Supplemental Online Content

Oronce CIA, Miake-Lye IM, Begashaw MM, Booth M, Shrank WH, Shekelle PG. Interventions to address food insecurity among adults in Canada and the US: a systematic review and meta-analysis. JAMA Health Forum. 2021;2(8):e212001. doi:10.1001/jamahealthforum.2021.2001

eTable 1. Cochrane Risk of Bias

eTable 2. Risk of Bias in Non-Randomized Studies of Intervention Tool

eTable 3. Before-After Risk of Bias

eTable 4. Health Care Utilization and Cost Outcomes

eAppendix 1. Search Strategy

eAppendix 2. Excluded Studies

eAppendix 3. Further Description of Methods and Results

This supplemental material has been provided by the authors to give readers additional information about their work.
| Author, year          | Random sequence generation | Allocation concealment | Blinding of participants and personnel | Blinding of outcome assessment | Incomplete outcome data | Selective reporting | Other sources of bias                        |
|-----------------------|-----------------------------|------------------------|---------------------------------------|-------------------------------|------------------------|--------------------|--------------------------------------------|
| Berkowitz, 2018 25    | Low risk                    | Low risk               | High risk                             | Low risk (Health Eating Index, hypoglycemia) | Low risk               | Low risk          |                                            |
|                      |                             |                        |                                       | Low risk (HbA1c)              |                        |                    |                                            |
| Seligman, 2018 26     | Low risk                    | Low risk               | High risk                             | Low risk (HbA1c)              | High risk              | Low risk          |                                            |
|                      |                             |                        |                                       | High risk (Food security, depressive symptoms) |                       |                    |                                            |
| Ferrer, 2019 27       | Unknown risk                | Low risk               | High risk                             | High risk (HbA1c, BMI, Diet assessment) | High risk              | Unknown           |                                            |
|                      |                             |                        |                                       |                               |                        |                    |                                            |
| Feuerstein-Simon, 2019 28 | Low risk                    | Unknown                | High risk                             | High risk (food insecurity, fruit and vegetable intake) | Low risk              | High risk          |                                            |
|                      |                             |                        |                                       |                               |                        |                    |                                            |
| Martin, 2013 29       | Low risk                    | Low risk               | High risk                             | High risk (Food insecurity, fruit) | High risk              | Unknown           |                                            |
| Study Reference | Status | Risk | Risk | Risk | Risk (Food Security) | Risk | Risk | Notes |
|-----------------|--------|------|------|------|----------------------|------|------|-------|
| Gubits, 2018<sup>30</sup> | Unknown | Low risk | High risk | High risk (Food insecurity, housing stability measures, self-reported health, psychological distress) | High risk | Low risk | Bias arising from limited study arms among locations |
| Eicher-Miller, 2009<sup>31</sup> | High risk | High risk | High risk | High risk (Food security) | Low risk | Unknown |
| Lohse, 2015<sup>32</sup> | Unknown | High risk | High risk | High risk (Food security) | High risk | Unknown | Data analyzed as a pre-post study |
cTable 2. ROBINS-I

| Author, Year     | Confounding bias | Selection bias | Bias in measurement classification of interventions | Bias due to deviations from intended interventions | Bias due to missing data | Bias in measurement of outcomes | Bias in selection of the reported result |
|------------------|------------------|----------------|-----------------------------------------------------|--------------------------------------------------|--------------------------|----------------------------------|------------------------------------------|
| Berkowitz, 2019<sup>33</sup> | Low              | Low            | Low                                                 | Low                                              | Low                      | Low                              | Low                                      |
| Gurvey, 2013<sup>46</sup>     | Moderate         | Low            | Low                                                 | Low                                              | High                     | Low                              | Low                                      |
| Chatterjee, 2018<sup>49</sup> | Low              | Low            | Low                                                 | Low                                              | High                     | High                             | Low                                      |
| Frongillo, 2010<sup>47</sup>  | Low              | Low            | Low                                                 | Low                                              | High                     | High                             | Low                                      |
| Lee, 2011<sup>48</sup>        | Low              | Low            | Low                                                 | Low                                              | High                     | High                             | Low                                      |
| Mabli, 2017<sup>63</sup>      | Low              | Low            | Low                                                 | Low                                              | High                     | High                             | Low                                      |
| Andrade, 2019<sup>50</sup>    | Low              | Low            | Low                                                 | Low                                              | High                     | High                             | Low                                      |
| Brown, 2019<sup>56</sup>      | Low              | Low            | Low                                                 | Unknown                                          | Low                      | High                             | Low                                      |
| Himmelstein, 2019<sup>,57</sup> | Low              | Low            | Low                                                 | Unknown                                          | Low                      | High                             | Low                                      |
| Ionescu-Ittu, 2015<sup>58</sup> | Low             | High           | Low                                                 | Unknown                                          | Low                      | High                             | Low                                      |
| Li, 2016<sup>59</sup>         | Low              | Low            | Low                                                 | Unknown                                          | Low                      | High                             | Low                                      |
| Londhe, 2019<sup>60</sup>     | Low              | Low            | Low                                                 | Unknown                                          | Low                      | High                             | Moderate                                 |
| McIntyre, 2016<sup>61</sup>   | Low              | Low            | Low                                                 | Unknown                                          | Low                      | Low                              | Moderate                                 |
| Schmidt, 2016<sup>62</sup>    | Low              | Low            | Moderate                                            | Low                                              | High                     | High                             | Low                                      |
| Study                     | Risk of Bias | Sample Size | Expense of Treatment | Cost-effectiveness | Safety | Mortality | Adverse Events |
|--------------------------|--------------|-------------|----------------------|-------------------|--------|-----------|----------------|
| Sonik, 2019              | Low          | Low         | Low                  | Low               | High   | Low       |
| Richardson, 2017         | Low          | Low         | Low                  | Low               | High   | Low       |
| Roncarolo, 2016          | Low          | Low         | Low                  | Low               | High   | High      |
| Phojanakong, 2020        | Low          | Moderate    | Moderate             | Low               | High   | High      | Low            |
**eTable 3. Before-After Risk of Bias**

| Study Reference | Risk | Questions Answered |
|-----------------|------|---------------------|
| Cheyne, 2020    | High risk | No |
| Wright, 2015    | High risk | Yes |
| Palar, 2017     | High risk | No |
| Aiyer, 2019     | High risk | No |
| Seligman, 2015  | High risk | Yes |
| Wetherill, 2019 | High risk | No |
| Khan, 2019      | High risk | n/a |
| Wilkinson, 2019 | High risk | Yes |
| Durward, 2019   | High risk | No |
| Cueva, 2018     | High risk | Unknown |
| Carney, 2012    | High risk | Yes |
| Berkowitz, 2018 | High risk | Yes |
| Feinberg, 2018  | High risk | Unknown |

7. Were the outcome measures prespecified, clearly defined, valid, reliable, and assessed consistently across all study participants?

9. Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?
| Author, year | Study Design | Population | Intervention | Comparison | Utilization outcome |
|-------------|--------------|------------|--------------|------------|-------------------|
| Palar, 2017 | Before-After | Client of non-profit organization that provides food assistance | “Food=Medicine”, which was designed to provide meals and snack fulfilling 100% of daily caloric intake, tailored to patients with HIV or Diabetes | Pre-intervention | ED visits (at least 1 in prior 3 months)  
Pre: 26.9%  
Post: 17.3%  
(p=0.15)  
Hospitalizations (at least 1 in prior 3 months)  
Pre: 15.7%  
Post: 5.8%  
(p=0.11) |
| Gurvey, 2013 | Before-After (control group only in post) | Clients of the program (chronic disease) for 3 months or more and members of a local Medicaid managed care organization | Metropolitan Area Neighborhood Nutrition Alliance of New Jersey, providing 3 nutritionally-balanced meals 3 times a day, 7 days | Comparison group matched for Charlson Comorbidity Index and 8 nutrition-related diagnosis codes | Mean monthly cost of all participants  
Intervention: $28268  
Comparison: $40906 |
| Intervention | Comparison  |
|--------------|------------|
| Costs of Patients with HIV | $16765 | $37287 | (p<0.001) |
| Mean monthly ER visits | Intervention: 0.6 | Comparison: 0.3 | (p<0.001) |
| Mean monthly ER costs | Intervention: $4893 | Comparison: $3700 | (p=not significant) |
| Mean monthly inpatient costs | | | |
| Berkowitz, 2019<sup>33</sup> | Retrospective matched cohort | Aged 18 and older | Medically-tailored meal, chosen by a registered dietician from 1 of 17 dietary tracks; meals delivered to home | Instrumental variable- matched comparison group | Incidence rate ratio for:  
**Inpatient admission**  
= 0.51 (95% CI 0.22-0.80) favoring intervention  
**Nursing facility admission** = 0.28,  
(95% CI 0.01-0.60) favoring intervention |

**Intervention:**  
$132441  
Comparison:  
$219639  
(p<0.001)  
**Mean monthly inpatient visits**  
Intervention: 0.2  
Comparison: 0.4  
(p<0.001)
| Feinberg, 2018 45 | Before-After | Adults 18 and older in Geisinger Health System Type 2 diabetes with HbA1C ≥ 8% | Grocery box intended to provide ten meals in one week | Pre-intervention | Mean annual costs |
|------------------|--------------|------------------------------------------------------------------------|-----------------------------------------------------|-----------------|-------------------|
|                  |              |                                                                        |                                                     |                 | Pre: $240,000      |
|                  |              |                                                                        |                                                     |                 | Post: $48,000      |

| Feinberg, 2018 45 | Before-After | Adults 18 and older in Geisinger Health System Type 2 diabetes with HbA1C ≥ 8% | Grocery box intended to provide ten meals in one week | Pre-intervention | Mean annual costs |
|------------------|--------------|------------------------------------------------------------------------|-----------------------------------------------------|-----------------|-------------------|
|                  |              |                                                                        |                                                     |                 | Pre: $240,000      |
|                  |              |                                                                        |                                                     |                 | Post: $48,000      |
eAppendix 1. Search Strategy

DATABASE SEARCHED & TIME PERIOD COVERED:

Academic Search Complete – From 2000 to January 23, 2020

SEARCH STRATEGY: 1923 results

(TI/AB/KW) “food insecurity” OR “food insecure” OR “food access”
AND
(TI/AB/KW) health
OR
(TI/AB/KW) “food supply”
AND
(TI/AB/KW) "vulnerable population" OR "vulnerable populations" OR "vulnerable group" OR "vulnerable groups"
Language: English

DATABASE SEARCHED & TIME PERIOD COVERED:

Cochrane Trials – From 2000 to January 23, 2020

SEARCH STRATEGY: 348 results

(TI/AB/KW) “food insecurity” OR “food insecure” OR “food access”
OR
(TI/AB/KW) “food supply” OR food supply[MESH]
AND
(TI/AB/KW) "vulnerable population" OR "vulnerable populations" OR "vulnerable group" OR "vulnerable groups" OR vulnerable population[MESH]
Language: English
DATABASE SEARCHED & TIME PERIOD COVERED:

PubMed – From 2000 to January 23, 2020 (new interface)

SEARCH STRATEGY: 4282 results

"food insecurity"[Title/Abstract] OR "food access"[Title/Abstract] OR "food insecure"[Title/Abstract]

OR

(food supply[MeSH Terms]) OR ("food supply"[Title/Abstract])) AND ((vulnerable population[MeSH Terms]) OR ("vulnerable population"[Title/Abstract] OR "vulnerable populations"[Title/Abstract] OR "vulnerable group"[Title/Abstract] OR "vulnerable groups"[Title/Abstract]))

Language: English

SIREN SEARCH, 12/10/19

DATABASE SEARCHED & TIME PERIOD COVERED:

SIREN – All entries to December 10, 2019, repeated on May 17, 2021 after reviewer suggestions

SEARCH STRATEGY: 36 results (up to 12/10/19), 66 results (up to 5/17/21)

“Food/Hunger” categorization (first search)
“Food/Hunger,” “Economic Security,” and “Health or Health Behavior” categorization (second search)

Language: English

Google search of gray literature after reviewer suggestions

SEARCH STRATEGY: 250 results

(first 50 results of search terms below “food insecurity interventions,” “evidence-based interventions for food insecurity,” “Language: English

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eAppendix 2. Citations for Excluded Studies

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eAppendix 3. Further Description of Methods and Results

Methods

Study Inclusion and Exclusion Criteria

We included all studies that evaluated a food insecurity intervention and included health outcomes or food insecurity as an outcome measured at the person-level. We defined a food insecurity intervention as a program or policy that either directly addresses food needs or improves the ability to obtain food. We also included studies if investigators explicitly stated that the intervention’s objective was to address participants’ food insecurity or if the study measured food insecurity as a study outcome. Therefore, an intervention could be included if it improved household financial resources, but was not designed to address food insecurity as its primary goal, and the study measured its association with food insecurity. We excluded studies on the Supplemental Nutrition Assistance Program (SNAP) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), which are established interventions with a voluminous literature. Because we were most interested in clinically oriented health outcomes, we excluded studies that only reported fruit and vegetable intake as the sole outcome. We rejected publications that employed community-level metrics as well as those that were descriptive narrative studies. As our focus was interventions applicable to the United States, we excluded studies conducted in low- and middle-income countries, in addition to those that took place in Western countries outside of the U.S. and Canada. Some studies in Canada were focused on indigenous populations unique to the country and we excluded these given limited generalizability. Finally, we also excluded studies focusing on children and adolescents, such as school lunch programs, as the focus of the sponsor was adults with food insecurity. While
pediatric food insecurity interventions may also have impact on adults since food insecurity is often measured at the household-level, we sought to focus on interventions that could be widely targeted to adults.

Analysis

As mentioned in the main body of the manuscript, we conducted a random-effects meta-analysis and pooled results of studies in the same intervention category. The random effects meta-analysis takes into account the between-study variation as well as the variation across studies. Prior to conducting the meta-analysis, we performed an exploratory meta-regression to assess the association of 3 variables on outcomes: study design, baseline degree of food insecurity, and intervention type. Bivariate meta-regressions were done controlling separately for each of the three variables. Studies grouped as “miscellaneous studies” were not pooled and were not included in the meta-regressions. Outliers were assessed and removed from all pooled results and meta-regressions. None of the variables examined had statistically significant evidence of a differential association.

Results

Food insecurity interventions included provision of food, monetary assistance, food desert interventions, and a miscellaneous category. The food provision interventions were further categorized as those delivering food to the program participant and those where participants went
to a secondary site to receive the intervention. We expand below on the results of studies evaluating the effectiveness of food provision interventions on reducing food insecurity.

**Providing Food Delivered to Home**

*Medically tailored meals*

Among the six studies that provided home delivered food, one was a small randomized trial of medically tailored meals, in which dieticians designed meals to address patients’ nutritional needs based on their medical conditions (e.g. diabetes or HIV). In this pilot randomized cross-over trial, 44 individuals were enrolled to receive either immediate home delivery of medically tailored meals for 12 weeks (through an organization called Community Servings) or delayed delivery and usual care before crossing over to the “on-meals” arm. This study found that 42% of those receiving meals were food insecure versus 62% of those who were not receiving home-delivered medically tailored meals, compared to the baseline food insecurity prevalence of 71-80%.

*All Other Kinds of Foods Provided*

There were 5 studies comprising home delivery of non-medically tailored food (Table 1). One provided food to families in motel shelters, but found no changes in food insecurity. Four other studies examined the same intervention—home delivered meals under the Older Americans Act Nutrition Program (OAANP) or “Meals on Wheels”. These included Before-After studies from multiple states and a nationally-representative cross-sectional study. The three Before-After studies found that home delivered meals were associated with reduced food insecurity. The cross-sectional study, which used a matched comparison group of Medicare beneficiaries, did not observe a difference in food insecurity.

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Providing Food at a Secondary Site

Ten studies examined interventions where food was provided at a secondary location and were differentiated by degree of tailoring towards the patients’ comorbidities—medically tailored meals, medically tailored or appropriate food boxes, or other (no further individualization, see Table 1).

Medically tailored Meals

One intervention provided medically tailored meals at a distribution site. Meals provided 100% of daily calorie needs to individuals living with HIV or diabetes. The evaluation used a Before-After without control design and found that those receiving medically tailored meals for a 6-month period experienced a statistically significant increase in food security from 10% to 54%.

Medically tailored groceries (i.e. “diabetic diet” groceries, not individually prescribed)

One RCT and 3 observational studies evaluated medically tailored grocery interventions (Table 1). These interventions targeted populations with common cardiometabolic conditions, including obesity, hypertension, and diabetes. The RCT was conducted across 3 states and included 568 diabetic individuals with an HbA1c of at least 7.5% randomized to control or a bundled intervention of diabetes self-management education, primary care referral, and diabetes-appropriate food boxes provided twice monthly. Food insecurity at the end of the 6-month trial was 60% in the intervention group versus 69% in the control, corresponding to a relative risk reduction of 15% in multivariate analysis (p=0.04). In a Before-After study evaluating a bundle of a diabetes-appropriate food box, patient education, and components of the Diabetes Prevention Program, the intervention was associated with a significant reduction in food insecurity from
44% to 29% (p<0.001) 37. Remaining Before-After studies included providing food boxes aligned with the Dietary Approaches to Stopping Hypertension (DASH) diet and food prescriptions for fruits, vegetables, and pre-approved items that the patient could select 36,39. The latter was associated with a statistically significant decrease in food insecurity from 100% food insecurity to 6% 36.

“Healthy eating” Groceries (i.e. more fruits and vegetables)

Two studies, both RCTs, examined food provision interventions that were not medically tailored but intended to encourage healthy food intake in general 28,29. One RCT evaluated a single site employer-based program of 60 participants 28. Participants received 8 community supported agriculture boxes over 4 months containing vegetables, fruit, eggs, and content to encourage use of the groceries, like recipes and food storage tips. The other RCT examined a multifaceted food provision program implemented in a high poverty area in Connecticut at a local food pantry 29. Participants selected their groceries, received support towards their individual goals of food security and self-sufficiency, and were connected with services to address unmet social needs. Only the first study had a statistically significant effect with an 89% reduction in the odds of food insecurity. The latter study showed a small reduction through 9 months, which was diminished and no longer statistically significant at 12 months (p=0.12).

All Other Kinds of Foods Provided

Three observational studies provided non-medically tailored food to older adults (Table 1). These included two studies that evaluated group meal programs under the OAANP 48,63. Two studies observed a reduction in food insecurity associated with food provision 40,48.