physically and mentally, respectively, and rendered them unable to implement the desired dietary changes. A study by Hammarstrom et al. [23] also identified that middle-aged women faced physical struggles that hindered their effective participation in healthy nutrition interventions. These physical struggles included difficulties in altering food habits and patterns, inadequate self-control and insecurities. Caperchione et al. [11] identified poor cooking skills and abilities as a further internal barrier to healthy eating. Jelsma et al. [12] also mentioned prohibition by a lack of time, easy availability of unnatural food at home and desires for pre-packaged food such as sweets.

External barriers: The review identified various external barriers including lack of family support, unsuitable environments, high food costs, work commitments and cultural practices [11,12,20,22,24-26]. Abbott et al. [20] identified that Aboriginal

persons struggled to implement dietary changes and were impeded by a lack of family support for meal alterations and different generational food preferences. Thus, the individuals were forced to compromise according to familial dietary preferences and needs [20].

The environment was also identified as a major factor impeding participants' engagement in healthy nutrition. A qualitative study by Jilcott et al. [22] involving 28 women of both low and moderate income (aged 37-67 years) from rural and urban areas found that the participants' perceptions of their food environment influenced their diet choices. Women in rural settings did not have adequately healthy diets compared to those in urban areas because of the existence of fewer supermarkets and produce stands in rural areas [22-25]. In terms of social environment, Jilcott et al. [22] revealed that women's food choices were greatly influenced by co-workers and the surrounding food environment, including limited availability of healthier food choices. Hence, it can be deduced that the environment affected food accessibility and thus, individuals' eating patterns.

Smoking

Internal facilitators: The only internal facilitators of stopping smoking were medical conditions [20]. These included both the fear of developing a disease and actual diagnosis, specifically with such as diabetes, cardiovascular disease and COPD. Some participants may also have quit smoking because of the perceived health risk of smoking itself. Nagelhout et al. [21] argued that the observed phenomenon can be explained by a health belief model, where individuals tend to engage in activities that may reduce their perceived health risk. The study also identified some individuals who quit smoking because they were curious to experience what quitting was like.

External facilitators: Nagelhout et al. [21] also reported that cost was a major factor that motivated the participants to quit smoking. This included both the high cost of cigarettes and the fact that some participants perceived smoking as an economic problem and a waste of money and resources. A study by Grace et al. [25] identified that religious leaders were essential in providing considerable support of healthy behaviours to prevent diabetes. This included Islamic teachings on the cessation of unhealthy behaviours, such as smoking and drinking alcohol.

Internal barriers: Only Nagelhout et al. [21] identified an internal barrier to cessation of smoking stress. The participants utilised smoking as a means of relieving stress, which also contributed to a return smoking after quitting. The researchers argued that smoking was promoted as a negative adaptation to stress in the form of household, family and social issues including limited income.

External barriers: One of the main barriers to quitting smoking was the social environment. According to Nagelhout et al. [21], participants who had quite reported that they returned to smoking because of friends who smoked. Similarly, Grace et al. [25] revealed that cultural influences, including the desire to comply

with cultural norms, such as drinking and smoking, increases an individual's tendency to engage in these unhealthy practices.

Discussion

Facilitators of modifiable behaviours

Personal factors: This integrative review identified various personal factors that facilitate behaviour modification to reduce the adult risk of developing T2DM. The main influencer is motivation: a reason that guides or prompts an individual to act or behave in a particular way [13]. The studies reviewed identified various factors that motivate adults to exercise, eat a healthy diet or stop smoking and found that individuals who had high level of motivation engaged adequately in PA, consumed healthy diets and avoided risky behaviours, such as smoking [14,27]. Similar studies indicated that this is the same in positively motivated individuals [5]. From a theoretical perspective, the self-determination theory states that motivation elicits individuals' internal resources such as rational thinking and positive decision-making, which improves their abilities and capacities for an action or behaviour [28].

Social factors: The reviewed studies identified that adults who have adequate social support through supportive relationships (including family support in the form of verbal encouragement and support from friends) engage in PA, practice healthy nutritional habits and avoid risky unhealthy behaviours like smoking [14,23]. Additionally, this review revealed that adults who derive adequate support from healthcare systems and prevention programs have a positive tendency to effectively participating in healthy interventions [23]. According to Grace et al. [25] enhancement and facilitation of social support can facilitate healthy behaviour modification, which is integral in disease preventions. This is essentially because social support enhances emotional, tangible, informational and companionship support, which increases an individual's capacity for decision-making, enhances knowledge and awareness and increases acquisition and accessibility of resources that enhance behaviour modification [29].

Informational factors: Information is a powerful tool to enhance behaviour modification and the studies reviewed showed that individuals who have adequate information concerning T2DM effectively engage in PA, healthy diets and cessation of smoking [22,24]. The studies also identified that individuals who have adequate information concerning the need for behavioural change, diabetes prevention and management strategies and the benefits of modifiable behaviours tend to embrace positive lifestyles by exercising and eating healthy diets [30,31]. Thus, to facilitate modifiable behaviours that reduce the risk of T2DM, the focus should be on enhancing individuals' knowledge and awareness through health education, health campaigns and the provision of adequate informational resources to guide them.

Barriers to modifiable behaviours

Personal factors: This review has revealed the numerous personal factors that impede modifiable behaviours to prevent T2DM. These can be largely classified as health issues and self-

efficacy. For instance, some studies showed that adults diagnosed with health issues, such as depression, arthrosis and cardiovascular conditions, have low propensity for PA [20,23]. These health issues may limit the person's physical ability to exercise and introduce nutritional variations [32]. According to the studies reviewed, self-efficacy issues may include a lack of motivation and willpower, inability to find time, difficulties in changing behaviour and poor prioritisation of healthy habits [11,16]. Additional studies have identified limited self-efficacy as prohibitive of behavioural change to prevent chronic diseases [5]. For instance, Amireault et al. [33] found that individuals with low self-efficacy (limited personal motivation and improper prioritisation) do not effectively engage in PA programs and interventions strategies.

Social factors: The review identified social support systems as paramount in behaviour modification as they may determine the level of assistance an individual requires to embrace healthy practices [18]. Leung et al. [29] revealed that limited family support is a significant barrier to healthy nutrition and exercise. Similarly, Ludwig et al. [26] reported that most family members of individuals at risk of developing diabetes have difficulties in adjusting to new diet recommendations to managing diabetes; hence, they provide limited support to the affected family member. Thus, dietary changes may be challenging in an unsupportive family environment. Other studies identified further prohibitive social factors in the form of cultural and religious practices [19,20,25,26]. These largely operate in cases of dietary restrictions [34] and may thwart individuals' attempts to practice healthy nutrition.

Informational factors: The main informational factor that hinders adults' engagement in modifiable behaviours that prevent T2DM is a lack of knowledge or awareness of their benefits in preventing and reducing the risk of T2DM [11,35]. This finding has been confirmed by other studies. For instance, Enjezab et al. [30] revealed that improved awareness of the importance of exercise results in increased participation in healthy physical activities. Gele et al. [24] stated that participants who engaged in physical activities and healthy dietary practices had greater knowledge and increased awareness. Arguably, adequate information and knowledge enhance an individual's decision-making capacity and self-efficacy, which consequently leads to increased healthy behaviours, such as PA, proper nutrition and diet.

Environmental factors: This review found that an individual's environment can impede their engagement in modifiable behaviours. Environmental impediments to PA and healthy nutrition include unprecedented wet weather, climate change, the built environment and rural settings [13,14]. These findings are supported by other studies. For instance, Jilcott et al. [22] identified that individuals living in rural settings do not practice healthy nutrition and have poor diets compared to those in urban settings. Similarly, Dyck et al. [36] revealed that individuals in rural populations are also unable to effectively participate in physical exercise and activity compared to those who live in urban areas. Arguably, these differences are due to differing availability and accessibility of food and amenities for physical activities in the different settings [22]. Therefore, it can be deduced that those in areas with poor availability of a variety

of food and physical exercise facilities, such as in rural areas, may not have adequate healthy nutrition or engage in proper PA. Hence, they may be at increased risk of developing T2DM.

Recommendations

This study recommends that facilitators of modifiable behaviours be enhanced through health education self-efficacy and social environment. First, it is already widely established that education and counselling are effective approaches to enhance facilitators of modifiable behaviours of preventing T2DM [14]. A multi-sectorial partnership between government bodies including health & education may enhance the delivery of program about PA, healthy diet, smoking awareness [37]. Second, this review recommends enhancement of self-efficacy to improve adult engagement in modifiable behaviours that prevent T2DM. Chung-Yan [38] suggested that this can be achieved by providing examples of other individuals who have benefited from PA, healthy nutrition and cessation of smoking. These individuals can act as models in encouraging others to have strong belief in their own ability to change. Last, social environment plays an integral part in facilitating or barring individuals' engagement in PA, healthy nutrition and not smoking [22]. Thus, to aid participation in these activities, initiatives should improve the social environment by enhancing family and social support systems, improving social networks and increasing accessibility to social resources, such as healthcare facilities [29]. This can be achieved by embracing social marketing in healthcare, formulation of important policies that promote community-based interventions and establishment of social infrastructure [25].

Limitations

This integrative review has identified facilitators and barriers of modifiable behaviours that prevent the development of T2DM in adulthood. However, there are some limitations. First, the review has identified the factors affecting PA and diet but has not exhaustively investigated other factors such as cessation of smoking and alcohol consumption. This is because only a single study concerned smoking, making it difficult to adequately address. The second limitation is that the population of focus was adults; hence the findings may not be applicable across all population's groups or to children. Also, T2DM tend to be diagnosed in adulthood and modifiable factors such as PA, unhealthy eating and tobacco smoking may have been learned behaviours from childhood. Lastly, despite well-established evidence that T2DM prevalence rate highly increasing in middle- and low-income countries [39,40], the review only discovered studies from developed countries.

Conclusion

This integrative review has identified numerous facilitators and barriers of modifiable behaviours that reduce the risk of T2DM development (exercise, healthy nutrition and not smoking). They include both internal and external factors: personal factors, emotional issues, and health problems as well as social, environmental and informational factors. The most important finding here is that these factors are interlinked and have effect each other through synergistic and exclusive interactions. Indeed,

the presence or absence of one factor may reinforce or diminish the effects of another. Therefore, any strategy aimed at enhancing the facilitators of modifiable behaviours that prevent T2DM should be integrated and comprehensive in nature and tailored to target the unique needs and concerns of an individual.

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