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How is food variety conceptualized and measured as a diet quality indicator in developed settings?: protocol for a systematic scoping review

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4 **How is food variety conceptualized and measured as a diet quality indicator in**
5 **developed settings?: protocol for a systematic scoping review**
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ABSTRACT

Objectives: Dietary diversity (DD) is a pillar of healthy eating guidance and can be used to assess diet quality. Despite its longstanding acceptance and widespread use in nutrition, many inconsistencies in its definition and measurement exist and meanings vary across the development spectrum. This protocol outlines a research trajectory whereby a scoping review will be undertaken to illustrate and map the methodological approaches that have been utilized to measure diversity in the general population in developed countries. It seeks to determine what are the most common and less used methodological approaches to measure DDV in the diet of healthy adults?

Methods and analysis: A scoping review of peer-review and grey literature from five bibliographic databases: Embase, MEDLINE, Scopus, CINAHL, and ProQuest Dissertations and Theses Global. Handsearching of reviews and reference lists will identify any missing publications. Search terms will include dietary diversity, food variety, mixed diet, balanced diet, and food group variety. Eligible articles must include a measure for DD as an indicator of diet quality in the general population living in developed settings. Two independent reviewers will screen titles or abstracts, and read full-texts. Consensus will resolve any disagreements on study eligibility with a third reviewer consulted if needed. Data will be extracted using a standardized evidence table and analysed using a narrative synthesis approach. Data will be managed using Covidence.

Discussion: This scoping review will help to map, classify and assess the methodological approaches used in the nutrition literature to measure DD with a view to standardization and study comparability. The information it will provide is essential for understanding: 1) how DD is conceptualized, operationalized, and measured; 2) whether DD is validated and against what markers; and 3) what main measurement issues require consideration to improve research on this nutritional concept.

Strengths and limitations of this study

- The concept of food variety is longstanding but a wide range of approaches are used in the literature to assess it.
- This scoping review will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension (PRISMA-ScR) methodology.
- Peer-reviewed and grey literature will be searched using 5 databases and hand-referencing.
- This will be the first comprehensive scoping review of DD operationalization in developed settings.

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INTRODUCTION

It is well-known that a healthy diet is one that involves eating a variety of foods, which incorporates a longstanding nutritional concept of dietary diversity (DD) which is also referred to food variety (FV). Numerous countries have some form of recommendation to eat a variety in their dietary guidelines, including Australia, Canada, China, the United Kingdom, and the United States (1–5). DD has been a pillar of healthy eating guidance since the 1970s, and it serves as a conceptual benchmark for nutrient adequacy and diet quality (1,6,7). From a nutrition standpoint, it is thought that individuals should strive to maximize their DD to meet their nutrient needs and optimize their health (6,7). While DD may be a seemingly simple recommendation for health eating, guidelines typically lack any tangible advice to accompany this nutritional message which results in vastly different interpretations of variety (6,7). For example, Australia’s guideline shows a plate with five food groups and recommends people “enjoy a wide variety of nutritious foods from these core food groups every day” and also specifies that eating plenty of vegetables “includes different types of colours” (4). Thus, it remains unclear what is meant by DD, and how can this concept be operationalised to accurately measure whether a diet is diverse or not. That is, is DD a concern of having multiple food groups in the diet, or having different foods from within a single food group or both?

Variety, adequacy, moderation, and balance are all related and critical components of diet quality (8). Diet adequacy tends to refer to sufficient food and nutrient intake; moderation suggests non-excessive consumption of food and nutrients; and balance implies even distribution of intake (8). While the primary focus of this scoping review is on DD as a diet quality indicator, the interrelated nature of these factors means that the other three may

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3 be embedded into DD measures. Food variety refers to the degree to which an individual
4
5 consumes heterogenous foods across and within all food groups (6,7). This heterogeneity has
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7 been captured through various approaches which will be investigated with a view to
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9 standardisation and comparability in our paper. For example, some researchers measure DD
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11 by counting the number of unique foods or food groups consumed in a week (6). Other studies
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13 operationalize DD by measuring the relative distribution of calories consumed for each food
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15 (6). The third type of DD measures estimates the degree of food item similarity based on
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17 characteristics or nutritional value (6).
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23 To our knowledge, no comprehensive, published review has detailed the various
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25 interpretations and measures of DD in the general population of developed countries.
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27 Without a standard measurement or summary of the varying conceptualizations, there
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29 remain significant limitations in the ability to compare findings across studies. As there
30
31 continues to be interest and active research in DD and health outcomes (9–12), it is important
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33 to clarify and potentially standardize the measures of DD. A previous scoping review sought
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35 to consolidate DD indicators and summarize the evidence linking these indicators to health
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37 outcomes in adults and adolescents (11). Although that review offers some insight into DD
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39 measures, its primary purpose was to review the link between DD and health, and therefore
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41 does not offer a detailed summary or analysis of the various measures to improve
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43 standardisation and cross-national comparisons. Moreover, the limitations of that review
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45 include: a search limited to English, no grey literature, few databases and publications up to
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47 July 2018.
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54 Another scoping review by Marshall and colleagues (2020) examined 405 articles to
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3 investigate how fruit and vegetable variety has been operationalized. Looking just at the fruit
4 and vegetable group, the researchers found that nearly all 51 included studies had different
5 definitions of variety which makes it difficult to compare findings (13). Given the growing
6 interest in DD in recent years, an updated and more comprehensive scoping review on the
7 measurement of DD beyond the variety of only fruits and vegetables is warranted. The
8 scoping review process outlined in this protocol aims to fill this gap by systematically
9 identifying the literature operationalizing DD to summarise, and critically compare the
10 measurement of this longstanding dietary construct. Of particular interest is how dietary
11 diversity is operationalized by considering food intake from across as well as within food
12 groups.

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15 An older 2003 review describes key interpretations and operationalization of DD, but
16 focuses primarily on developing countries where DD is used as a nutritional tool to address
17 food penury rather than an indicator of diet quality (7). While DD is an important dietary goal
18 across the development spectrum, the concept has different meanings and objectives in
19 different contexts. In developing settings, where inadequate caloric intake or starvation is
20 more prevalent, DD is commonly a measure of food security or minimal nutrient adequacy
21 (7,10). This is due to the fact that starchy foods (e.g., rice or cassava) are a major source of
22 calories and carbohydrates in less-resourced nations, whereas other nutrient-dense foods like
23 meats, fruits, and vegetables are harder to obtain and contribute less to the diet (7). It is
24 consequently more common to see DD measured in the global south by the accessibility of
25 the different foods in one's community, and thus DD is a reflection of environmental
26 availability and not quality of a diet (13). To fill a clear knowledge gap on DD, this scoping Has

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3 the following research questions: *What are the most common and less frequently used*
4 *methodological approaches to measure DD (or FV) in the diet of the general population living*
5 *in developed countries?* Secondary questions include: *how has DD been validated, and what*
6 *main measurement issues require consideration to improve research on this nutritional*
7 *concept?*

15 **METHODS AND ANALYSIS**

17 **Study objectives**

19 This scoping review will consolidate the various methods researchers have measured DD as
20 an indicator of diet quality in developed settings. The review has three objectives: review aims
21 to understand the following: 1) how DD is conceptualized, operationalized, and measured; 2)
22 whether DD is validated and against what markers; and 3) what main measurement issues
23 require consideration to improve research on this nutritional concept.

31 **Study design**

33 This protocol is informed by a methodological paper for conducting a scoping review (14) and
34 the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols 2015
35 checklist (PRISMA-P) adapted for the scoping review process (15). The presentation of final
36 results will be guided by PRISMA's extension for Scoping Reviews 2018 checklist (PRISMA-
37 ScR). A scoping review was selected over a systematic review as the goal of the study is to
38 examine how research is conducted on a certain topic, that is, measuring DD (16). However,
39 the literature review will be conducted using a systematic, structured approach outlined in
40 this protocol for transparency and reproducibility purposes (16).

52 **Patient and public involvement:** There were no patients or public involved in the design of
53 this review protocol.

Eligibility criteria

To be eligible for this systematic scoping review, the articles must include a quantitative measure of DD as an indicator of diet quality, either within certain food groups or across food groups. Grey literature such as technical reports, government documents, working papers, evaluations and theses, will also be eligible for inclusion. Inclusion criteria will be limited to literature involving human participants and including a measure for DD as either an outcome or exposure. Studies that use other terminology for DD, such as food variety (FV), are still eligible for inclusion. Any measures of diet quality that do not explicitly mention DD or alike terms, but intend to measure DD (i.e., measure consumption frequency from different food groups or sub-groups) will be considered (e.g., Recommended Food Score). Diet quality and health indices (e.g., the USDA Healthy Eating Index) that include DD as a component of multi-variable measures will also be considered. Thus, this search is focused on the operationalization of DD of individual and households living in developed settings, defined as OECD countries or World Bank upper income countries (10,17).

The search will exclude papers if the operationalization of DD is focused exclusively on food quantity or nutrient adequacy, which is common in many developing settings (7). Articles focusing exclusively on the introduction of foods or increasing quantity of food intake in the pediatric population will also be excluded. Documents reflecting subjective, opinion-based information such as in editorials, commentaries, or blogs will be excluded. No language limits will be used as the databases used often translate titles and abstracts into English. However, final full-texts will be read in English, French and Persian/Farsi as the languages of the research team.

Information sources

The systematic search of relevant literature is anticipated to take place between November 2022 and mid-January 2023. Five bibliographic databases will be used to find articles: CINAHL (EBSCOhost), Embase (Ovid), MEDLINE (Ovid), Scopus, and ProQuest Dissertations and Theses Global. Citation chaining forward and backward will be completed by reviewing the reference lists of any review articles and all included full-text articles to capture possibly missed publications. We will search for gray literature using websites of food-related governmental and non-governmental organizations and professional societies (see Table 1).

Table 1. List of food organizations and websites in developed nations as information sources for gray literature

Organization	Website
American Society for Nutrition (ASN)	https://nutrition.org
Canadian Nutrition Society (CNS)	https://cns-scn.ca
European Public Health Association Food and Nutrition section (EUPHA)	https://eupha.org/food-and-nutrition
Food Banks Canada	https://foodbanksCanada.ca
Food Foundation in UK	https://foodfoundation.org.uk
The Nutrition Society (UK based)	https://www.nutritionSociety.org
UN Food and Agricultural Organisation (FAO)	https://www.fao.org/home/en
USDA Supplemental Nutrition Assistance Program	https://www.fns.usda.gov/snap/supplemental-nutrition-assistance-program
World Food Programme WFP	https://www.wfp.org/
European Food Banks Federation – FEBA	https://www.eurofoodbank.org
The Emergency Food Assistance Program (TEFAP)	https://www.feedingamerica.org/take-action/advocate/the-emergency-food-assistance-program
The Commodity Supplemental Food Program (CSFP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-programs/csfp
The Child and Adult Care Food Program (CACFP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-programs/child-and-adult-care-food-program
The National School Lunch Program (NSLP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-

The School Breakfast Program (SBP)	programs/national-school-lunch-program https://www.feedingamerica.org/need-help-find-food/school-breakfast
The Summer Food Service Program (SFSP)	https://www.feedingamerica.org/our-work/hunger-relief-programs/summer-food-service-program
Women, Infants, and Children (WIC)	https://www.feedingamerica.org/need-help-find-food/wic

Search strategy

The search terms to be used include: ‘dietary diversity’, ‘diet diversity’, ‘food variety’, ‘fruit variety’, ‘vegetable variety’, ‘meat variety’, ‘dairy variety’, and ‘recommended food score’.

Table 2 provides the full electronic search strategy including final search syntaxes and limits used in each database. No MeSH terms (medical subject headings) will be integrated into the strategy as relevant terms were not available, or were too broad (e.g., Diet) to provide relevant results.

Ovid best practices will be followed For Medline and Embase; that is, the “Humans only (removes records about animals)” special Ovid filters will be used rather than the standard “Humans only” filter to avoid unintentional exclusion of non-indexed articles (18). This filter will assist with removing articles that are focused on only animals, plants, or fungi. A similar filter will be used for CINHALL (Embase) by adapting a strategy outlined in a Cochrane Handbook for systematic reviews (19). The remaining databases do not offer a human filter, so studies will be manually screened for human participants according to the search criteria. A reference librarian with subject expertise in human nutrition will also be consulted to review and pilot the search strategies and techniques. Simple searches of gray literature will be conducted on relevant websites using ‘food variety’ or ‘diet diversity’.

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Table 2. Search strategy for each bibliographic database

Database	Search Syntax
CINHAL (EBSCOhost)	<p>TI (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>AB (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>1 OR 2</p> <p>MH (animals+) OR MH (animal studies) OR TI (animal model*)</p> <p>MH (human)</p> <p>4 NOT 5</p> <p>3 NOT 6</p>
EMBASE (Ovid)	<p>(“balanced diet*” or “dairy diversity” or “dairy variety” or “diet diversity” or “diet variety” or “dietary diversity” or “dietary variety” or “diversified diet*” or “food diversity” or “food group diversity” or “food group variet*” or “food variety” or “fruit diversity” or “fruit variety” or “grain diversity” or “grain variety” or “meat diversity” or “meat variety” or “mixed diet*” or “protein diversity” or “protein variety” or “Recommended Food* Score*” or “starch diversity” or “starch variety” or “variety in fruit*” or “variety in vegetable*” or “variety of fruit*” or “variety of vegetable*” or “vegetable diversity” or “vegetable variety”).ti,ab,kf.</p> <p>Limit 1 to “humans only (removes records about animals)”</p>
Medline (Ovid)	<p>(“balanced diet*” or “dairy diversity” or “dairy variety” or “diet diversity” or “diet variety” or “dietary diversity” or “dietary variety” or “diversified diet*” or “food diversity” or “food group diversity” or “food group variet*” or “food variety” or “fruit diversity” or “fruit variety” or “grain diversity” or “grain variety” or “meat diversity” or “meat variety” or “mixed diet*” or “protein diversity” or “protein variety” or “Recommended Food* Score*” or</p>

Database	Search Syntax
	<p>“starch diversity” or “starch variety” or “variety in fruit*” or “variety in vegetable*” or “variety of fruit*” or “variety of vegetable*” or “vegetable diversity” or “vegetable variety”).ti,ab,kf. Limit 1 to “humans only (removes records about animals)”</p>
ProQuest Dissertations & Theses Global	<p>TI (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”) AB (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”) 1 or 2</p>
Scopus	<p>TITLE-ABS-KEY (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”) AND SUBJAREA (medi OR nurs OR heal OR mult)</p>

Study records

Data management

The systematic and scoping review software, Covidence with data extraction 2.0, will be used to organize, review and extract data from the database results. The included articles will be exported to EndNote v20 for reference management to manage citations.

Selection process

Covidence will automatically identify and remove duplicate results. Once duplicates are removed, two reviewers will jointly screen the results in a two-stage process. First, titles or abstracts will be screened by each reviewer and eligibility marked as “yes”, “no”, or “maybe” according to the inclusion criteria. All ‘yes’ and ‘maybe’ titles will be retrieved for full-text screening for eligibility (20). All articles not eligible for inclusion will have the reason for exclusion noted and reported in a PRISMA flow diagram. A third reviewer will screen a random sample of 10% of the screened records and all excluded articles (21). This approach to partial double screening is to increase the reliability of the screening process while balancing the capacity and time required to conduct a second screening and resolve related discrepancies. Any discrepancy in eligibility for inclusion will be resolved by discussion among the three reviewers and any lack of consensus resolved by the senior author.

Data extraction process

Two reviewers will jointly extract data using Covidence. In alignment with PRISMA recommendations to implement strategies to reduce data extraction error (22), the two reviewers will pilot the data extraction process with twenty-five studies. In addition, Covidence will allow the research team to compare data extraction and inform the team of

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3 any discrepancies. Data extraction will include bibliographic details (author, publication year,
4 title) and details on how DD is operationalized. The information collected on DD measures is
5 adapted from Trijsburg and colleagues' (2019) extraction method and will include: the dietary
6 instrument (e.g. 7-day food record, FFQ, 24-hr recall, etc.); theoretical basis; country and
7 target population; food components; DD scoring system (timeframe, unit); and other notes
8 such as whether the measure has been validated (23).

17 **Outcomes**

18 There is no primary outcome of interest as this is a scoping review of the operationalisation
19 of DD. Intervention studies will be included insofar as they measure DD either as an outcome
20 or as an exposure.

26 **Data synthesis**

27 The scoping review process will be presented in PRISMA's four-phase flow diagram (15) and
28 the reported findings will be synthesized through a narrative approach. All interpretations of
29 the data will be discussed among the reviewers and any disagreements will be resolved by
30 the senior author. The narrative data synthesis will be described in the main text and
31 presented in tables. As a scoping review, no critical appraisal of the quality of evidence or
32 methods used in the included studies will be completed (20). Nevertheless, the research team
33 will evaluate the methodological strengths and limitations of the reported DD/FV measures
34 with a view to understanding the main measurement issues to address comparability and
35 standardisation across nutrition and food studies.

50 **Ethics and dissemination**

51 An ethics review will not be conducted as this study will not involve primary data collection.
52 This scoping review is anticipated to be disseminated as a peer-reviewed publication and
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3 scientific conference presentations. If amendments to this published protocol are required,
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5 the date of the modification, description, and rationale will be reported in the final scoping
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7 review publication. All data will be available in the final publication.
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10 **DISCUSSION**

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12 This scoping review is expected to generate a comprehensive inventory of DD measures and
13
14 summary of research approaches to the measurement of DD as a diet quality indicator in
15
16 developed settings. The few existing reviews related to DD operationalization are limited to a
17
18 narrow subset of DD (e.g., fruit and vegetable variety) (24). Moreover, much of current
19
20 literature has a focus on developing economies where DD is used to assess caloric sufficiency
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22 of the diet (7). Previous reviews are also too broad in scope to offer a detailed understanding
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24 of DD measures available (11). Understanding the various interpretations and measures
25
26 previously used may assist with future studies by aligning their measures to enhance
27
28 comparability and provide stronger evidence and clarity on the impact of DD on health. It may
29
30 also lay the groundwork for creating a standardized measure of DD which may encourage
31
32 tangible, specific recommendations beyond “eat a variety of food”. This scoping review will
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34 therefore expand awareness of the various interpretations and measures of DD by following
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36 the rigorous review process outlined in this protocol.
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5
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9 manuscript. A.C. and H.M. provided critical input into the manuscript and methods and read
10 and approved the final manuscript.
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REFERENCES

1. Mozaffari H, Hosseini Z, Lafrenière J, Conklin AI. Is eating a mixed diet better for health and survival?: A systematic review and meta-analysis of longitudinal observational studies. *Crit Rev Food Sci Nutr*. 2021 May 27;0(0):1–17.
2. NHS. The Eatwell Guide [Internet]. nhs.uk. 2022 [cited 2022 Nov 18]. Available from: <https://www.nhs.uk/live-well/eat-well/food-guidelines-and-food-labels/the-eatwell-guide/>
3. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. 9th Edition. [Internet]. 2020. Available from: https://www.dietaryguidelines.gov/sites/default/files/2021-03/Dietary_Guidelines_for_Americans-2020-2025.pdf
4. Australian Government. Eat for Health: Australian Dietary Guidelines [Internet]. 2021 [cited 2022 Nov 18]. Available from: <https://www.eatforhealth.gov.au/guidelines>
5. Chinese Center for Disease Control and Prevention. Revision and explanation of Chinese Food Guide Pagoda and Plate (2022) [Internet]. [cited 2023 Jan 17]. Available from: https://en.chinacdc.cn/health_topics/nutrition_health/202206/t20220622_259773.htm
6. de Oliveira Otto MC, Anderson CAM, Dearborn JL, Ferranti EP, Mozaffarian D, Rao G, et al. Dietary Diversity: Implications for Obesity Prevention in Adult Populations: A Science Advisory From the American Heart Association. *Circulation*. 2018 Sep 11;138(11):e160–8.
7. Ruel MT. Operationalizing dietary diversity: a review of measurement issues and research priorities. *J Nutr*. 2003 Nov;133(11 Suppl 2):3911S–3926S.
8. Garriguet D. Diet quality in Canada. *Health Reports*. 2009 Aug;20(3):41–52.
9. Lv Y, Kraus VB, Gao X, Yin Z, Zhou J, Mao C, et al. Higher dietary diversity scores and protein-rich food consumption were associated with lower risk of all-cause mortality in the oldest old. *Clin Nutr*. 2020 Jul 1;39(7):2246–54.
10. Mozaffari H, Hosseini Z, Lafrenière J, Conklin AI. The role of dietary diversity in preventing metabolic-related outcomes: Findings from a systematic review. *Obes Rev*. 2021;22(6):e13174.
11. Verger EO, Le Port A, Borderon A, Bourbon G, Moursi M, Savy M, et al. Dietary Diversity Indicators and Their Associations with Dietary Adequacy and Health Outcomes: A Systematic Scoping Review. *Adv Nutr*. 2021 Oct 1;12(5):1659–72.
12. Zhou J, Wang H, Zou Z. Inverse Association between Dietary Diversity Score Calculated

- 1
2
3 from the Diet Quality Questionnaire and Psychological Stress in Chinese Adults: A
4 Prospective Study from China Health and Nutrition Survey. *Nutrients*. 2022 Aug
5 12;14(16):3297.
6
7
8 13. Marshall AN, van den Berg A, Ranjit N, Hoelscher DM. A Scoping Review of the
9 Operationalization of Fruit and Vegetable Variety. *Nutrients*. 2020 Sep;12(9):2868.
10
11 14. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for
12 conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015 Sep;13(3):141–6.
13
14 15. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred
15 reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015
16 statement. *Syst Rev*. 2015 Jan 1;4(1):1.
17
18 16. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review
19 or scoping review? Guidance for authors when choosing between a systematic or
20 scoping review approach. *BMC Med Res Methodol*. 2018 Nov 19;18:143.
21
22 17. World Bank Group. Data for High income, OECD members | Data [Internet]. World Bank
23 Group. [cited 2022 Nov 18]. Available from: [https://data.worldbank.org/?locations=XD-](https://data.worldbank.org/?locations=XD-OE)
24 [OE](https://data.worldbank.org/?locations=XD-OE)
25
26 18. Wolters Kluwer Health. Special Ovid Filters for MEDLINE [Internet]. [cited 2022 Nov 13].
27 Available from: <https://ospguides.ovid.com/OSPguides/medline.htm#limits>
28
29 19. Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf M, et al.
30 Searching for and selecting studies. In: Higgins JPT, Thomas J, Chandler J, Cumpston M,
31 Li T, Page MJ, et al., editors. *Cochrane Handbook for Systematic Reviews of*
32 *Interventions* [Internet]. 1st ed. Wiley; 2019 [cited 2022 Nov 15]. p. 67–107. Available
33 from: <https://onlinelibrary.wiley.com/doi/10.1002/9781119536604.ch4>
34
35 20. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc*
36 *Res Methodol*. 2005 Feb 1;8(1):19–32.
37
38 21. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020
39 explanation and elaboration: updated guidance and exemplars for reporting systematic
40 reviews. *BMJ*. 2021 Mar 29;372:n160.
41
42 22. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred
43 reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015:
44 elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647–g7647.
45
46 23. Trijsburg L, Talsma EF, de Vries JHM, Kennedy G, Kuijsten A, Brouwer ID. Diet quality
47 indices for research in low- and middle-income countries: a systematic review. *Nutr Rev*.
48 2019 Aug 1;77(8):515–40.
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60

- 1
2
3 24. Marshall AN, Ranjit N, van den Berg A, Gill M, Hoelscher DM. Associations between
4 variety of fruits and vegetables consumed, diet quality, and sociodemographic factors
5 among 8th and 11th grade adolescents in Texas. Public Health Nutr. 2022 Aug;1:1–25.
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BMJ Open

How is food variety conceptualized and measured as a diet quality indicator in developed settings?: protocol for a systematic scoping review

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Manuscripts

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4 **How is food variety conceptualized and measured as a diet quality indicator in**
5 **developed settings?: protocol for a systematic scoping review**
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35 **Keywords:** Dietary diversity, Food variety, Diet quality, Measurement, Scoping Review
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38 Word count: 3362
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ABSTRACT

Objectives: Dietary diversity (DD) is a pillar of healthy eating guidance and can be used to assess diet quality. Despite being an established nutrition concept, many inconsistencies in its definition and measurement exist and meanings vary across the development spectrum. This protocol outlines a research trajectory whereby a scoping review will be undertaken to illustrate and map the methodological approaches that have been utilized to measure diversity as a marker of diet quality in the general population. It seeks to determine the most common and less used methodological approaches to measure DD in the diet of healthy adults.

Methods and analysis: Scoping review of peer-reviewed and gray literature from five bibliographic databases, supplemented by handsearching of reviews and reference lists. Search terms will include dietary diversity, food variety, mixed diet, balanced diet, and food group variety. Eligible articles must include a measure for DD as an indicator of diet quality in the general population living in developed settings. Two independent reviewers will screen titles or abstracts, and read full-texts. Consensus will resolve any disagreements on study eligibility with a third reviewer consulted if needed. Data will be extracted using a standardized evidence table and analysed using a narrative synthesis approach. Data will be managed using Covidence.

Ethics and dissemination: No ethics is required for this study using public documents. Results will be disseminated through peer-reviewed papers and scientific conferences.

Discussion: This scoping review will help to map, classify and assess the methodological approaches used in the nutrition literature to measure DD as a diet quality indicator. We anticipate a wide range of DD measures and expect to identify the most prevalent DD measures used to assess diet quality. Our findings will inform standardisation to improve future research on this nutritional concept.

Strengths and limitations of this study

- This scoping review will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension (PRISMA-ScR) methodology.
- Both peer-reviewed and grey literature will be searched using 5 databases and hand-referencing.
- A systematic approach will be used to enhance transparency and reproducibility.
- Full-text articles must be available in the research team's fluencies (English, French, Farsi, and Chinese).

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INTRODUCTION

It is well-known that a healthy diet is one that involves eating a variety of foods, which incorporates a longstanding nutritional concept of dietary diversity (DD) which is also referred to food variety (FV). Numerous countries have some form of recommendation to eat a variety in their dietary guidelines, including Australia, Canada, China, the United Kingdom, and the United States. DD has been a pillar of healthy eating guidance since the 1970s, and it serves as a conceptual benchmark for nutrient adequacy and diet quality (1–3). From a nutrition standpoint, it is thought that individuals should strive to maximize their DD to meet their nutrient needs and optimize their health (1,2). While DD may be a seemingly simple recommendation for health eating, guidelines typically lack any tangible advice to accompany this nutritional message which results in vastly different interpretations of variety (1,2). For example, Australia’s guideline shows a plate with five food groups and recommends people “enjoy a wide variety of nutritious foods from these core food groups every day” and also specifies that eating plenty of vegetables “includes different types of colours” (4). Thus, it remains unclear what is meant by DD, and how can this concept be operationalised to accurately measure whether a diet is diverse or not. That is, is DD a concern of having multiple food groups in the diet, or having different foods from within a single food group or both?

Variety, adequacy, moderation, and balance are all related and critical components of diet quality (5). Diet adequacy tends to refer to sufficient food and nutrient intake; moderation suggests non-excessive consumption of food and nutrients; and balance implies even distribution of intake (5). While the primary focus of this scoping review is on DD as a diet quality indicator, the interrelated nature of these factors means that the other three may

1
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3 be embedded into DD measures. Food variety refers to the degree to which an individual
4 consumes heterogenous foods across and within all food groups (1,2). This heterogeneity has
5 been captured through various approaches which will be investigated with a view to
6 standardisation and comparability in our paper. For example, some researchers measure DD
7 by counting the number of unique foods or food groups consumed in a week (1). Other studies
8 operationalize DD by measuring the relative distribution of calories consumed for each food
9 (1). The third type of DD measures estimates the degree of food item similarity based on
10 characteristics or nutritional value (1).
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23 To our knowledge, no comprehensive, published review has detailed the various
24 interpretations and measures of DD in the general population of developed countries.
25 Without a standard measurement or summary of the varying conceptualizations, there
26 remain significant limitations in the ability to compare findings across studies. As there
27 continues to be interest and active research in DD and health outcomes (6–9), it is important
28 to clarify and potentially standardize the measures of DD. A previous scoping review sought
29 to consolidate DD indicators and summarize the evidence linking these indicators to health
30 outcomes in adults and adolescents (8). Although that review offers some insight into DD
31 measures, its primary purpose was to review the link between DD and health, and therefore
32 does not offer a detailed summary or analysis of the various measures to improve
33 standardisation and cross-national comparisons. Moreover, the limitations of that review
34 include: a search limited to English, no grey literature, few databases and publications up to
35 July 2018.
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54 Another scoping review by Marshall and colleagues (2020) included just over 400
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3 articles to reveal how fruit and vegetable variety has been operationalized (10). Looking only
4
5 at the variety of fruits and vegetables, the researchers found that nearly all 51 included
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7 studies had different definitions of variety which makes it difficult to compare findings (10).
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10 Given the growing interest in DD in recent years, an updated and more comprehensive
11
12 scoping review on the measurement of DD beyond the variety of only fruits and vegetables is
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14 warranted. The scoping review process outlined in this protocol aims to fill this gap by
15
16 systematically identifying the literature operationalizing DD to summarise, and critically
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18 compare the measurement of this longstanding dietary construct. Of particular interest is
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20 how dietary diversity is operationalized by considering food intake from across as well as
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22 within food groups.
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28 An older 2003 review describes key interpretations and operationalization of DD, but
29
30 focuses primarily on developing countries where DD is used as a nutritional tool to address
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32 food penury rather than an indicator of diet quality (2). While DD is an important dietary goal
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34 across the development spectrum, the concept has different meanings and objectives in
35
36 different contexts. In developing settings, where inadequate caloric intake or starvation is
37
38 more prevalent, DD is commonly a measure of food security or minimal nutrient adequacy
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40 (2,7). This is due to the fact that starchy foods (e.g., rice or cassava) are a major source of
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42 calories and carbohydrates in less-resourced nations, whereas other nutrient-dense foods like
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44 meats, fruits, and vegetables are harder to obtain and contribute less to the diet (2). It is
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46 consequently more common to see DD measured in the global south by the accessibility of
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48 the different foods in one's community, and thus DD is a reflection of environmental
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50 availability and not quality of a diet (10). To fill a clear knowledge gap on DD, this scoping
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3 review will determine how DD has been conceptualised, operationalised and measured. This
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5 will improve our understanding of the most common and less frequently used methodological
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7 approaches to measure DD (or FV) in the diet of the general population to determine diet
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9 quality in a developed setting. This scoping review will also determine whether DD scores are
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11 validated and against what markers. Most importantly, it will identify what main
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13 measurement issues require consideration to improve research on this longstanding
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15 nutritional concept.
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20 **METHODS AND ANALYSIS**

21 **Study objectives**

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23 This scoping review will consolidate the various methods researchers have measured DD as
24
25 an indicator of diet quality in developed settings. The review has three objectives: review aims
26
27 to understand the following: 1) how DD is conceptualized, operationalized, and measured; 2)
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29 whether DD is validated and against what markers; and 3) what main measurement issues
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31 require consideration to improve research on this nutritional concept.
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36 **Study design**

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38 This protocol is informed by a methodological paper for conducting a scoping review (11) and
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40 the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols 2015
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42 checklist (PRISMA-P) adapted for the scoping review process (12). The presentation of final
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44 results will be guided by PRISMA's extension for Scoping Reviews 2018 checklist (PRISMA-
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46 ScR). A scoping review was selected over a systematic review as the goal of the study is to
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48 examine how research is conducted on a certain topic, that is, measuring DD (13). However,
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50 the literature review will be conducted using a systematic, structured approach outlined in
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52 this protocol for transparency and reproducibility purposes (13).
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3 **Patient and public involvement:** There were no patients or public involved in the design of
4 this review protocol.
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6 **Eligibility criteria**

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8 To be eligible for this systematic scoping review, the articles must include a quantitative
9 measure of DD as an indicator of diet quality, either within certain food groups or across food
10 groups. Grey literature such as technical reports, government documents, working papers,
11 evaluations and theses, will also be eligible for inclusion. Inclusion criteria will be limited to
12 literature involving human participants and including a measure for DD as either an outcome
13 or exposure. Studies that use other terminology for DD, such as food variety (FV), are still
14 eligible for inclusion. Any measures of diet quality that do not explicitly mention DD or alike
15 terms, but intend to measure DD (i.e., measure consumption frequency from different food
16 groups or sub-groups) will be considered (e.g., Recommended Food Score). Diet quality and
17 health indices (e.g., the USDA Healthy Eating Index) that include DD as a component of multi-
18 variable measures will also be considered. Thus, this search is focused on the
19 operationalization of DD of individual and households living in developed settings, defined as
20 OECD countries or World Bank upper-income countries (7,14).
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40 The search will exclude papers if the operationalization of DD is focused exclusively on
41 food quantity or nutrient adequacy, which is common in many developing settings (2). Articles
42 focusing exclusively on the introduction of foods or increasing quantity of food intake in the
43 pediatric population will also be excluded. Documents reflecting subjective, opinion-based
44 information such as in editorials, commentaries, or blogs will be excluded. No language limits
45 will be used as the databases used often translate titles and abstracts into English. However,
46 final full-texts will be read in English, French, Persian/Farsi, and Chinese as the languages of
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the research team.

Information sources

The systematic search of relevant literature is anticipated to take place between November 2022 and mid-January 2023. Five bibliographic databases will be used to find articles: CINAHL (EBSCOhost), Embase (Ovid), MEDLINE (Ovid), Scopus, and ProQuest Dissertations and Theses Global. These databases were selected as reputable sources of medical and health science literature and ProQuest offers a comprehensive inventory of graduate research globally. Citation chaining forward and backward will be completed by reviewing the reference lists of any review articles and all included full-text articles to capture possibly missed publications. We will search for gray literature using websites of food-related governmental and non-governmental organizations and professional societies (see Table 1).

Table 1. List of food organizations and websites in developed nations as information sources for gray literature

Organization	Website
American Society for Nutrition (ASN)	https://nutrition.org
Canadian Nutrition Society (CNS)	https://cns-scn.ca
European Public Health Association Food and Nutrition section (EUPHA)	https://eupha.org/food-and-nutrition
Food Banks Canada	https://foodbanksCanada.ca
Food Foundation in UK	https://foodfoundation.org.uk
The Nutrition Society (UK based)	https://www.nutritionSociety.org
UN Food and Agricultural Organisation (FAO)	https://www.fao.org/home/en
USDA Supplemental Nutrition Assistance Program	https://www.fns.usda.gov/snap/supplemental-nutrition-assistance-program
World Food Programme WFP	https://www.wfp.org/
European Food Banks Federation – FEBA	https://www.eurofoodbank.org
The Emergency Food Assistance Program (TEFAP)	https://www.feedingamerica.org/take-action/advocate/the-emergency-food-assistance-program
The Commodity Supplemental Food Program (CSFP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-programs/csfp

The Child and Adult Care Food Program (CACFP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-programs/child-and-adult-care-food-program
The National School Lunch Program (NSLP)	https://www.feedingamerica.org/take-action/advocate/federal-hunger-relief-programs/national-school-lunch-program
The School Breakfast Program (SBP)	https://www.feedingamerica.org/need-help-find-food/school-breakfast
The Summer Food Service Program (SFSP)	https://www.feedingamerica.org/our-work/hunger-relief-programs/summer-food-service-program
Women, Infants, and Children (WIC)	https://www.feedingamerica.org/need-help-find-food/wic

Search strategy

Since DD is an emerging research topic, standardized terminology has not been well-established. To ensure a robust search strategy was adopted, we generated a list of common phrases used to reflect DD (e.g., diet variety) and combined the concept of variety with major food groups such as fruits, meat, and dairy. The search term ‘Recommended Food Score’ was also included in the strategy as it is a DD measure known to the research team that is missed when only searching for DD-related terminology. The search terms to be used include: ‘dietary diversity’, ‘diet diversity’, ‘food variety’, ‘fruit variety’, ‘vegetable variety’, ‘meat variety’, ‘dairy variety’, and ‘recommended food score’. Table 2 provides the full electronic search strategy including final search syntaxes and limits used in each database. This search strategy is the product of many test searches on each database to ensure focused yet comprehensive results. Notably, no MeSH terms (medical subject headings) will be integrated into the strategy as relevant terms were not available, or were too broad (e.g., Diet) to provide relevant results.

Ovid best practices will be followed For Medline and Embase; that is, the “Humans

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3 only (removes records about animals)” special Ovid filters will be used rather than the
4
5 standard “Humans only” filter to avoid unintentional exclusion of non-indexed articles (15).
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8 This filter will assist with removing articles that are focused on only animals, plants, or fungi.
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11 A similar filter will be used for CINHAL (Embase) by adapting a strategy outlined in a Cochrane
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13 Handbook for systematic reviews (16). The remaining databases do not offer a human filter,
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15 so studies will be manually screened for human participants according to the search criteria.
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18 A reference librarian with subject expertise in human nutrition will also be consulted to review
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20 and pilot the search strategies and techniques. Simple searches of gray literature will be
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23 conducted on relevant websites using ‘food variety’ or ‘diet diversity’.
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Table 2. Search strategy for each bibliographic database

Database	Search Syntax
CINHAL (EBSCOhost)	<p>1) TI (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>2) AB (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>3) 1 OR 2</p> <p>4) MH (animals+) OR MH (animal studies) OR TI (animal model*)</p> <p>5) MH (human)</p> <p>6) 4 NOT 5</p> <p>7) 3 NOT 6</p>
EMBASE (Ovid)	<p>1) (“balanced diet*” or “dairy diversity” or “dairy variety” or “diet diversity” or “diet variety” or “dietary diversity” or “dietary variety” or “diversified diet*” or “food diversity” or “food group diversity” or “food group variet*” or “food variety” or “fruit diversity” or “fruit variety” or “grain diversity” or “grain variety” or “meat diversity” or “meat variety” or “mixed diet*” or “protein diversity” or “protein variety” or “Recommended Food* Score*” or “starch diversity” or “starch variety” or “variety in fruit*” or “variety in vegetable*” or “variety of fruit*” or “variety of vegetable*” or “vegetable diversity” or “vegetable variety”).ti,ab,kf.</p> <p>2) Limit 1 to “humans only (removes records about animals)”</p>
Medline (Ovid)	<p>1) (“balanced diet*” or “dairy diversity” or “dairy variety” or “diet diversity” or “diet variety” or “dietary diversity” or “dietary variety” or “diversified diet*” or “food diversity” or “food group diversity” or “food group variet*” or “food variety” or “fruit diversity” or “fruit variety” or “grain diversity” or “grain variety” or “meat diversity” or “meat variety” or “mixed diet*” or “protein diversity” or “protein variety” or “Recommended Food* Score*” or</p>

Database	Search Syntax
	<p>“starch diversity” or “starch variety” or “variety in fruit*” or “variety in vegetable*” or “variety of fruit*” or “variety of vegetable*” or “vegetable diversity” or “vegetable variety”).ti,ab,kf.</p> <p>2) Limit 1 to “humans only (removes records about animals)”</p>
<p>ProQuest Dissertations & Theses Global</p>	<p>1) TI (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>2) AB (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>3) 1 or 2</p>
<p>Scopus</p>	<p>1) TITLE-ABS-KEY (“balanced diet*” OR “dairy diversity” OR “dairy variety” OR “diet diversity” OR “diet variety” OR “dietary diversity” OR “dietary variety” OR “diversified diet*” OR “food diversity” OR “food group diversity” OR “food group variet*” OR “food variety” OR “fruit diversity” OR “fruit variety” OR “grain diversity” OR “grain variety” OR “meat diversity” OR “meat variety” OR “mixed diet*” OR “protein diversity” OR “protein variety” OR “Recommended Food* Score*” OR “starch diversity” OR “starch variety” OR “variety in fruit*” OR “variety in vegetable*” OR “variety of fruit*” OR “variety of vegetable*” OR “vegetable diversity” OR “vegetable variety”)</p> <p>AND SUBJAREA (medi OR nurs OR heal OR mult)</p>

Study records

Data management

The systematic and scoping review software, Covidence with data extraction 2.0, will be used to organize, review and extract data from the database results. The included articles will be exported to EndNote v20 for reference management to manage citations.

Selection process

Covidence will automatically identify and remove duplicate results. Once duplicates are removed, two reviewers will jointly screen the results in a two-stage process. First, titles or abstracts will be screened by each reviewer and eligibility marked as “yes”, “no”, or “maybe” according to the inclusion criteria. All ‘yes’ and ‘maybe’ titles will be retrieved for full-text screening for eligibility (17). All articles not eligible for inclusion will have the reason for exclusion noted and reported in a PRISMA flow diagram. A third reviewer will screen a random sample of 10% of the screened records and all excluded articles (18). This approach to partial double screening is to increase the reliability of the screening process while balancing the capacity and time required to conduct a second screening and resolve related discrepancies. Any discrepancy in inclusion eligibility will be resolved through a clear process. Initially, the three reviewers will independently evaluate the studies and record their findings separately, including adding notes to the record. The group will hold regular meetings to resolve disagreements or discrepancies during the process. When conflicts remain unresolved, the senior author, an epidemiology expert with extensive experience, will serve as an arbitrator and will have final decision if consensus is not reached. All decisions made to resolve discrepancies will be thoroughly recorded, including the rationale behind each determination.

Data extraction process

Two reviewers will jointly extract data using Covidence. In alignment with PRISMA recommendations to implement strategies to reduce data extraction error (19), the two reviewers will pilot the data extraction process with twenty-five studies. In addition, Covidence will allow the research team to compare data extraction and inform the team of any discrepancies. Data extraction will include the following elements: (a) Source and publication year of studies; (b) Location and population; (c) Dietary diversity assessment tool; (d) Definition of dietary diversity; (e) Scoring system (count, proportion, etc.); (f) Food compositions of diversity scores; (g) Threshold for counting foods toward diversity score; (h) Timeframe; (i) Validation status of the measure. The information collected on DD measures is adapted from Trijsburg and colleagues' (2019) extraction method and will include: the dietary instrument (e.g. 7-day food record, FFQ, 24-hr recall, etc.); theoretical basis; country and target population; food components; DD scoring system (timeframe, unit); and other notes such as whether the measure has been validated (20).

Outcomes

There is no primary outcome of interest as this is a scoping review of the operationalisation of DD. Intervention studies will be included insofar as they measure DD either as an outcome or as an exposure.

Data synthesis

The scoping review process will be presented in PRISMA's four-phase flow diagram (12) and the included research will be synthesized through summary statistics and graphical display as we anticipate a large volume of relevant results. We will calculate the proportion of publications across time (year) and location (country); we will calculate the mean timeframe

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2
3 for each type of DD score. We will use a histogram to display the prevalence of different
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5 consumption cut-points used for each type of DD score. We will calculate and display the
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7 mean number of studies using each type of DD score, and we will classify and group scores
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9 based on their definition and scoring method. We will construct a heatmap to display what
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11 proportion of food item is used in each type of DD score. We will use a pie chart to show the
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13 proportion of DD scores that have been validated. All interpretations of the data will be
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15 discussed among the reviewers and any disagreements will be resolved by the senior author.
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18 As a scoping review, no critical appraisal of the quality of evidence or methods used in the
19
20 included studies will be completed (17). Nevertheless, the research team will evaluate the
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22 methodological strengths and limitations of the reported DD/FV measures with a view to
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24 understanding the main measurement issues to address comparability and standardisation
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26 across nutrition and food studies.
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32 **ETHICS AND DISSEMINATION**

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34 An ethics review will not be conducted as this study will not involve primary data collection.
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36 Findings from this scoping review are expected to be disseminated as scientific conference
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38 presentations and a peer-reviewed publication. If amendments to this published protocol are
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40 required, the date of the modification, description, and rationale will be reported in the final
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42 scoping review publication. All data will be available in the final publication.
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46 **DISCUSSION**

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48 This scoping review is expected to generate a comprehensive inventory of DD measures and
49
50 summary of research approaches to the measurement of DD as a diet quality indicator in
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52 developed settings. To date, little attention has been given to the actual composition of DD
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54 scores, or to the numerous methodological choices involved in constructing DD scores.
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3 However, these issues are crucial for assessing the usefulness and validity of a specific index
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5 as a tool for dietary assessment. It will include a broader range of scores, thus adding to
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7 previous literature on DD operationalization that tends to focus only on variety of specific
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9 food groups (e.g., fruits and vegetables) (10). And, while other scoping reviews include DD
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11 scores for the whole diet, their objective is to scope the evidence on the health effects of DD
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13 scores (8), rather than showcase score characteristics and measurement concerns.
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18 Another strength of this scoping review study is the clear criteria for searching the
19
20 literature on DD scores as a measure of diet quality (i.e. nutrient-dense diets) rather than as
21
22 a measure of energy adequacy. Much of the current literature has a focus on DD as a
23
24 nutritional tool for public health surveillance of child undernutrition and the risk of caloric
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26 insufficiency of the diet from food penury (21) and thus predominantly comes from research
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28 in developing settings (7). Knowing the range of interpretations and measures of DD as an
29
30 indicator of diet quality and healthy eating in the literature can help to identify knowledge
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32 gaps and common approaches for better comparability of future studies of diet quality and
33
34 health. A standardized measure of DD is needed to provide tangible, specific
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36 recommendations beyond “eat a variety of food”. This scoping review will therefore expand
37
38 awareness of the various interpretations and measures of DD by following the rigorous review
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40 process outlined in this protocol.
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47 This scoping review is designed to answer three broad questions about DD as a diet
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49 quality indicator: (a) What is the extent, range and nature of existing DD research? (b) What
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51 are the areas where significant progress in measurement has been made? and (c) What are
52
53 the potential gaps and limitations of current approaches? This review will provide an
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3 inventory of key characteristics of DD scores to map common approaches and assess the
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5 potential for standardisation to improve research and future evidence for this nutritional
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7 concept as a marker of diet quality and healthy eating. Our research question is framed to
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9 capture literature from developed countries because in this context food is more abundant,
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11 and dietary diversity correlates more closely with nutrient density of the diet (7). The focus of
12
13 this scoping review is purposeful to ensure that the context and population under study in
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15 the relevant literature aligns with how DD is defined for the purpose of identifying a high-
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17 quality diet.
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23 Another strength of this research is the search of multiple bibliometric databases of
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25 peer-reviewed and gray literature, using broad keywords and specific names (e.g.,
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27 Recommended Food Score) that have been overlooked in previous reviews (1,2,8,10).
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29 Screening and data extraction will be conducted by at least two independent reviewers to
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31 minimize bias and enhance accuracy. Comprehensive data extraction will also help to better
32
33 identify emerging themes, concepts, or patterns within the included studies. Finally, the
34
35 scoping review will be conducted using Covidence, a web-based software platform that keeps
36
37 a detailed audit trail of decisions made during screening and data extraction so that others
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39 can follow and verify the process. This transparency enhances the scoping review's credibility
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41 and facilitates future updates or revisions.
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47 Finally, it is important to acknowledge certain limitations in our scoping review. First,
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49 language restrictions were imposed to reflect literacy of the research team and thus some
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51 literature may be missed, although major languages are covered (i.e., English, French,
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53 Persian/Farsi, and Chinese). Second, the breadth of the topic may result in a large volume of
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3 literature that may require quantification that can lose nuance and detailed information.
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6 Moreover, the broad scope of the DD literature may results in a wide range of publications
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8 with varying levels of detail that could limit data quality and rigor of this review which does
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10 not include a quality appraisal of the literature. Third, this review will be limited to the
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12 publication bias that may exist for DD scores that are over-represented because they showed
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14 significant effects on health outcomes.
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or peer review only

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4 University of British Columbia for her guidance on the scoping review process.
5
6

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10
11
12

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For peer review only

REFERENCES

1. de Oliveira Otto MC, Anderson CAM, Dearborn JL, Ferranti EP, Mozaffarian D, Rao G, et al. Dietary Diversity: Implications for Obesity Prevention in Adult Populations: A Science Advisory From the American Heart Association. *Circulation*. 2018 Sep 11;138(11):e160–8.
2. Ruel MT. Operationalizing dietary diversity: a review of measurement issues and research priorities. *J Nutr*. 2003 Nov;133(11 Suppl 2):3911S-3926S.
3. Mozaffari H, Hosseini Z, Lafrenière J, Conklin AI. Is eating a mixed diet better for health and survival?: A systematic review and meta-analysis of longitudinal observational studies. *Crit Rev Food Sci Nutr*. 2021 May 27;0(0):1–17.
4. Australian Government. Eat for Health: Australian Dietary Guidelines [Internet]. 2021 [cited 2022 Nov 18]. Available from: <https://www.eatforhealth.gov.au/guidelines>
5. Garriguet D. Diet quality in Canada. *Health Reports*. 2009 Aug;20(3):41–52.
6. Lv Y, Kraus VB, Gao X, Yin Z, Zhou J, Mao C, et al. Higher dietary diversity scores and protein-rich food consumption were associated with lower risk of all-cause mortality in the oldest old. *Clin Nutr*. 2020 Jul 1;39(7):2246–54.
7. Mozaffari H, Hosseini Z, Lafrenière J, Conklin AI. The role of dietary diversity in preventing metabolic-related outcomes: Findings from a systematic review. *Obes Rev*. 2021;22(6):e13174.
8. Verger EO, Le Port A, Borderon A, Bourbon G, Moursi M, Savy M, et al. Dietary Diversity Indicators and Their Associations with Dietary Adequacy and Health Outcomes: A Systematic Scoping Review. *Adv Nutr*. 2021 Oct 1;12(5):1659–72.
9. Zhou J, Wang H, Zou Z. Inverse Association between Dietary Diversity Score Calculated from the Diet Quality Questionnaire and Psychological Stress in Chinese Adults: A Prospective Study from China Health and Nutrition Survey. *Nutrients*. 2022 Aug 12;14(16):3297.
10. Marshall AN, van den Berg A, Ranjit N, Hoelscher DM. A Scoping Review of the Operationalization of Fruit and Vegetable Variety. *Nutrients*. 2020 Sep;12(9):2868.
11. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015 Sep;13(3):141–6.
12. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015 Jan 1;4(1):1.

13. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018 Nov 19;18:143.
14. World Bank Group. Data for High income, OECD members | Data [Internet]. World Bank Group. [cited 2022 Nov 18]. Available from: <https://data.worldbank.org/?locations=XD-OE>
15. Wolters Kluwer Health. Special Ovid Filters for MEDLINE [Internet]. 2023 [cited 2022 Nov 13]. Available from: <https://ospguides.ovid.com/OSPguides/medline.htm#limits>
16. Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf M, et al. Searching for and selecting studies. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors. *Cochrane Handbook for Systematic Reviews of Interventions* [Internet]. 1st ed. Wiley; 2019 [cited 2022 Nov 15]. p. 67–107. Available from: <https://onlinelibrary.wiley.com/doi/10.1002/9781119536604.ch4>
17. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005 Feb 1;8(1):19–32.
18. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ*. 2021 Mar 29;372:n160.
19. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015 Jan 2;349(jan02 1):g7647–g7647.
20. Trijsburg L, Talsma EF, de Vries JHM, Kennedy G, Kuijsten A, Brouwer ID. Diet quality indices for research in low- and middle-income countries: a systematic review. *Nutr Rev*. 2019 Aug 1;77(8):515–40.
21. Molani-Gol R, Kheirouri S, Alizadeh M. Does the high dietary diversity score predict dietary micronutrients adequacy in children under 5 years old? A systematic review. *J Health Popul Nutr*. 2023 Jan 6;42(1):2.