

Review

The Impact of Food Insecurity on Glycemic Control among Individuals with Type 2 Diabetes

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Abstract: The global prevalence of diabetes exceeds half a billion people globally. The Diabetes Prevention Program, a 27-site, randomized clinical trial demonstrated that dietary and other lifestyle changes can prevent more than half (58%) of diabetes cases. Implementation of dietary recommendations can be challenging for those who are not food secure. In a review on the intersection of food insecurity (FI) and diabetes (date range through May 2014), the authors concluded that the lack of access to sufficient, safe, and nutritious food impairs the ability of those with diabetes to implement the dietary modifications required to manage the condition. A challenge to diabetes self-management among this population was adverse social determinants of health. This study assessed insights gleaned about the association between FI and suboptimal glycemic control among adults with type 2 diabetes from research published after May 2014. Conflicting evidence emerged regarding the impact of FI on HbA1c levels among adults with type 2 diabetes. Glycemic control was impacted by social and medical factors. Potential areas for further research are also presented.

Keywords: type 2 diabetes; food insecurity; food security; glycemic control



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1. Introduction

The global prevalence of diabetes, a metabolic disease characterized by elevated blood glucose levels, exceeds half a billion people globally [1]. More than 11% of adults (20–79 years) from 215 countries and territories have this chronic condition; as prevalence rates increase, healthcare costs likewise escalate. In 2021, worldwide diabetes health care costs totaled 970 billion USD [1]. Treatment options for type 2 diabetes (T2DM) include medications and lifestyle interventions [2–4].

Hemoglobin A1c (HbA1c) is the biochemical index commonly used for diagnosing T2DM among community-dwelling populations [5]. According to the American Diabetes Association, HbA1c within normal limits is below 5.7%, prediabetes ranges from 5.7 to 6.4%, and above 6.5% is a diagnosis of diabetes [6]. The level of glycemic control has further been categorized as well-controlled (HbA1c < 8.0%) and uncontrolled (HbA1c ≥ 8.5%) [7]. Of note, HbA1c results can be impacted by health and lifestyle choices. Physiological stress, acute illness (major surgeries), medications (corticosteroids), and niacin can increase HbA1c readings. Intense exercise, prolonged fasting (starvation), pregnancy, alcohol, acute illness (sepsis, renal insufficiency), chronic conditions (central obesity, dyslipidemia), and medications (hypoglycemic agents, antibiotics, salicylates) can lower HbA1c readings [5]. In addition, HbA1c varies by birth gender; adjusting for other factors, HbA1c results for females are higher than for males [8,9].

The Diabetes Prevention Program, a 27-site, randomized clinical trial (3234 US adults at risk for T2DM; 68% female), demonstrated that dietary and other lifestyle changes can prevent more than half (58%) of diabetes cases [3]. For those diagnosed with T2DM, research supports the efficacy of dietary modification for controlling blood glucose levels and achieving glycemic control [2–4]. Furthermore, meta-analyses indicate that lifestyle adaptations contribute to putting T2DM into remission, defined as A1C readings of <6.5% coupled with no utilization of anti-diabetic medications for six or more months [2,10].

Lifestyle choices influence the pathogenesis of T2DM [11]. The typical Western diet (hypercaloric, high fat, high carbohydrate) produces a cascade of detrimental reactions in the body. By elevating both blood glucose levels and circulating triglyceride-rich compounds, this eating pattern increases the concentration of reactive oxygen species (ROS). The increase in ROS provokes molecular inflammation; a sustained spike in ROS contributes to insulin resistance [11]. Consumption factors have also been associated with gut dysbiosis-induced metabolic disturbances underlying chronic diseases such as diabetes [11,12]. Dietary lipids disrupt microbial diversity which negatively affects the metabolic pathways responsible for regulating blood glucose levels and contributes to the development of low-grade inflammation and insulin resistance [11,12]. Conversely, dietary and activity adaptations can help mitigate inflammation [12,13]. Of note, Shivappa et al. developed the Dietary Inflammation Index (DII). Based on the findings of a comprehensive review (~2000 peer-reviewed studies), the DII assigns an evidence-based inflammatory score for foods, nutrients, and food components [13].

Dietary modifications are a standard treatment for those with T2DM [6]. Guidelines include avoiding ultra-processed foods and consuming fresh, whole foods with health benefits [3,10]. For those who are overweight or obese, an additional goal is losing weight [3,10]. Indeed, weight loss (≥ 15 kg) appears to be instrumental in the T2DM remission process [2]. Both low-carbohydrate and low-fat eating patterns have been found to be effective for weight loss and improved glycemic control among this population [10]. Engaging in physical activity at least 150 min per week is also recommended [3]. Sedentary behaviors exacerbate the chronicity of the inflammatory state; in contrast, regular exercise promotes the production of anti-inflammatory substances in the body and, thereby, can help improve T2DM-related oxidative stress [11].

Implementation of dietary recommendations can be challenging for those who are not food secure. The United Nations Committee on World Food Security defines food security as “when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” [14]. Research has found that diabetes is more prevalent among food insecure (FI) individuals [15–17]. Of note, the American Diabetes Association recommends screening patients for food security status [7]. Food insecure individuals with T2DM are more apt to select inexpensive, ultra-processed foods and beverages that may result in a diet low in nutrient-dense items [7]. In a review on the intersection of FI and diabetes (date range through May 2014), Gucciardi et al. concluded that lack of access to sufficient, safe, and nutritious food impairs the ability of those with diabetes to implement the dietary modifications required to manage the condition. The authors found that adverse social determinants of health experienced by this population impose further challenges to engaging in diabetes self-management [17].

This study aimed to assess insights gleaned about the association between FI and suboptimal glycemic control among adults with T2DM from research published after May 2014. Contributing medical and social factors were explored. Potential areas for further research are also presented.

2. Materials and Methods

The review followed the requirements of the Preferred Reporting of Systematic Reviews and Meta Analyses (PRISMA) statement [18]. A systematic review process was employed to collect articles, and a qualitative approach to assess the included studies.

A Boolean search of three databases was conducted (MEDLINE, CINAHL, and Academic Search Complete, May 2014 to February 2022). Medical Subject Heading (MeSH) terms and text words were: “food insecurity (all fields)” and “diabetes (all fields)” and not “type 1 diabetes (all fields)” and “glycemic control (all fields)” and “not review of literature or literature review or meta-analysis”. Included studies reported on the association (observational studies) or effect (intervention studies) of FI (as exposure) on glycemic control (HbA1c) among food-insecure adults (≥ 18 years) with T2DM. Only articles published in

English were retrieved, as the author is not fluent in other languages. Abstracts, presentations, commentaries, protocols, and review articles were excluded. In addition, studies that did not provide discrete results on adult populations with T2DM were omitted. Table 1 displays the search strategy, and inclusion and exclusion criteria.

Table 1. Search strategy and inclusion/exclusion criteria based on PICO (2014–2022).

PICO	Inclusion Criteria	Exclusion Criteria
Population	Adults (>18 years) with T2DM	Children with diabetes and adults with type 1 diabetes
Intervention	Observational and interventional studies evaluating food insecurity and diabetes control	Abstracts, presentations, commentaries, protocols, and review articles
Comparison	Food secure adults (>18 years) with T2DM or no control	No discrete findings for food insecure adults (>18 years) with T2DM
Outcome	Glycemic control (HbA1c)	Did not report HbA1c as a measure of glycemic control

Titles and abstracts of candidate items were screened. Duplicates were removed both automatically by the search platform and manually. Out-of-scope items were omitted. Full-text articles were retrieved for potential inclusion and additional out-of-scope items were removed. Articles were included from duplicate research cohorts if the study aim yielded unique findings. For articles replicating results, only the most recent article was included. Reference lists of selected articles and past relevant review articles were scanned for additional potential items.

The following was extracted from each study: first author and publication year, specific aims, study design, setting, population, assessment tools, and main findings. Quality was assessed with the Cochrane risk of bias tool [19]. For secondary analysis of datasets, original articles were retrieved to gather more information on study protocols [20–23]. To compare and synthesize study findings, a content analysis was performed, and emerging themes were compiled.

3. Results

3.1. Search Results

Figure 1 provides the PRISMA Flowchart illustrating identification, screening, eligibility, and inclusion of the search results. The search strategy produced 159 records; 57 duplicates were removed yielding 102 titles and abstracts for review. During this screening, an additional 67 items were excluded. Full texts for the remaining 35 articles were retrieved; 24 were excluded because of paper type (abstract/poster/protocol/review, $n = 10$), lack of discrete focus on T2DM ($n = 7$), and a focus on social determinants of health without offering discrete findings on FI ($n = 9$).

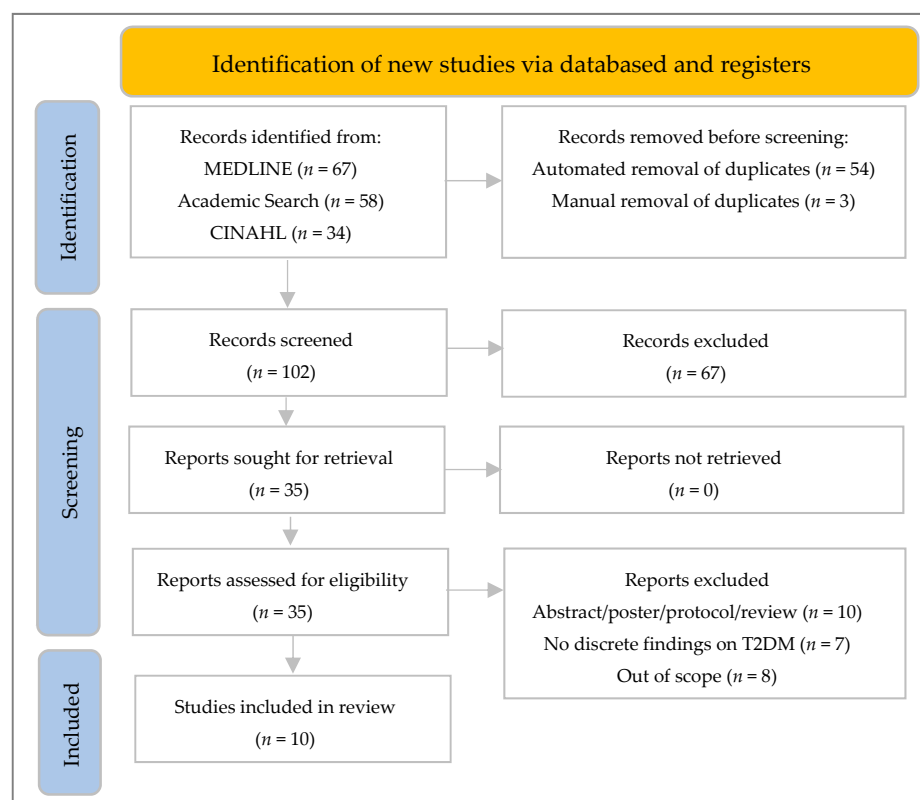


Figure 1. PRISMA flow diagram of the literature review process on the association between FI and glycemic control among adults with T2DM.

3.2. Study Characteristics

Ten studies, published 2014–2021, were included in this review; nine from the US ($n = 15,684$), [7,15,24–30] and one from South Africa ($n = 250$) [31]. The studies reflect the experiences of 7549 community-dwelling adults with T2DM; food insecurity rates ranged from 20% to 100%. Seven studies investigated the contributing factors to FI among adults with T2DM and, thereby, glycemic control. Examples of such factors included dietary intake [24,27], challenges with diabetes self-care/self-management [25,26,30], psychosocial considerations, [30] and other social determinants of health [15].

Validated tools were used to assess food insecurity. The nine US-based studies employed the USDA Household Food Security Survey; albeit, different modules were used (18-item [15,27,28], 10-item [24], 6-item [7,29,30], 3-item [25,26]). The South African study used the Household Food Insecurity Access Scale [31]. All of the study protocols utilized HbA1c as a measure of glycemic control [7,15,24–31]. Table 2 provides a summary of the studies included in this review.

Table 2. Studies investigating food insecurity and glycemic index (2014–2021).

Author, Year	Specific Aims	Study Design	Setting and Population	Assessment Tools	Findings
Berkowitz, 2014	Evaluate if dietary patterns related to FI are associated with poor longitudinal glycemic control	Observational	USA	USDA (10-item)	HbA1c higher among FI, but not significant ($p = 0.14$)
		Prospective Longitudinal Random sample No control 24 months	Puerto Rican Health Study 584, 45–75 years 70% female 100% Hispanic 26% FI	HbA1c HEI 2005	FI with better diet quality lower HbA1c ($p = 0.004$)

Table 2. *Cont.*

Author, Year	Specific Aims	Study Design	Setting and Population	Assessment Tools	Findings
Blitstein, 2021	Evaluate clinic-based program for individuals with diabetes aimed at improving food security and HbA1c	Observational Longitudinal Convenience sample No control	USA FQHCs 933, mean 51 ± 13.2 years 64% female	USDA (6-item) HbA1c ARMS	FS greater improvements HbA1c than FI ($p = 0.04$)
		6–9 months	73% Hispanic 43.4% FI		No significant differences between HbA1c and FS status ($p = 0.21$)
Heerman, 2015	Investigate the association between FI, diabetes self-care and glycemic control	Observational Cross-sectional Random sample No control 30 months	USA PRIDE Study 401, median 52 years 61% female 57% non-Hispanic White 73% FI	USDA (3-item) HbA1c SDSCA PDQ-11 ARMS	FI associated with lower glycemic control ($p = 0.03$) No significant association self-care non-adherence and HbA1c
Ippolito, 2017	Assess relationship between FI level and diabetes self-management	Observational Cross-sectional Convenience sample No control 24 months	USA Food pantries 1237, mean 56.4 ± 12.5 years 70% female 55% Hispanic 84% FI	USDA (3-item) HbA1c Diabetes self-management evaluation	FI not significantly associated diabetes control ($p = 0.65$) Diabetes self-efficacy scores for FI (very low). 51 units less than those for FS
Kim, 2021	Investigate relationship social determinants of health (including FI) and diabetes control	Observational Cross-sectional Random sample No control 36 months	USA NHANES 2011–2014 9609, 20–65+ years 49% female 67% non-Hispanic white 22% FI	USDA (18-item) HbA1c Diabetic foot exam Pupil dilation	FI associated uncontrolled T2DM ($p < 0.05$)
Nsimbo, 2021	Evaluate the prevalence of FI and its association with glycemic control	Descriptive Cross-sectional Convenience sample No control Time not reported	South Africa Primary care center 250, mean 58.7 years 64% female 64% FI	HFIAS HbA1c	High HbA1c readings were 5.38 times more likely among FI ($p \leq 0.001$)
Shaheen, 2021	Investigated the association of dietary quality, FI, and glycemic control	Observational Cross-sectional Random sample No control 60 months	USA NHANES 2011–2016 1682, 49% 60–85 years 49% female 62% non-Hispanic white 68% FI	USDA (18-item) HbA1c HEI-2015	Poor glycemic control was associated with FI and/or diet quality ($p = 0.01$)
Shalowitz, 2015	Investigate if FI is associated longitudinally with poor glycemic control	Observational Longitudinal Convenience sample No control 24 months	USA Multi-site FQHC 336, mean 51.8 ± 10.9 years 90% non-Hispanic black 56% female 56% FI	USDA (18-item) HbA1c	FI impairs glycemic control among adults with T2DM ($p = 0.013$) FI individuals more likely to be on insulin for T2DM ($p = 0.01$)
Silverman, 2015	Assess relationship between FS status and depression, diabetes distress, medication adherence and HbA1c	Observational Cross-sectional Random Sample Control group 24 months	USA Peer-AID 287 49% female 25% non-Hispanic black 47% FI	USDA (6-item) HbA1c SDSCA	Average unadjusted A1c level for FI was 0.64% higher than FS
Walker, 2019	Assess pathways through which FI impacts glycemic control and diabetes self-care	Observational Cross-sectional Convenience sample No control	USA Primary care clinics 615, mean 61 years 38% female 65% non-Hispanic black	USDA (6-item) HbA1c	FI indirectly associated high HbA1c ($p = 0.001$) through diabetes distress Psychosocial factors impact diabetes self-care, thereby, glycemic control

FI = food insecurity; FS = food security; HbA1c = Hemoglobin A1c; T2DM = type 2 diabetes mellitus. FQHC = federally qualified health center; HFIAS = Household Food Insecurity Access Scale; NHANES = National Health and Nutrition Examination Survey; Peer-AID = Peer Support for Achieving Independence in Diabetes study; PRIDE = Prediabetes Informed Decisions and Education; USDA = United States Department of Agriculture Household Food Security Survey. ARMS = Adherence to Refills and Medications Scale; HEI = Healthy Eating Index; PDQ-11 = Personal Diabetes Questionnaire; SDSCA = Summary of Diabetes Self Care Activities.

3.3. Risk of Bias and Publication Bias

All of the studies were observational. Half of the studies employed random sampling ($n = 5$), [15,24,25,27,29] the remaining studies recruited convenience samples ($n = 5$) [7,26,28,30,31]. Seven of the nine studies employed cross-sectional study designs, limiting causal inferences [15,25–27,29–31]. The nature of two studies prevented the blinding of participants and researchers [7,26].

Two of the studies were analyses of the National Health and Nutrition Examination Survey (NHANES) dataset. Kim et al. examined three years of data, 2011–2014 ($n = 9609$), and Shaheen et al. examined five years, 2011–2016 ($n = 1682$) [15,27]. One study was a secondary analysis of the Peer Support for Achieving Independence in Diabetes study (Peer-AID) baseline data. Peer-AID is a randomized controlled trial evaluating diabetes self-management [29]. Heerman et al. performed a secondary analysis of the Prediabetes Informed Decisions and Education (PRIDE) study, a cluster randomized trial conducted at 20 primary care clinics in the US from 2015–2018 [25].

Figure 2 provides the Cochrane risk of bias assessment chart. The overall rating for five studies was high risk for bias [7,25,26,30,31], and the remaining five scored unclear overall risk [15,24,27–29]. The assessment items with the least risk of bias were incomplete outcome data and selective reporting. The highest risk was introduced due to a lack of blinding.

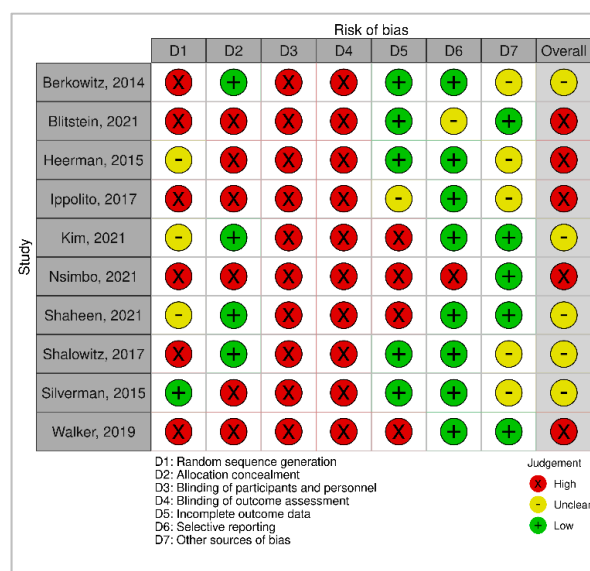


Figure 2. Cochrane Risk of Bias Assessment Chart.

The restriction of English language articles introduced language bias into this review. Given the time between data collection and publication, the two analyses of the NHANES datasets [15,27] introduced the risk of time-lag bias. All of the articles were published in reputable, peer-reviewed journals; three were published in the same journal [15,29,30]. The inclusion of only the most recent article reporting on the same findings of studies eliminated the risk of multiple publication bias. No evidence of citation bias was identified.

3.4. Findings

3.4.1. Association between FI and Glycemic Control

Conflicting evidence was found on the association between FI and glycemic control. Of note, the ten studies included in this review did not employ a consistent definition of poor control; HbA1c levels ranged from >6 to $\geq 8.5\%$ [7,15,24–31].

Seven studies reported statistically significant associations between FI and poor glycemic control [15,25,27–31]; albeit, Walker et al. reported an indirect association precipitating through diabetes distress ($p < 0.01$) [30]. In a South African population, FI adults with T2DM were over five times more likely to have HbA1c levels $>7\%$ [31]. Three studies

reported insignificant associations between FI and glycemic control [7,24,26]; two defined poor glycemic control as $\text{HbA1c} \geq 8.5\%$ [7,26]. Conversely, one study found that food security was associated with greater improvements in HbA1c ($p = 0.04$) [7].

Disparate findings precipitated regarding the longitudinal association (across 24 months) between FI and increasing HbA1c levels; Shalowitz et al. reported a significant association and Berkowitz et al. reported an insignificant association [24,28]. Indicative of poorer glycemic control, a greater percentage of FI adults with T2DM were found to rely on hypoglycemic agents including insulin and metformin [28,29].

3.4.2. Social Factors Influencing Glycemic Control

The studies offered insights into the impact of several of the social determinants of health on glycemic control among adults with T2DM, including food access/selection issues, educational considerations, income and employment status, race/ethnicity and immigration status, and household size. Of note, an inverse relationship was also found between the number of adverse social determinants of health and optimal glycemic control emerged [15]. Kim et al. also reported variations in the impact of specific social determinants of health on glycemic control [15]. Nsimbo et al. reported insignificant findings between household size (three or more people), FI, and glycemic control [31].

Food access/selection issues appear to play a considerable role in glycemic control among the FI. Less than optimal glycemic control among FI individuals was significantly associated with poorer diet quality in two longitudinal studies [24,27]. Furthermore, better diet quality was found to improve glycemic control among FI adults with T2DM ($p = 0.004$) [24]. Compared with their food-secure counterparts, FI adults were more likely to have lower intakes of vegetables, fruits, and total energy, and higher intakes of saturated fats [24].

Kim et al. analyzed three years (2011–2014) of NHANES data and found a significant association with poor glycemic control among FI adults with limited English proficiency [15]. Furthermore, adjusted statistical models found that those with low education were less apt to have had HbA1c tests during the last year ($\text{OR} = 0.56$ ($0.34\text{--}0.93$)) [15].

Poor glycemic control was significantly associated with low income in a large ($n = 9,609$) 3-year observational study [15]. Those with low incomes were also less apt to have HbA1c tests during the last year ($\text{OR} = 0.36$ ($0.28\text{--}0.57$)) [15]. Among the severely poor, 26.2% had an $\text{HbA1c} \geq 9\%$ (<0.001) [27].

In an analysis of a representative sample of the US, HbA1c levels of $\geq 9.0\%$ were highest among the non-Hispanic Black and Hispanic adults ($p < 0.001$) [27]. In a longitudinal study of patients at community health centers, poor glycemic control was associated with Hispanic ethnicity [28]. Nsimbo et al., however, found no significant association with immigration status among FI South African adults with T2DM [31].

3.4.3. Medical Factors Influencing Glycemic Control

Poor glycemic control among FI adults was significantly associated with a lack of adequate health insurance coverage and usage [15]. Kim et al. determined that FI adults with T2DM are less apt to seek medical care and undergo preventive tests aimed at monitoring patients for diabetes complications [15]. Shaheen et al. reported a similar significant finding—15% of those with an $\text{HbA1c} \geq 9\%$ did not have regular health care ($p < 0.001$) [27]. Statistical modeling of a representative sample of US adults found that those without health insurance were less apt to have had HbA1c tests during the last year ($\text{OR} = 0.35$ ($0.21\text{--}0.59$), respectively) [15].

Poorer diabetes self-management behaviors were also associated with being FI [25,26]. Heerman et al. found an association between FI and adherence with diabetes self-management recommendations among adults with T2DM participating in a health-literacy intervention [25], and Ippolito et al. found the same in those visiting food pantries [26]. Significant associations were found between lower adherence to dietary modifications, calorie restrictions, physical activity, and medication ($p = 0.02, 0.03, 0.04$, and

0.002, respectively), but no significant association was found between lack of adherence with those self-care behaviors and HbA1c [25,26].

Psychological concerns emerged as a potential barrier to adhering to self-care recommendations among FI adults with T2DM. In a cross-sectional analysis, Walker found that psychosocial factors impacted adherence with diabetes self-care and, thereby, glycemic control [30]. Walker demonstrated that via diabetes distress (burnout), FI was associated with higher HbA1c ($p < 0.01$) [30]. Ippolito et al. investigated the association between the emotional burden of managing diabetes, or diabetes distress, and food insecurity. The authors found that as the severity of FI worsened, the implementation of diabetes self-care strategies became more challenging [26]. Both depression and diabetes distress were associated with higher mean HbA1c among FI adults with T2DM [27,29,30].

The percentage of FI adults with T2DM participating in preventive care measures was also lower than their food-secure counterparts, thereby increasing their risk for diabetes complications. Kim et al. found lower odds for dilated pupil exams among individuals experiencing three or more adverse social determinants of health compared with only one (OR = 0.18, (0.11–0.29) vs. OR = 0.49, (0.27–0.88)) [15].

3.4.4. A Social Medical Approach to FI and Diabetes

Blitstein documented the findings of a clinic-based program that adopted food security screening as a standard of practice [7]. Food insecurity alerts were recorded in the electronic record that triggered providers to offer nutrition education about eating on a budget and refer patients to food pantries and other community programs. Clinic staff also helped eligible patients to apply for government nutrition assistance benefits. For FI patients, after-visit printouts reinforced available resources and provided a voucher for the purchase of produce [7]. Employing statistical modeling, the researchers found that the program reduced HbA1c (0.22%, $p = 0.005$) and that patients with poorer glycemic control experienced greater increases in HbA1c (0.8% vs. 0.06%, $p = 0.1$) [7].

4. Discussion

Opposing findings emerged about the association between FI and glycemic control among adults with T2DM; one confounding variable was variations in the definition of poor control. Two of the studies reporting insignificant findings, for example, used very high HbA1c cut-off levels. Given that HbA1c levels for females have been found to be higher than males [8,9], another potential confounder was the percentage of females vs. males included in each study. The population samples for six of the studies were primarily female (ranging from 56% to 70%); all of them controlled for gender in their statistical analysis [7,24–26,28,31].

Gucciardi et al. noted the need for longitudinal population studies to further examine if food insecurity was a risk factor for diabetes and glycemic control [17]. Four studies offered insights from longitudinal studies [7,15,24,28]. The importance of quality dietary intake emerged as a factor that can improve control over time [24]. The lower intake of fresh produce among FI adults with T2DM has been recognized by others and food as medicine programs has been implemented to help improve diet quality [32]. Bryce et al. reported on a 13-week fresh prescription program for patients at or below the poverty level ($n = 65$) sponsored by a midwestern community clinic in the US. The program improved access to and consumption of produce among FI adults with T2DM; participants also experienced a statistically significant decrease in HbA1c (9.54% to 8.83%, $p = 0.001$) [32]. In contrast, a produce prescription program operated by a mid-Atlantic nonprofit association in the US ($n = 699$) found increased fruit and vegetable consumption patterns but no significant improvements in diabetes measures [33].

The conflicting findings of the produce prescription programs highlight the complex web of social and medical factors that contribute to poor glycemic control among FI adults with T2DM. An effective approach to improving the diabetes status of this population was presented in the clinic-based social medical program ($n = 933$) published by Blitstein

et al. [7]. This program went beyond the provision of funds for food, it helped enroll individuals in food benefit programs and shepherd them to community programs [7]. Also of note, this program responded to the call for research by Gucciardi et al. for research on effective strategies for helping low-income individuals with diabetes improve their dietary choices, systematic strategies for monitoring food security status, and better engaging healthcare providers in addressing the challenges of being FI and glycemic control [17].

Glycemic control challenges, nonadherence with self-care measures, and mental health issues are not unique to FI adults with T2DM. Among the general population of adults with T2DM, about half achieve glycemic control ($\text{HbA1c} < 7\%$) [34]. In addition to nonadherence with medication, clinical depression is more prevalent among adults with diabetes compared to those without the condition. The psychological burden of diabetes emerged as a challenge among the studies included in this review. Safren et al. conducted a randomized clinical trial evaluating the efficacy of cognitive behavioral therapy for adherence and depression, and thereby glycemic control. Participants in this study ($n = 87$ adults with uncontrolled diabetes) participated in nine to 11 therapy sessions across four months. Post-intervention, HbA1c levels were lower among participants. The 0.72-unit reduction was equivalent to a weak hypoglycemic medication. Also of note, both medication adherence and blood glucose self-monitoring measures improved. Eight-months post-intervention, diabetes control improvements persisted [34].

This study employed an evidence-based protocol for identifying, vetting, and extracting data from candidate articles. Limitations included the restriction of only articles published in the English language, which may have contributed to the heavy volume of US-based studies (9/10, 90%). A strength of the narrative content analysis was the flexibility in identifying emerging themes; a limitation was the lack of quantitative, objective findings.

Areas for further research thus include the evaluation of a social medical psychological approach to glycemic control among FI adults with T2DM. Given the range of definitions employed to define poor glycemic control, studies evaluating the ramifications of specific levels of HbA1C may offer insights into a uniform definition for optimal control among adults with T2DM. An analysis of qualitative studies on the FI patient experience would be a beneficial contribution to the body of literature on this topic and potentially help identify effective approaches to helping this population maintain glycemic control.

5. Conclusions

Diabetes is a global pandemic. For adults with T2DM, regardless of food security status, diabetes self-care strategies can be overwhelming. Adherence is challenging. A social medical psychological is needed to help prevent and shepherd newly diagnosed individuals into remission.

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References

1. Sun, H.; Saeedi, P.; Karuranga, S.; Pinkepank, M.; Ogurtsova, K.; Duncan, B.B.; Stein, C.; Basit, A.; Chan, J.C.; Mbanya, J.C.; et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes Res. Clin. Pract.* **2022**, *183*, 109119. [[CrossRef](#)] [[PubMed](#)]
2. Brown, A.; McArdle, P.; Taplin, J.; Unwin, D.; Unwin, J.; Deakin, T.; Wheatley, S.; Murdoch, C.; Malhotra, A.; Mellor, D. Dietary strategies for remission of type 2 diabetes: A narrative review. *J. Hum. Nutr. Diet.* **2022**, *35*, 165–178. [[CrossRef](#)] [[PubMed](#)]
3. Knowler, W.C.; Barrett-Connor, E.; Fowler, S.E.; Hamman, R.F.; Lachin, J.M.; Walker, E.A.; Nathan, D.M.; Wacton, P.G.; Mendoza, J.T.; Smith, K.A.; et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N. Engl. J. Med.* **2002**, *346*, 393–403.

4. Nowlin, S.Y.; Hammer, M.J.; Melkus, G.D. Diet, inflammation, and glycemic control in type 2 diabetes: An integrative review of the literature. *J. Nutr. Metab.* **2012**, *2012*, 542698. [[CrossRef](#)] [[PubMed](#)]
5. Malkani, S.; Mordes, J.P. Implications of using hemoglobin A1C for diagnosing diabetes mellitus. *Am. J. Med.* **2011**, *124*, 395–401. [[CrossRef](#)] [[PubMed](#)]
6. American Diabetes Association. Standards of Medical Care in Diabetes—2021. *Diabetes Care* **2021**, *44* (Suppl. 1), S1–S2. [[CrossRef](#)]
7. Blitstein, J.L.; Lazar, D.; Gregory, K.; McLoughlin, C.; Rosul, L.; Rains, C.; Hellman, T.; Leruth, C.; Mejia, J. Foods for Health: An integrated social medical approach to food insecurity among patients with diabetes. *Am. J. Health Promot.* **2021**, *35*, 369–376. [[CrossRef](#)]
8. Duarte, F.G.; da Silva Moreira, S.; Conceição, C.A.; de Souza Teles, C.A.; Andrade, C.S.; Reingold, A.L.; Moreira, E.D., Jr. Sex differences and correlates of poor glycaemic control in type 2 diabetes: A cross-sectional study in Brazil and Venezuela. *BMJ Open* **2019**, *9*, e023401. [[CrossRef](#)]
9. Khattab, M.; Khader, Y.S.; Al-Khawaldeh, A.; Ajlouni, K. Factors associated with poor glycemic control among patients with type 2 diabetes. *J. Diabetes Complicat.* **2010**, *24*, 84–89. [[CrossRef](#)]
10. Taylor, R.; Ramachandran, A.; Yancy, W.S., Jr.; Forouhi, N.G. Nutritional basis of type 2 diabetes remission. *BMJ* **2021**, *7*, n1449. [[CrossRef](#)]
11. Galicia-Garcia, U.; Benito-Vicente, A.; Jebari, S.; Larrea-Sebal, A.; Siddiqi, H.; Uribe, K.B.; Ostolaza, H.; Martín, C. Pathophysiology of type 2 diabetes mellitus. *Int. J. Mol. Sci.* **2020**, *21*, 6275. [[CrossRef](#)] [[PubMed](#)]
12. Minihane, A.M.; Vinoy, S.; Russell, W.R.; Baka, A.; Roche, H.M.; Tuohy, K.M.; Teeling, J.L.; Blaak, E.E.; Fenech, M.; Vauzour, D.; et al. Low-grade inflammation, diet composition and health: Current research evidence and its translation. *BJN* **2015**, *114*, 999–1012. [[CrossRef](#)] [[PubMed](#)]
13. Shivappa, N.; Steck, S.E.; Hurley, T.G.; Hussey, J.R.; Hébert, J.R. Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutr.* **2014**, *17*, 1689–1696. [[CrossRef](#)]
14. Boero, V.; Cafiero, C.; Gheri, F.; Kepple, A.W.; Rosero Moncayo, J.; Viviani, S. *Access to Food in 2020. Results of Twenty National Surveys Using the Food Insecurity Experience Scale (FIES)*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2021.
15. Kim, E.J.; Abrahams, S.; Marrast, L.; Martinez, J.; Hanchate, A.D.; Conigliaro, J. Significance of multiple adverse social determinants of health on the diagnosis, control, and management of diabetes. *J. Gen. Intern. Med.* **2021**, *36*, 2152–2154. [[CrossRef](#)] [[PubMed](#)]
16. Seligman, H.K.; Bindman, A.B.; Vittinghoff, E.; Kanaya, A.M.; Kushel, M.B. Food insecurity is associated with diabetes mellitus: Results from the National Health Examination and Nutrition Examination Survey (NHANES) 1999–2002. *J. Gen. Intern. Med.* **2007**, *22*, 1018–1023. [[CrossRef](#)] [[PubMed](#)]
17. Gucciardi, E.; Vahabi, M.; Norris, N.; Del Monte, J.P.; Farnum, C. The intersection between food insecurity and diabetes: A review. *Curr. Nutr. Rep.* **2014**, *3*, 324–332. [[CrossRef](#)]
18. Page, M.J.; Moher, D.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ* **2021**, *372*, n160. [[CrossRef](#)]
19. Higgins, J.P.T.; Altman, D.G.; Gøtzsche, P.C.; Jüni, P.; Moher, D.; Oxman, A.D.; Savović, J.; Schulz, K.F.; Weeks, L.; Sterne, J.A.C.; et al. The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. *BMJ* **2011**, *343*, d5928. [[CrossRef](#)]
20. Tucker, K.L.; Mattei, J.; Noel, S.E.; Collado, B.M.; Mendez, J.; Nelson, J.; Griffith, J.; Ordovas, J.M.; Falcon, L. The Boston Puerto Rican Health Study, a longitudinal cohort study on health disparities in Puerto Rican adults: Challenges and opportunities. *BMC Public Health* **2010**, *10*, 107. [[CrossRef](#)]
21. Chen, T.C.; Clark, J.; Riddles, M.K.; Mohadjer, L.K.; Fakhouri, T.H. National Health and Nutrition Examination Survey, 2015–2018: Sample design and estimation procedures. National Center for Health Statistics. In *Vital and Health Statistics*; Centers for Disease Control and Prevention: Atlanta, GA, USA, 2020; Volume 2, pp. 1–27.
22. Nelson, K.; Drain, N.; Robinson, J.; Kapp, J.; Hebert, P.; Taylor, L.; Silverman, J.; Kiefer, M.; Lessler, D.; Krieger, J. Peer support for achieving independence in diabetes (Peer-AID): Design, methods and baseline characteristics of a randomized controlled trial of community health worker assisted diabetes self-management support. *Contemp. Clin. Trials* **2014**, *38*, 361–369. [[CrossRef](#)]
23. Moin, T.; Duru, O.K.; Turk, N.; Chon, J.S.; Frosch, D.L.; Martin, J.; Jeffers, K.S.; Castellon-Lopez, Y.; Tseng, C.-H.; Norris, K.; et al. Effectiveness of shared decision-making for diabetes prevention: 12-month results from the Prediabetes Informed Decision and Education (PRIDE) trial. *J. Gen. Intern. Med.* **2019**, *34*, 2652–2659. [[CrossRef](#)] [[PubMed](#)]
24. Berkowitz, S.A.; Gao, X.; Tucker, K.L. Food-insecure dietary patterns are associated with poor longitudinal glycemic control in diabetes: Results from the Boston Puerto Rican Health Study. *Diabetes Care* **2014**, *37*, 2587–2592. [[CrossRef](#)] [[PubMed](#)]
25. Heerman, W.J.; Wallston, K.A.; Osborn, C.Y.; Bian, A.; Schlundt, D.G.; Barto, S.D.; Rothman, R.L. Food insecurity is associated with diabetes self-care behaviours and glycaemic control. *Diabet. Med.* **2016**, *33*, 844–850. [[CrossRef](#)] [[PubMed](#)]
26. Ippolito, M.M.; Lyles, C.R.; Prendergast, K.; Marshall, M.B.; Waxman, E.; Seligman, H.K. Food insecurity and diabetes self-management among food pantry clients. *Public Health Nutr.* **2017**, *20*, 183–189. [[CrossRef](#)] [[PubMed](#)]
27. Shaheen, M.; Kibe, L.W.; Schrode, K.M. Dietary quality, food security and glycemic control among adults with diabetes. *Clin. Nutr. ESPEN* **2021**, *46*, 336–342. [[CrossRef](#)] [[PubMed](#)]
28. Shalowitz, M.U.; Eng, J.S.; O McKinney, C.; Krohn, J.; Lapin, B.; Wang, C.-H.; Nodine, E. Food security is related to adult type 2 diabetes control over time in a United States safety net primary care clinic population. *Nutr. Diabetes* **2017**, *7*, e277. [[CrossRef](#)]

29. Silverman, J.; Krieger, J.; Kiefer, M.; Hebert, P.; Robinson, J.; Nelson, K. The relationship between food insecurity and depression, diabetes distress and medication adherence among low-income patients with poorly-controlled diabetes. *J. Gen. Intern. Med.* **2015**, *30*, 1476–1480. [[CrossRef](#)]
30. Walker, R.J.; Campbell, J.A.; Egede, L.E. Differential impact of food insecurity, distress, and stress on self-care behaviors and glycemic control using path analysis. *J. Gen. Intern. Med.* **2019**, *34*, 2779–2785. [[CrossRef](#)]
31. Nsimbo, K.B.A.; Erumeda, N.; Pretorius, D. Food insecurity and its impact on glycaemic control in diabetic patients attending Jabulani Dumani community health centre, Gauteng province, South Africa. *Afr. J. Prim. Health Care Fam. Med.* **2021**, *13*, e1–e6. [[CrossRef](#)]
32. Bryce, R.; Guajardo, C.; Ilarraza, D.; Milgrom, N.; Pike, D.; Savoie, K.; Valbuena, F.; Miller-Matero, L. Participation in a farmers' market fruit and vegetable prescription program at a federally qualified health center improves hemoglobin A1C in low income uncontrolled diabetics. *Prev. Med. Rep.* **2017**, *7*, 176–179. [[CrossRef](#)]
33. Xie, J.; Price, A.; Curran, N.; Østbye, T. The impact of a produce prescription programme on healthy food purchasing and diabetes-related health outcomes. *Public Health Nutr.* **2021**, *24*, 3945–3955. [[CrossRef](#)] [[PubMed](#)]
34. Safren, S.A.; Gonzalez, J.S.; Wexler, D.J.; Psaros, C.; Delahanty, L.M.; Blashill, A.J.; Margolina, A.I.; Cagliero, E. A randomized controlled trial of cognitive behavioral therapy for adherence and depression (CBT-AD) in patients with uncontrolled type 2 diabetes. *Diabetes Care* **2014**, *37*, 625–633. [[CrossRef](#)] [[PubMed](#)]