Food Insecurity regarding the Diabetes Mellitus in Iran: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Food insecurity is an important global challenge associated with various health problems such as diabetes. Diabetes mellitus is one of the most common metabolic diseases and is considered priority in Iran's health system. The aim of this study is to evaluate the relationship between food insecurity and type 2 dibetes mellitus (T2DM) in Iran. **Methods**: The authors searched English databases including Scopus, Web of Science, PubMed, and Google Scholar and also Iranian databasesof SID and Magiran for the words food insecurity, Iran, and diabetes up to November 2021. **Results**: 8 articles, including 2853 participants, ranging from 148 to 440 were included in the meta-analysis. The pooled odds ratios (ORs) of the cross-sectional and case-control studies revealed that household food insecurity was significantly associated with the odds of diabetes (OR=2.04; 95% CI: 1.34-3.09) and there was no evidence for publication bias (Egger's test, $P = 0.59$); however, heterogeneity between studies (I^2=85.9%) was observed. Similarly, according to subgroup analyses based on age, there was a significant association between household food insecurity and diabetes among the people under 50 years (OR= 2.9; 95% CI: 2.13-3.93; $I^2 = 56.4\%$, P=0.057), but not among people over 50 years (OR=1.32; 95% CI: 0.69-2.52; $I^2 = 78.3\%$, P=0.032) or between 30 and 65 years (OR=0.85; 95% CI: 0.49-1.48). **Conclusion**: This study shows that food insecurity affects the progression of type 2 DM. However, more longitudinal studies are needed for better identification of the link between food insecurity and T2DM.

Keywords: *Food insecurity; Food security; Diabetes mellitus; Iran.*

Introduction

Food insecurity is a major health issue which impacts the quality of life and health of the population (Gundersen and Ziliak, 2015). According to the Food and Agriculture Organization of the United Nations' (FAO) definiation, "food security exists when all the people, at all times, have physical and economic access to sufficient safe and nutritious food which

meets their dietary needs and food preferences for an active and healthy life" (Practical, 2008). In 2017, nearly 10% of the world's population (769.4 million people) suffered from severe food insecurity. The prevalence of severe food insecurity in Asia and West Asia was 6.9% and 10.5%, respectively in this year (Shakiba *et al.*, 2021). Behzadifar et al. conducted a meta-analysis on Iranian experiential studies in 2016 which found the prevalence of food insecurity among Iranian households to be approximately 49% (Behzadifar *et al.*, 2016).

The concept of food insecurity encompasses environmental, cultural, social, behavioral, and economic factors that can be used as a valuable tool for assessing household nutritional patterns (Dastgiri *et al.*, 2006, Fakayode, 2021). Food insecurity is correlated with lower variety of foods and a poorer diet. Choosing low-quality, inexpensive, and calorie-dense foods increase the total energy intake, and as a consequence, visceral fat accumulation (Essien *et al.*, 2016, Kirkpatrick and Tarasuk, 2008). Thus, food insecurity can be considered a risk factor for poor health (Ahuja *et al.*, 2020, Laraia, 2013, Melchior *et al.*, 2009) as well as type 2 diabetes mellitus (T2DM), obesity, and insulin resistance (Essien *et al.*, 2016, Liu and Eicher-Miller, 2021, Van Der Velde *et al.*, 2020).

Diabetes mellitus is a chronic metabolic disorder which is increasing globally as an epidemic burden. Diabetes and its complications are the leading cause of death around the world (Maghsoudi and Azadbakht, 2012). Diabetes prevalence has increased globally in recent decades. Accordingly, diabetes prevalence in Iran was reported to be 11.9% in 2011, a 35% increase since 2005. By 2030, it is estimated that 9.2 million Iranians will have diabetes (Mirzaei *et al.*, 2020). Therefore, it seems necessary to identify the factors that contribute to the increased prevalence of the disease in order to mitigate the problem.

Dietary habits and food insecurity are among the factors that play a major role in the development of diabetes (Kastorini and Panagiotakos, 2009). As food insecurity relates to the lower quality of life as well as higher levels of stress and anxiety, it may lead to increased cortisol production, which may adversely affect insulin sensitivity and glucose tolerance (Ling *et al.*, 2019, Whitworth *et al.*, 2005).

Although some studies show a connection between food insecurity and T2DM among adults (Fitzgerald *et al.*, 2011, Tait *et al.*, 2018), the results in some other cases have been contradictory (Hasan-Ghomi *et al.*, 2015). For example, the study by Beltrán *et al*. indicated that there was no association between food insecurity and clinically determined T2DM either through fasting blood glucose (FBG) or hemoglobin *A1C* (HbA1c) (Beltrán *et al.*, 2022a). Considering that the was a study at global scale, not in Iran as a subgroup, the result can be different from the present study which is only in Iran, because Iran is significantly different from other countries in terms of the prevalence of food insecurity and diabetes. Therefore, the authors conducted a systematic review and meta-analysis to determine the association between household food insecurity and T2DM in Iran.

Materials and Method

Search strategy: English databases such as Scopus, Web of Science, Science Direct, PubMed, and Google Scholar, as well as Iranian databases such as SID and Magiran were searched from the beginning to July 2021. In addition, grey literature and conference proceedings related to the topic were reviewed. Keywords were ""Food Insecurity"[Mesh]" OR ""Food security"[Mesh]" AND ""Diabetes Mellitus"[Mesh]" AND "Iran "OR "Iranian" OR "Iranians", OR "Persia, OR "Persian", OR "Persians" in English and the equivalent keywords in Persian in Iranian databases.

Selecting studies and extracting data: The selected studies addressed diabetes and food insecurity among Iranians, were written in English or Farsi, and assessed food insecurity using Household Food Security Survey Module (HFSSM, 18 items), Household Food Insecurity Access Scale (HFIAS) (9 items), and USDA questionnaires. Duplicate studies were removed

using Endnote x8.

Data were extracted independently by two authors from the selected papers, and any disagreements were resolved through discussion between the authors. In these studies, the area, type of study, age, sex, sample size, year of publication, the questionnaire used, statistical model, and estimated effects of food insecurity related to diabetes were extracted. Inclusion and exclusion criteria based on population, intervention, comparison, and outcome (PICO) were explained in **Table 1**.

Table 1. Inclusion and exclusion criteria based on PICO.

Population	Iranian household
Intervention	Food insecurity
Comparison	Food security
Outcome	Diabetes

Data analysis: Food insecurity and diabetes' pooled odds were calculated with a random-effect model and a 95% level of confidence intervals (CIs). The researchers assessed heterogeneity between the studies by I^2 statistic. P-value≤0.001 and OR=2.04 (1.34,3.09) were considered statistically significant. Using subgroup analysis and taking into account study design and sample age, the authors evaluated the heterogeneity of studies. Publication bias was assessed using Egger's test, and data analysis was carried out using STATA 14 (Stata Corporation, College Station, TX, USA).

Study quality assessment: Using the National Institutes of Health (NIH) quality assessment tool for observational cohort and cross-sectional studies (National Heart Lung and Blood Institue, 2021), the two reviewers independently evaluated the quality of the evidence provided in each study. A total score was determined for each study based on the 14 criteria listed in the assessment tool, with zero indicating weak scientific evidence and 14 indicating strong scientific evidence. Inconsistencies were resolved by another author at this stage.

Result

As shown in PRISMA flow diagram (**figure 1**), 40 published articles were identified from Web of Sciences, PubMed, Scopus, Science Direct, Google Scholar, SID and Magiran. Due to duplication, 9 papers were removed. After reading the titles and abstracts of the 31 remaining articles, 20 were excluded for being unrelated to the topic. 3 articles were excluded after reviewing the full texts of the 11 remaining articles. 3 of them were cross-sectional and 5 were case-control studies. Thus, 8 articles were finally included in the meta-analysis.

Study quality assessment: **Table 2** shows that the selected studies scored 9 out of a possible score of 14, ranging from 8 to 10. All of them clearly stated the research question or objective and used clearly defined, valid, and reliable exposure and outcome measures, which were implemented consistently on all the participants.

Characteristics of the studies: According to **Table 3**, two studies were from Tehran (Gholizadeh *et al.*, 2018, Hasan-Ghomi *et al.*, 2015), one from each of the following areas; Shiraz (Najibi *et al.*, 2019), Eghlid (a county in Fars Province) (Mohammadi *et al.*, 2020), Mashhad (Bahrami *et al.*, 2018), Khoy (Heidari *et al.*, 2020), Qazvin (Janzadeh *et al.*, 2020) and Abadan (Ariya *et al.*, 2019). In total, from the three cross-sectional and five case-control studies, 2853 participants were included, ranging from 148 in Mohammadi's study (Mohammadi *et al.*, 2020) to 440 in Heidari's study (Heidari *et al.*, 2020).

To determine food security, three different questionnaires were used. 6 studies used an 18-item United States Department of Agriculture (USDA) questionnaire (Ariya *et al.*, 2019, Gholizadeh *et al.*, 2018, Hasan-Ghomi *et al.*, 2015, Janzadeh *et al.*, 2020, Mohammadi *et al.*, 2020, Najibi *et al.*, 2019), one used a 6-item Household Food Security Scale (HFSS) (Heidari *et al.*, 2020), and one used a 9-item Household Food Insecurity Access Scale (HFIAS) questionnaire (Bahrami *et al.*, 2018)..
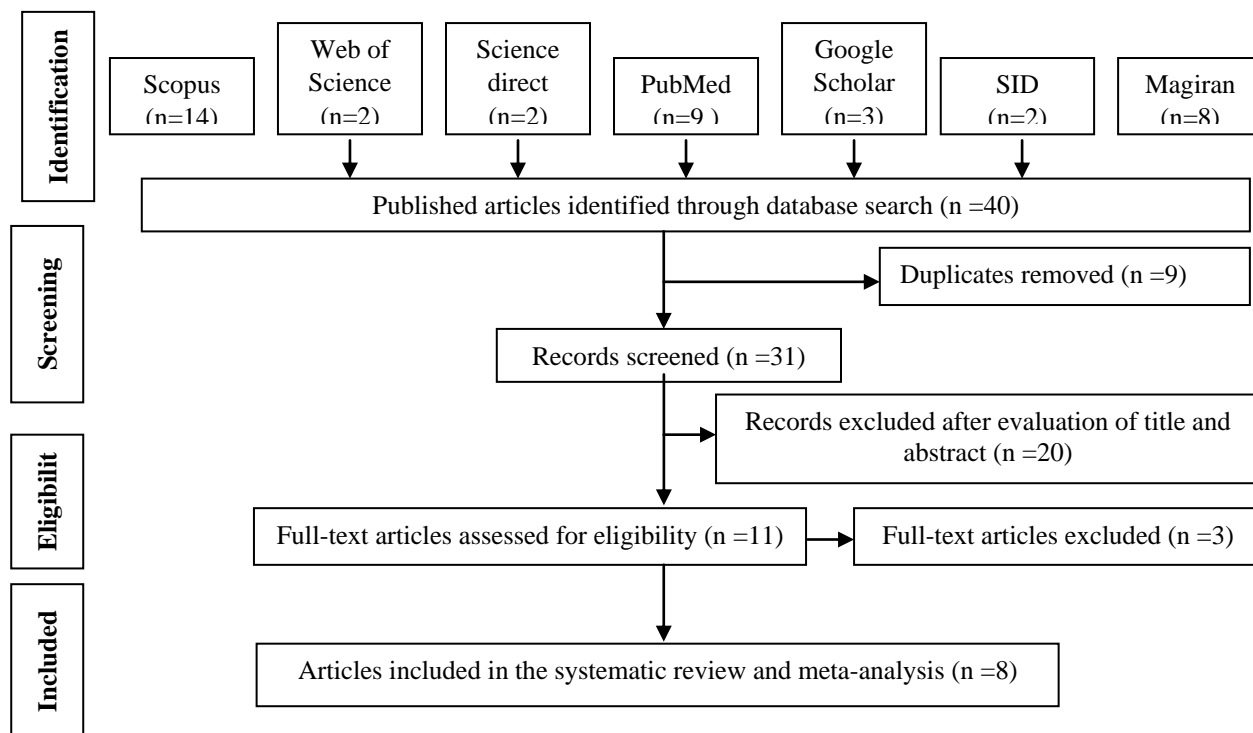
Figure 1. PRISMA flow diagram for the systematic review and meta-analysis.

Table 2. Quality assessment of included studies.

Reference	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total score
Mohammadi et al. (2020)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	10
Heidari et al. (2020)	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	N	Y	9
Janzadeh et al. (2020)	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	N	Y	9
Najibi et al. (2019)	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	N	N	8
Ariya et al. (2019)	Y	Y	Y	Y	Y	N	N	N	Y	N	N	Y	N	Y	8
Bahrami et al. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	N	N	8
Gholizadeh et al. (2018)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	10
Hasan-Ghomi et al. (2015)	Y	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	10

Table 3. The chractristis of the 8 included studies.

Author Published year	Study design	Study area	Sample size	Sex	Age(years)	Sample characteristics	Statistical model	Questionnaire	Quality Score
M Mohammadi 2020	Cross-sectional	Eghlid	148	Both	30 and 65	With T2DM	Logistic regression	18-item USDA	10
Heidari, F. 2020	Case-control	Khoy	440	Both	52.9 case/47.9 control	With T2DM without T2DM	Logistic regression	6-item HFSS	9
H Janzadeh 2020	Case-control	Qazvin	400	Both	47.14 case/46.32 control	With T2DM Without T2DM	logistic regression	18-item USDA	9
Najibi, N. 2019	Case-control	Shiraz	270	Both	46.8 cases/45.9 controls	with T2DM without T2DM	logistic regression	18-items USDA	8
Ariya, Mohammad 2019	Case-control	Abadan	217	Both	52.8 case/41.2 control	with T2DM without T2DM	Logistic regression	18-item USDA	8
Leila Sadat Bahrami 2018	Cross-sectional	Mashhad	300	Both	< 60 ≥ 60	Heart failure patients	Chi- square test	9-item HFIAS	8
Gholizadeh, F. 2018	Cross-sectional	Tehran	300	Both	44.8 case/44.9 control	Pre-diabetes and Healthy people	Multivariate adjusted means	18-items USDA	10
Hasan-Ghomi, M. 2015	Case-control	Tehran	400	Both	Aged over 40	with T2DM without T2DM	Logistic regression	18-item USDA	10

Association between household food insecurity and diabetes' risk: After pooling data from 8 cross-sectional and case-control studies, the results revealed that household food insecurity was significantly related to the odds of diabetes (OR= 2.04; 95% CI:1.34-3.09; I^2=85.9%). In other words, the likelihood of diabetes is increased by 104% as a result of food insecurity. (**Figure 2**). In the pooled analysis, there was significant heterogeneity among the studies ($P \leq 0.001$, I^2=85.9%).
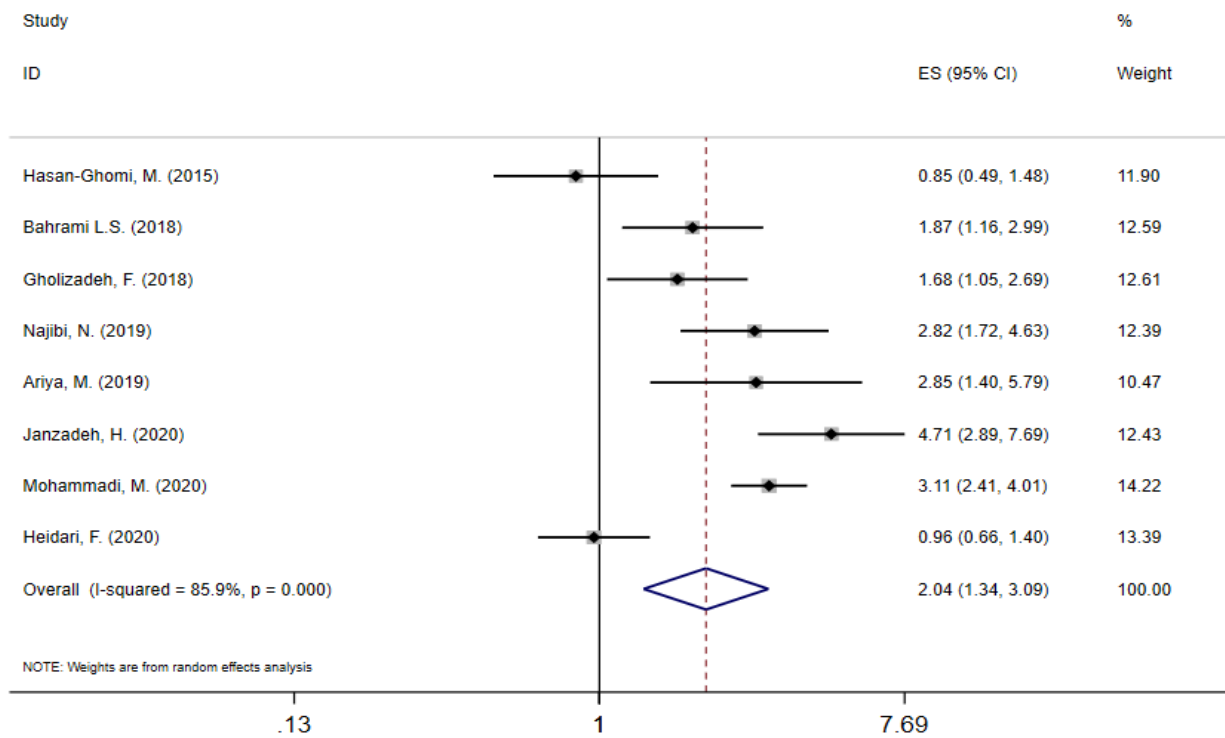

Figure 2. Forest plot of the ORs with the corresponding 95% confidence intervals (CIs) of cross-sectional and case-control studies. According to the author and year, the midpoint of each line illustrates the estimated OR in each study.

Subgroup analysis: Regarding the sources of heterogeneity in cross-sectional and case-control studies, subgroup analyses was performed by study design and age (above 50 and under 50 and 30-65); this was because the distribution of studies was such that the authors performed the subgroup analysis based on the criteria of being under and over 50 , but it would be better if it was divided between being over and under 65 (**Table 4**).

Table 4. Subgroup analysis base on the study design and age.

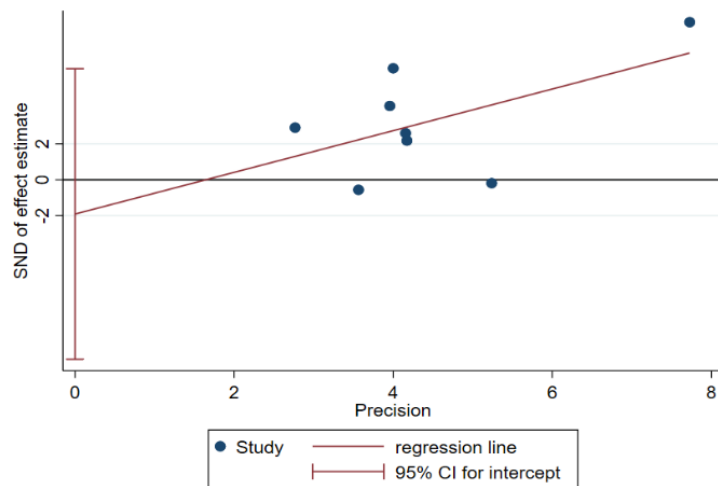| Subgroups	OR (95% CI)	P-vale	I^2	N
<u>Study design</u>				
Cross-sectional	2.22 (1.45, 3.40)	<0.001	85.9	3
Case-control	1.97(0.99, 3.93)	0.03	89.3	5
<u>Age</u>				
Under 50	2.90 (2.13, 3.93)	0.05	56.4	5
30 and 65	0.85 (0.49, 1.48)	-	-	1
More than 50	1.32 (0.69, 2.52)	0.03	78.3	2

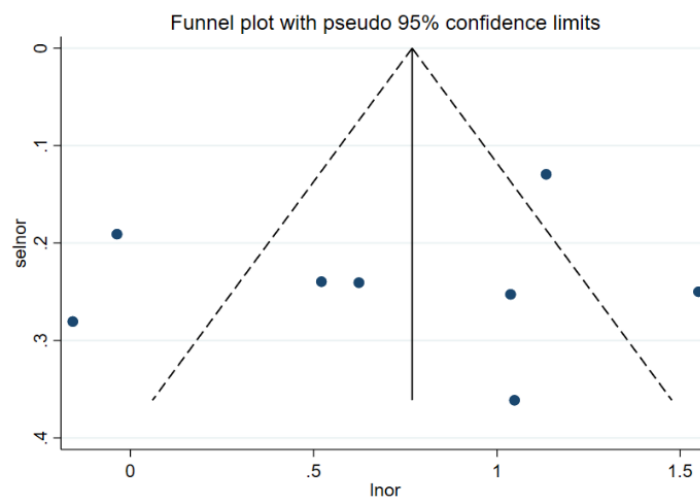**Figure 3.** Egger's publication bias plot.

Figure 4. Funnel plot of the ORs regarding cross-sectional and case-control studies.

A subgroup analysis of the study design revealed a significant association between household food insecurity and diabetes, both in cross-sectional (OR=2.22; 95% CI: 1.45-3.40; I^2=85.9%, $P\leq0.001$) and case-control studies (OR=1.97; 95% CI: 0.99-3.93; I^2= 89.3%, P=0.03).

According to a subgroup analysis based on age, there was a significant association between household food insecurity and diabetes among the people under 50 (OR=2.90; 95% CI: 2.13-3.93; I^2=56.4%, P=0.05), but not among the people over 50 (OR=1.32; 95% CI: 0.69-2.52; I^2=78.3%, P=0.032) or between 30 and 65 (OR=0.85; 95% CI 0.49-1.48)

Sensitivity analysis: To examine the effect of low-quality and high-bias-risk studies in general, a sensitivity analysis was performed by removing data from the meta-analytic model. Based on sensitivity analyses, the studies that may have affected the pooled results were not removed. Household food insecurity is still significantly associated with diabetes (OR=2.04; 95% CI: 1.35-3.09).

Publication bias: In analyzing the funnel plot for asymmetry by visual inspection, the authors found no evidence of publication bias using Egger's test (Egger's test, $P = 0.59$).

Discussion

In the present study, systematic reviews and meta-analyses were used to investigate the relationship between household food insecurity and T2DM in Iranian populations. 8 of the articles reviewed were eligible for meta-analysis. A review of studies showed that food-insecure households in Iran were twice as likely to develop T2DM as food-secure households.

The results of this study were in agreement with the findings of Tait CA *et al*, which indicated that people in food-insecure households showed a more than 2 times risk of developing T2DM compared to those in food secure households (Tait *et al.*, 2018). Similar to the results of this study, Abdurahman AA et al. reported that household food insecurity was significantly associated with T2DM (Abdurahman *et al.*, 2019); however, a study conducted in 2021 showed that there was no association between food insecurity and clinically determined T2DM either through FBG or HbA1c (Beltrán *et al.*, 2022b).

Food insecurity and T2DM may be linked by several possible mechanisms. There is a link between food insecurity, and poor diet quality, inadequate vitamin intake, and reduced fruit and vegetable consumption (Kirkpatrick and Tarasuk, 2008, Smith and Richards, 2008). Food-insecure households choose inexpensive foods because they do not have enough income or financial ability to provide nutritious food. Diabetes can be caused by low-quality foods which are often high in fat and sugar (Vozoris and Tarasuk, 2003). As a defense mechanism against future periods of deficiency, overeating is triggered by biological behavior. Consuming foods which are high in fat and sugar causes the storage of energy in abdominal area, leading to obesity and diabetes (Dallman *et al.*, 2005). In addition to affecting physical health and nutrition, food insecurity can also affect mental health. Food insecurity leads to psychological distresses such as depression by triggering a stress response (Pourmotabbed *et al.*, 2020). Stress disrupts glucose metabolism and insulin sensitivity (Hackett and Steptoe, 2017). Similarly, depression is associated with poorer control of blood sugar as well as poor adherence to diet and medication regimens (Ciechanowski *et al.*, 2000, Lustman *et al.*, 2000). Seligman *et al.*'s study indicated that food insecurity may be associated with poor glycemic control due to low adherence to a proper diabetes diet and increased emotional distress associated with self-management of diabetes (Seligman *et al.*, 2012).

Therefore, because of the relationship between food insecurity and T2DM, it is beneficial to prioritize improvements in food security for this particular group of people among the various programs and policies of the country. Food insecurity is a complex phenomenon with a number of factors including inadequate food production, inadequate access to food, poverty, low income, low level of education, as well as political, environmental, cultural, and religious aspects (Tarasuk, 2001). Food insecurity can be

reduced through a variety of interventions, including interventions aimed at increasing nutritional knowledge and household purchasing power. Government agencies should continue to provide extensive support to public interventions in future (Mortazavi *et al.*, 2021).

This review had some limitations. It is possible that additional articles were missed while every effort was made to ensure this review was comprehensive. As a result of the variety of approaches taken to measure food insecurity, comparing the results of different studies was challenging. As this systematic review included cross-sectional and case-control studies, it is unlikely to conclude that food insecurity and diabetes are linked longitudinally.

Conclusion

This systematic review and meta-analysis provides a significant association between FIS and T2DM in Iran. For a more comprehensive conclusion, additional studies are needed on the association between FIS and T2DM in larger populations. Practical interventions and policy support are needed to reduce food insecurity and the risk of diabetes.

Authors' contributions

Sobhani SR and Asadimehr S designed the research study. Govahi Kakhki F, Maddahi M and Asadimehr S performed the research. Ramezani Ahmadi A and Asadimehr S analyzed the data. Sobhani SR, Maddahi M and Asadimehr S prepared the draft manuscript. Sobhani SR critically reviewed and revised the manuscript. All authors have read and approved the final manuscript.

Conflict of interest

There is any conflicts of interest.

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