Food System Economics Commission

WORKING PAPER

Diet-focused Behavioral Interventions to Reduce the Risk of Non-Communicable Diseases in Low- and Middle-income Countries: A Scoping Review of the Existing Evidence.

Rachel Nugent
Harsha Thirumurthy
Averi Chakrabarti
Nathan Ellermeier
Arpita Tripathi

ACKNOWLEDGEMENT

This work has been supported by the Food System Economics Commission, funded by an award to the World Resources Institute (WRI) from the Norwegian Climate and Forest Initiative (NICFI), subgrant agreement no. 0581-2021.

CITATION

Nugent, R., Thirumurthy, H., Chakrabarti, A., Ellermeier, N. & Tripathi, A. (2023). Diet-focused Behavioral Interventions to Reduce the Risk of Non-Communicable Diseases in Low- and Middle-income Countries: A Scoping Review of the Existing Evidence.

DISCLAIMER

The opinions, findings, and conclusions or recommendations expressed in this material are those of the author/s and do not necessarily reflect the view of the Food System Economics Commission, including its Commissioners, Co-Chairs and Principals, the World Resources Institute (WRI) or the Norwegian Climate and Forest Initiative (NICFI). The author/s have been encouraged to submit this work to a scientific journal for which reason the materials here presented might be further developed.

CONTACT

Food System Economics Commission
contact@fsec.org

Diet-focused Behavioral Interventions to Reduce the Risk of Non-Communicable Diseases in Low- and Middle-income Countries: A Scoping Review of the Existing Evidence

Rachel Nugent[1,3], Harsha Thirumurthy[2], Averi Chakrabarti[2], Nathan Ellermeier[3], Arpita Tripathi[2]

1. University of Washington, Department of Global Health, Seattle WA
2. University of Pennsylvania, Center for Health Incentives and Behavioral Economics, Philadelphia PA
3. RTI International, Durham NC

Corresponding author: rnugent2@uw.edu

Keywords

Behavioral incentives, healthy diet, low- and middle-income countries

Author contributions

RN and HT conceived the manuscript, AC and RN prepared the first draft with contributions from NE, NE and AT conducted the initial search process, AC and NE conducted statistical analysis and prepared figures. All others have reviewed, commented on, and approved the manuscript.

Funding source

The research was conducted as background for the Food Systems Economics Commission, on which RN is a Commissioner. Financial support was provided. A background paper has been published on-line by the FSEC.

Abstract

Purpose

Non-communicable diseases (NCDs) are on the rise worldwide, with low- and middle-income countries (LMICs) bearing more than three-quarters of global deaths from NCDs. Unhealthy diet is a major risk factor for NCDs and reducing the burden of NCDs hinges crucially on improving dietary choices and intake. This scoping review compiles evidence on the effectiveness of diet-focused behavioral interventions in LMICs.

Methods

A broad set of behavioral interventions to address diet were defined with inclusion criteria. Financial interventions (such as sugar taxes) were excluded as their impacts have been studied in prior research. To ensure coverage of multiple disciplines and methodologies, five separate databases were used to identify eligible studies. The final sample comprised 52 studies. The interventions investigated were education (N=10), messaging (N=12), multi-component (N=26) and other (N=4). The most common evaluation methods were randomized controlled trials (N=31) followed by pre-post comparisons (N=13). We extracted effect sizes from the studies for three categories of outcomes: biological risk factors (such as cholesterol), nutritional intake for different food groups (e.g., fruits and vegetables) and nutritional knowledge.

Results

Studies of behavioral interventions to promote dietary change reported a broad range of outcomes. The most commonly reported outcomes were body mass index (BMI), intake of specific foods, and nutrition knowledge. Most interventions produced small effects in the expected direction. Many of the studies fell short on quality measures, with quality being affected by small sample sizes, no adjustment for multiple hypothesis testing, poorly described outcomes, and lack of objectively measured outcomes. A few LMICs were heavily represented but many LMICs were not represented at all. Overall, there was limited evidence on how to effectively promote healthier diets through behavioral interventions in LMICs. Existing studies have examined a narrow range of potential interventions and provided little evidence of end-point health effects.

Introduction

There is an increasing burden of non-communicable diseases (NCDs) worldwide driven by aging populations, growing health risks in many countries, and changes in work and personal behaviors. The annual global death toll of these diseases was 42 million in 2019, a significant increase from the 31 million NCD deaths in 2000. About 77 percent of current NCD deaths occur in low- and middle-income countries (LMICs),[1] mostly among adults under the age of 70 years. This paper reviews evidence on the effectiveness of behavioral interventions to reduce risk of NCDs through dietary changes in LMICs.

Suboptimal diets that are high in sugar, saturated fats, and sodium and low in whole grains and fruits are common across the world and are a major risk factor for many NCDs and the leading cause of cardiovascular disease globally.[2] Cardiovascular disease, obesity, diabetes, and cancer are all influenced by dietary intake. Globally, 11 million deaths stemmed from poor diets in 2017 and one in five of all deaths could be prevented by improved diet.[3] Obesity and overweight have reached epidemic levels, with global obesity prevalence tripling since 1975 such that 13 percent of adults are currently obese.[4] The economic cost of overweight and obesity in 161 countries is estimated to be USD 2.9 trillion in 2019, rising to USD 22.8 trillion by 2060 under status quo conditions.[5]

Eating behaviors are highly modifiable but are influenced by many contextual factors, including culture, psychology, social conditions, risk perception and many more aspects of daily life.[6-8] The field of behavioral science provides insights and evidence on approaches that can be used to improve diet-specific behaviors.[9,10] For example, presenting caloric information on menus can prompt the selection of relatively healthy food options.[11,12] Periodic text messages sent to individuals can equip them with the motivational tools and knowledge they need to reduce sodium consumption.[13] School-based healthy diet education can be useful for promoting healthy eating.[14-16] In this review, we explore the potential for these types of behavioral interventions – as well as others – to improve dietary intake and select health outcomes.

Much of the evidence on the efficacy of behavioral interventions to improve dietary patterns and choices comes from high-income countries (HIC).[17-19] The literature on diet-focused fiscal interventions is an exception. Many countries around the world, including LMICs, tax unhealthy foods and drinks such as sugar sweetened beverages (SSBs) with the goal of reducing consumption

patterns, and several reviews have summarized how these policies have performed in different settings.[20-24] The World Bank inaugurated a database on global SSB taxes.[25] Other national policies – such as regulations on marketing to children and requirements for package labeling – have also been implemented and evaluated in LMICs.[26]

Less is known about a wide range of other behavioral interventions that can affect dietary behaviors, such as those that modify food choice architecture (for example, the way in which meal options are presented in stores) or seek to increase adherence to healthy food habits (for example, by guiding individuals through intention setting exercises). Given the importance of contextual factors and level of development, it is not clear whether these interventions – which have shown promise in high-income countries – will be successful in LMICs. Accordingly, this review focuses on non-fiscal, micro-level behavioral interventions to promote healthy diets in LMICs. The review provides a broad overview of a growing body of literature that spans multiple disciplines and diverse locations.

Methods

We carried out a multi-step scoping review on behavioral interventions to influence dietary change in LMICs. Sucharew and Macaluso describe a scoping review as a "research method and strategy to map, describe, and provide an overview of the published literature to identify relevant data and gaps to inform policymaking and research.[27] The review was performed in a two-step process. The first step was to identify databases to be searched as well as inclusion and exclusion criteria. The second step involved performing a scoping search that aligned with Arksey and O'Malley's five-stage framework,[28] a process that includes the identification of a research question, identifying relevant studies that met the inclusion criteria, study selection, mapping of the data, and a summary of results. The search was performed between June 21, 2021 and July 14, 2021.

Step 1: Develop parameters for the search

We began by identifying prominent research in the dietary behavior change literature, which we defined as interventions aimed at influencing individual and household-level purchase and consumption of foods. We were driven by the hypothesis that there is a scarcity of dietary behavior change intervention studies originating from LMICs. This was confirmed in initial searches that

uncovered many systematic reviews of behavioral interventions for dietary change in high-income countries, but few that focused on LMICs.[29,30]

We developed preliminary inclusion and exclusion criteria, which would be elaborated post-hoc as reviewers became more familiar with the literature. We exclude financial interventions, complementary feeding interventions, and other interventions that sought to reduce undernutrition, as these areas of research have received greater attention in LMICs as compared with behavioral interventions that focus on improving dietary behaviors associated with obesity and overweight status and NCD risk.

Step 2: Conduct 5-stage scoping review

2.1 Formulate the research question

The development of the research question was guided by domain expertise in both NCD interventions and behavioral economic interventions. We formulated the following research question: "What behavioral interventions have been applied at the individual (micro) level to effectively improve healthy dietary intake [and reduce the risk of overweight and obesity and subsequent NCDs]?"

Behavioral interventions for diet were defined as those interventions that sought to use provision of knowledge, incentives, or behavioral cues to measurably alter an individual's decisions regarding food purchasing and consumption. Included individuals were adults and children in settings where they have agency in choosing major aspects of their dietary intake.

LMICs were defined according to World Bank definitions for these country categories in 2021.

2.2 Search databases for relevant studies

The search was conducted using five electronic databases: PubMed, Web of Science, EMBASE, PsycINFO, and EconLit. The databases were selected to represent an array of disciplines and were chosen with guidance from a university research librarian. A comprehensive list of search terms that were used as part of the search strategy is provided in Table 1.

Table 1: Databases searched and inclusion terms

DATABASES SEARCHED

PubMed, Web of Science, EMBASE, PsycINFO, and EconLit

	Search terms
Countries	See Appendix A
Intervention	incentiv*[tiab] OR reward*[tiab] OR nudge*[tiab] OR "choice architecture"[tiab] OR "behavioral economic*"[tiab] OR "behavioural economic*"[tiab] OR "calorie labeling"[tiab] OR "labeling"[tiab] OR "labelling"[tiab] OR "commitment contract"[tiab] OR "deposit contract"[tiab] OR "commitment device"[tiab] OR "framing"[tiab] OR "intertemporal choice"[tiab] OR "present bias"[tiab] OR "loss aversion"[tiab] OR "social norm"[tiab] OR "status quo bias"[tiab] OR "mental accounting"[tiab] OR "social comparison"[tiab] OR "industry regulations"[tiab] OR "information provision"[tiab] OR "food composition"[tiab] OR "food formulation"[tiab] OR "marketing restrictions"[tiab] OR "dietary guidelines"[tiab] OR "ban+trans fats"[tiab] OR "food labeling"[tiab] OR "food labelling"[tiab] OR "menu labeling"[tiab] OR "labeling requirements"[tiab] OR "package labeling"[tiab] OR "nutrient labeling"[tiab] OR "nutrition labeling"[tiab] OR "voucher" [tiab] OR "labeling"[tiab] OR "text messag*"[tiab] OR "messag*"[tiab]
Outcome	

	"BMI"[tiab] OR "body mass index"[tiab] OR "body weight decrease"[tiab] OR "weight reduc*"[tiab] OR "weight loss"[tiab] OR "weight loss diet"[tiab] OR "weight reduc* diet"[tiab] OR "health-promoting diet"[tiab] OR "healthy diet"[tiab] OR "healthy food"[tiab] OR "food consumption"[tiab] OR "healthful diet"[tiab] OR reducing diet[tiab] OR healthy eating[tiab] OR feed* behavior*[tiab] OR "dietary behavior"[tiab] OR eat* behavior*[tiab] OR eating habit*[tiab] OR "feed* pattern*"[tiab] OR "feed* habit*"[tiab] OR "food intake*"[tiab] OR "diet* habit*"[tiab] OR "sodium intake*"[tiab] OR "dietary intake"[tiab] OR "salt intake*"[tiab] OR "fat intake*"[tiab] OR "sugar* intake*"[tiab] OR vegetable*[tiab] OR fruit*[tiab] OR "nutri* adequacy"[tiab] OR "nutrition outcomes"[tiab] OR "excessive eat*"[tiab] OR "food consum*"[tiab] OR "blood glucose"[tiab] OR "food decision making"[tiab] OR "meal practices"[tiab] OR "food acqui*"[tiab] OR "serving size"[tiab] OR "dietary diversity"[tiab] OR "meal proportion*"[tiab] OR "food waste"[tiab] OR "traditional diet"[tiab] OR "unprocess* food*"[tiab] OR "fresh ingredient*"[tiab] OR "new ingredient*"[tiab] OR "body mass index*"[tiab] OR "body weight decrease"[tiab] OR "weight reduc*"[tiab] OR "weight loss diet"[tiab]

We searched for peer-reviewed English-language studies published since January 2000 that examined the effect of behavioral interventions on changes in diet and diet-related outcomes. We included studies that had an explicitly stated behavioral intervention and that reported a quantitative effect or impact on the outcomes examined. To be included for review, studies had to have been conducted in an LMIC defined by the World Bank as low-income, low-middle income,

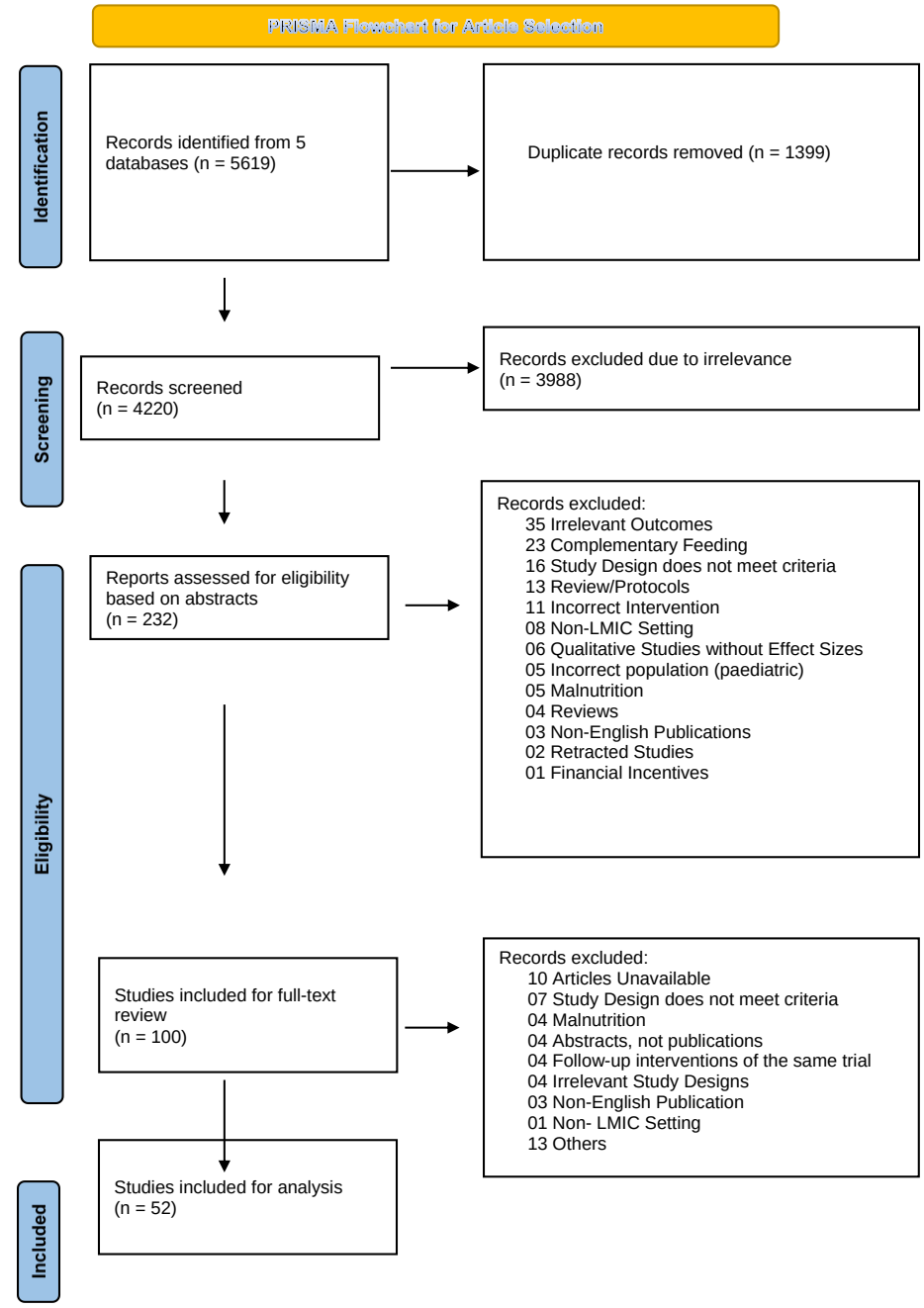
and upper-middle income.[31] Relevant literature reviews were excluded but flagged for later reference during data extraction and analysis.

2.3 Abstract and full-text review of eligible studies

The selection of relevant evidence was based on inclusion and exclusion criteria developed at the outset of the review and elaborated post-hoc as the reviewers became more familiar with the literature.

Study abstracts were screened by two researchers, and conflicts were resolved by the study's Principal Investigators (PIs). Studies that were included based on abstracts were then subject to full-text review that was performed in the same method as the abstract review, where a team of two researchers performed the primary screening and conflicts were resolved by the review's PIs. Figure 1 depicts the number of studies screened and the reasons for exclusion from the review.

Figure 1: PRISMA flowchart



2.4 Data extraction

Data was compiled on article characteristics such as year of publication, author(s), country, study design and sample size. In extracting information on changes/effects reported by the included studies, we focus on three categories of outcomes – 1) effects on biological risk factors or biometrics, 2) changes in nutritional intake or purchases, and 3) level of nutritional/health knowledge. These types of outcomes appeared frequently, hence our decision to include them in

our review. Within biological risk factors, we specifically extracted changes/effects observed for blood pressure, glucose, cholesterol, blood sugar (HbA1C) and body mass index (BMI). In sourcing information on changes in/effects on nutritional intake, we looked at outcomes related to the following food groups – 1) sugar, 2) salt, 3) fruits, 4) vegetables, and 5) fats. Sugar-sweetened beverages were counted within the sugar sub-category. We included these food groups because the dietary intake of these foods is sub-optimal in almost all regions of the world,[3] and WHO recommends cost-effective behavioral interventions that can alter intake of all those foods.[4]

Each study's data was extracted in full by one researcher and reviewed by another researcher. Data was extracted and compiled into a single Microsoft Excel file.

2.5 Analyzing and reporting results

We computed and presented summary statistics for various study characteristics. Given the heterogeneity in study design across papers, we adjusted the effect sizes to depict these in a standardized manner and facilitate comparison across studies. When intervention and control/comparison group outcome means/medians were available pre- and post-intervention, we computed difference-in-differences (DiD) estimates for the different outcome categories identified above.[1] For pre-post studies, we used the difference between the post- and pre-intervention outcome means/medians. We computed estimates for effects only when these were found to be statistically significant and indicate where results failed to attain statistical significance. Studies that did not test whether the difference in the changes across intervention and comparison groups was statistically significant were coded as having an 'unknown' effect. Since the biological risk factor sub-categories we examined were measured in standard units (for example, BMI is in kilogram/meter^2), we presented the effect estimates for these outcomes without further adjustment. Nutritional intake and knowledge outcomes, however, tended to be measured differently across studies and therefore the estimates by themselves were not comparable. Accordingly, we presented the DiD/pre-post difference as a percentage of the reference point – either the baseline

[1] To illustrate, if the intervention groups' BMI is 28 and 25 pre- and post-intervention respectively and the control group's BMI is 29 and 32 pre- and post-intervention, the DiD estimate is ((25 – 28) – (32 – 29)) = -6.

mean/median or the baseline control group mean/median. Some studies covered multiple outcomes that fell within one of the outcome categories of interest (for example, three different knowledge outcomes). For these, we computed changes for each measure (as a percentage of the reference mean/median) and presented the average of these numbers.[2,3,4]

Results

Our review included 52 papers published between 2007 and 2021. As the map in Figure 2 shows, the geographical coverage of the studies was broad, but most studies were conducted in one of a few countries: India, Iran, China, and Mexico. Study details are summarized in Table 2 (extracted data is in Table A1 in the Appendix). All investigations were published between 2007 and 2021, with half published since 2017.

Three study designs were used most frequently to capture program impacts: 31 studies used a randomized controlled trial (RCT) design, 13 compared pre-post changes in outcomes, and six used longitudinal data for both treatment and comparison groups. The remaining two studies in the review employed modelling approaches.

Table 2: Details of reviewed studies (N = 52)

Year of publication	
Min	2007

[2] Some studies examine outcomes that fall within one of the outcome categories of interest, but the estimates presented do not lend themselves to the standardization and other adjustments we conduct (for example, the nutrition intake outcome studied – such as healthy snack consumption – does not correspond exactly to the nutrition intake groups we focus on – such as fruits and vegetables). We do not compute change/effect estimates for these studies.

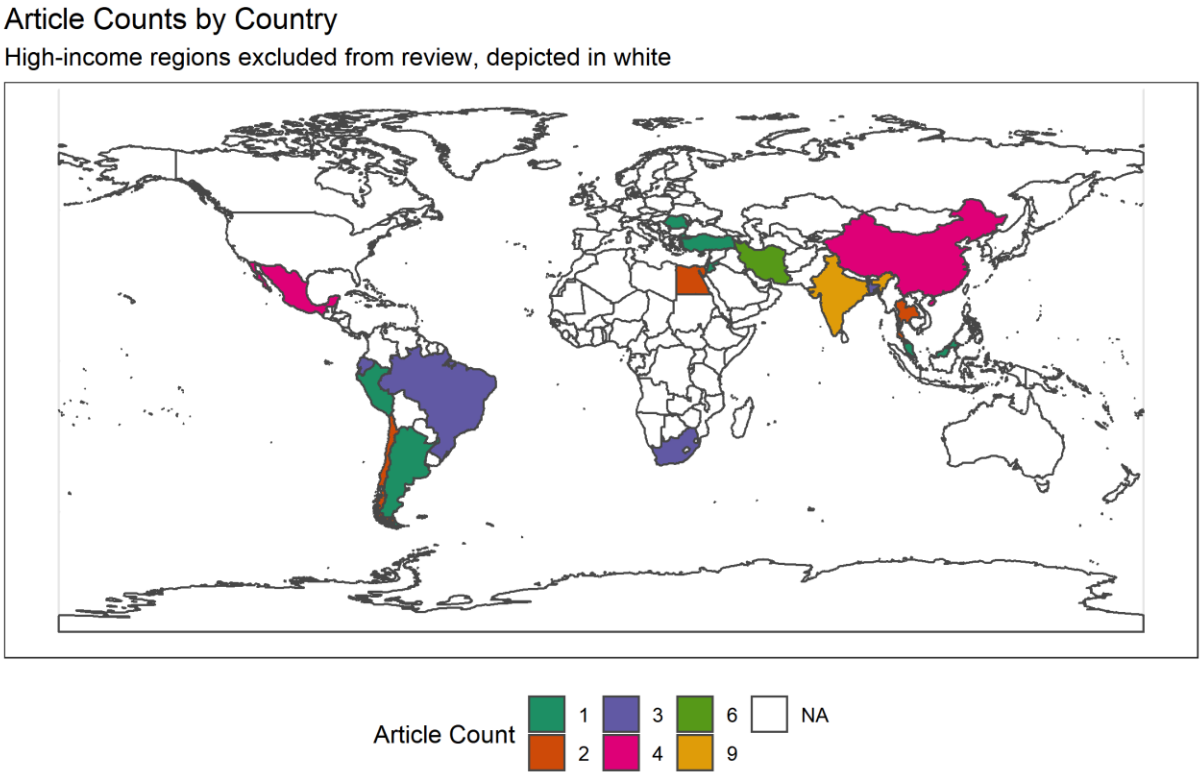
[3] We look at changes/effects for fruit and vegetable consumption separately, but several studies probe a single category for consumption of these foods. For these studies, we present the same estimate in both the fruit intake category as well as in the vegetable intake category.

[4] When the change/effect for any measure is a null, we use a zero change/effect for that measure in these computations.

Max	2021
Participants recruited from	
Schools	16
Health centers/Hospitals	14
Urban community/Communities	6
Rural community/Communities	6
Others (e.g. workplaces, provinces, unclear)	10
Target population	
Children	13
Children with chronic conditions	2
Adults (some focused on only men or only women)	17
Adults with chronic conditions	11
Entire population	5
Others (e.g. households, healthcare workers)	4
Intervention type	
Education	10
Messaging	12
Multi-component[1]	26
Others (e.g. Labelling, market restrictions)	4
Intervention duration (in months)	
Min[2]	0
Max	72
Mean	10
Median	6
Study design	
Randomized control trial (RCT)	31
Treatment versus Comparison, longitudinal	6
Pre-post	13
Others (e.g. modelling)	2
Sample size - Total	
Min	5
Max	12047
Mean	800
Median	320
Sample size - Treatment	
Mean	495
Sample size - Control	
Mean	369

Notes: [1]The most common components for these interventions are education and messaging. Examples of other components include behavior change techniques, policy/environmental/design change, food vouchers and counselling.
[2]Interventions delivered on a single day/through a single session are considered to have lasted for 0.03 or 0 months.

Figure 2: Article Counts by Country



The bulk of the populations in the studies were recruited from schools and health centers/hospitals. The median number of participants in studies was 320 (range 5-12,047). The populations targeted by the interventions were: children (13 studies), children with chronic conditions (2 studies), adults (17 studies), adults with chronic conditions (11 studies), the entire population of the region covered by the intervention (5 studies) and others such as households or healthcare workers (4 studies). Note that we included obesity/overweight status as a chronic condition in this classification. Also, some of the interventions targeting adults focused only on adult men or adult women.

Of the interventions analyzed, 10 were educational interventions, 12 were messaging programs, 26 were multi-component and four were other types such as labelling efforts or market restrictions. The most common types of interventions included in the multi-component programming were education and messaging. Intervention duration ranged from one day to 72 months, with the typical and median duration being 10 and six months respectively. Figures 3-5 show the magnitude of effects/changes for each outcome. Studies that failed to detect statistically significant effects/changes are depicted along the vertical line at zero.

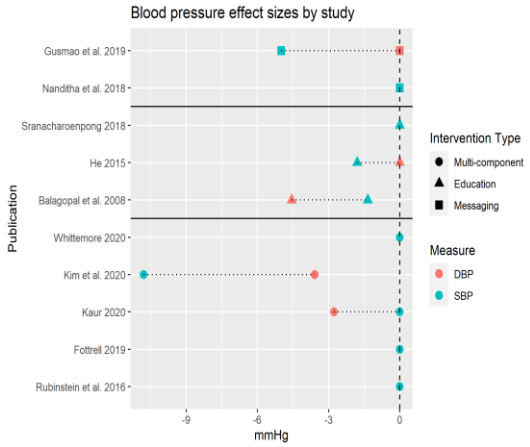
Among biological risk factors, BMI was the most frequently studied outcome. We extracted changes in BMI from 16 studies. Blood pressure outcomes were reported by 10 studies, glucose by seven studies, cholesterol measures by five studies, and HbA1c by three studies.

The effects of the interventions on the five selected biometric measures (blood pressure, blood glucose, cholesterol, HbA1c, and BMI) were generally in the desired direction of change (lowering disease risk) but most changes were small and there were many statistically insignificant results (displayed as zeros). The strongest results were for BMI (Panel 3e). Most of the studies with non-zero effects clustered around a drop in BMI of 0.25 to 0.5 kg/m^2. Multi-component interventions and direct messaging generally had larger BMI impacts than education only interventions. The largest reduction in BMI occurred from a multi-component weight-loss motivational messaging plus parental intervention for obese and overweight adolescents (Kose, 2021). In the experimental arm, participants had an average BMI reduction of 2.66 (kg/m2) over 6 months. Text messages for obese adults were added to an existing program of education at primary health care facilities in Brazil (Gusmao, 2019). The results showed a reduction in BMI of 1.4 between baseline and four months.

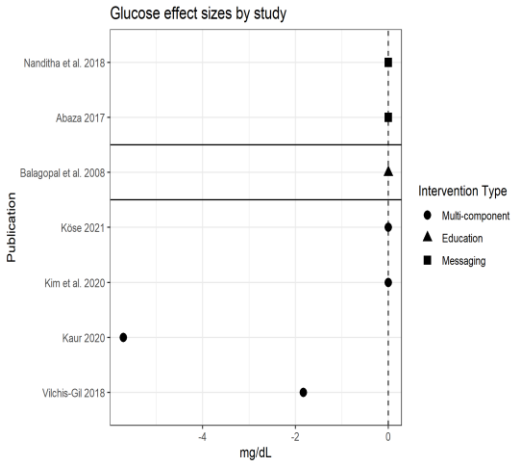
Ten studies measured impact on blood pressure (BP) from education, messaging, and multi-component dietary interventions (Panel 3a). The strongest effect was from a comprehensive BP control program carried out in PHC facilities in low-income urban areas of Peru (Kim et al, 2020). The study design was pre-post interventions and continued for two years. The intervention resulted in a 9 mmHg reduction in systolic BP among hypertensive and pre-hypertensive adults from baseline. Aside from the Kim et al study, the changes in blood pressure (either systolic or diastolic) were in the range of 1.5 mmHg to 4.5 mmHg declines with no intervention type clearly dominating the others.

Figure 3: Effect sizes by biological risk factor

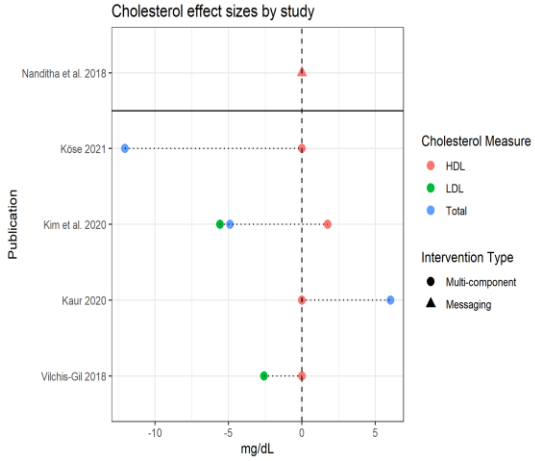
Panel 3a: Blood pressure



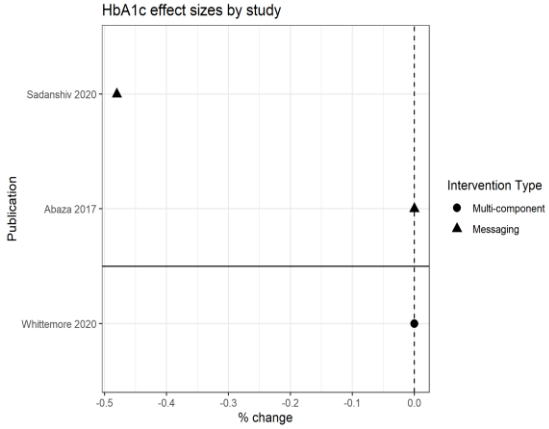
Panel 3b: Glucose



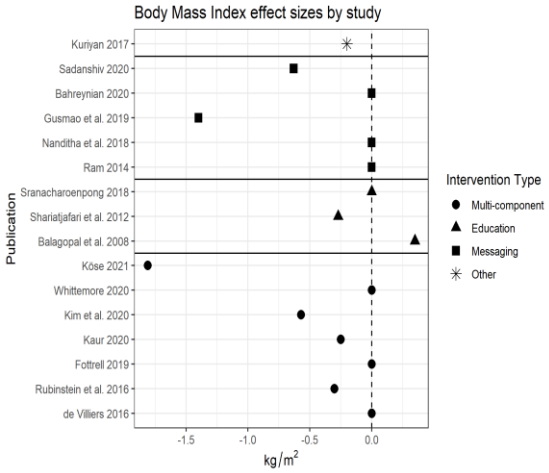
Panel 3c: Cholesterol



Panel 3d: HbA1c



Panel 3e: BMI

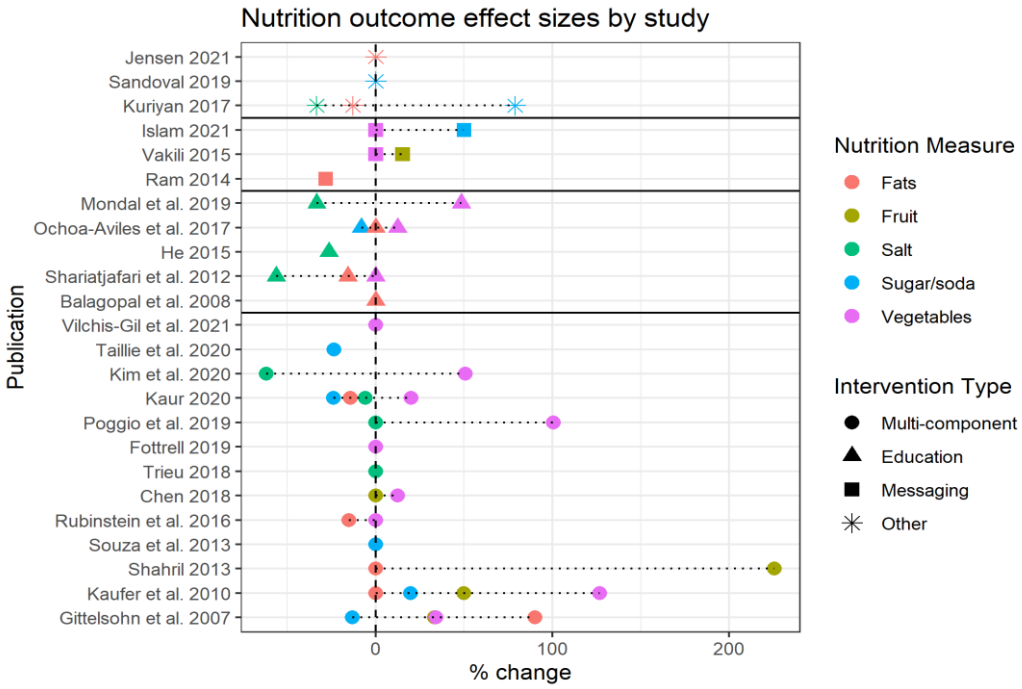


The changes in other biometric outcomes due to healthy diet and lifestyle were mixed (Figures 3b-3d). Five of seven studies that measured changes in blood glucose had no significant effect. Two multi-component studies had effects ranging from almost 2 mg/dl to almost 6 mg/dl declines. Changes in cholesterol were measured in five studies with conflicting results. Of the non-zero, significant results, there were both increases and decreases in various measures of cholesterol. The largest decline occurred in the same study of multi-component weight-loss motivational messaging plus parental intervention for obese and overweight adolescents that showed large BMI decline (Kose, 2021). HbA1c, an indicator of diabetes, was the primary outcome in only three of the studies we reviewed. The only non-zero effect came from Sadanshiv et al. (2020) who showed a substantial decline in HbA1c (-0.48) among diabetes patients in Tamil Nadu, India from a 3-month telephone messaging intervention that provided educational content.

Nutritional intake and food purchase outcomes were investigated by 24 of the studies in the review (Figure 4). Once again, most of the studies showed insignificant effects for all or most dietary intake outcomes. Results for the interventions that focused on nutritional intake are difficult to compare as they are heterogeneous. We measured the effect of those interventions as a percent change from baseline in the primary outcome measured. Fruits and vegetables were the most common categories examined whereas salt reduction and increase in vegetables were the outcomes with the most significant and largest impacts. Most results were in the expected direction – sugar. soda, salt and fat consumption typically declined in

the aftermath of interventions, and fruit and vegetable consumption went up. The largest effects were in the positive direction – primarily increased consumption of fruits and vegetables by 25% or more – while small declines of less than 25% predominated among the non-zero changes for fat, salt, sugar, and soda.

Figure 4: Change/effects sizes by nutritional intake category



There were 12 studies from which we extracted impacts on knowledge measures pertaining to health and nutrition (Figure 5). Most investigations showed post-intervention improvements in knowledge. Nutritional knowledge increased 25-50% from baseline in 8 out of twelve studies while two out of twelve showed much higher improvements in nutritional knowledge. Abaza and Marschollek (2017) sent text messages to adult patients in Cairo, Egypt who were living with diabetes. They did not demonstrate a significant effect on HbA1c after 12 weeks of the study, however nutritional knowledge increased more than 250%. Chan et al (2019) carried out an intervention in rural China with pre and post measures that showed a roughly 100% improvement in food- and health-related knowledge but limited change in healthy dietary behaviors.

Figure 5: Change/effects sizes for nutritional knowledge

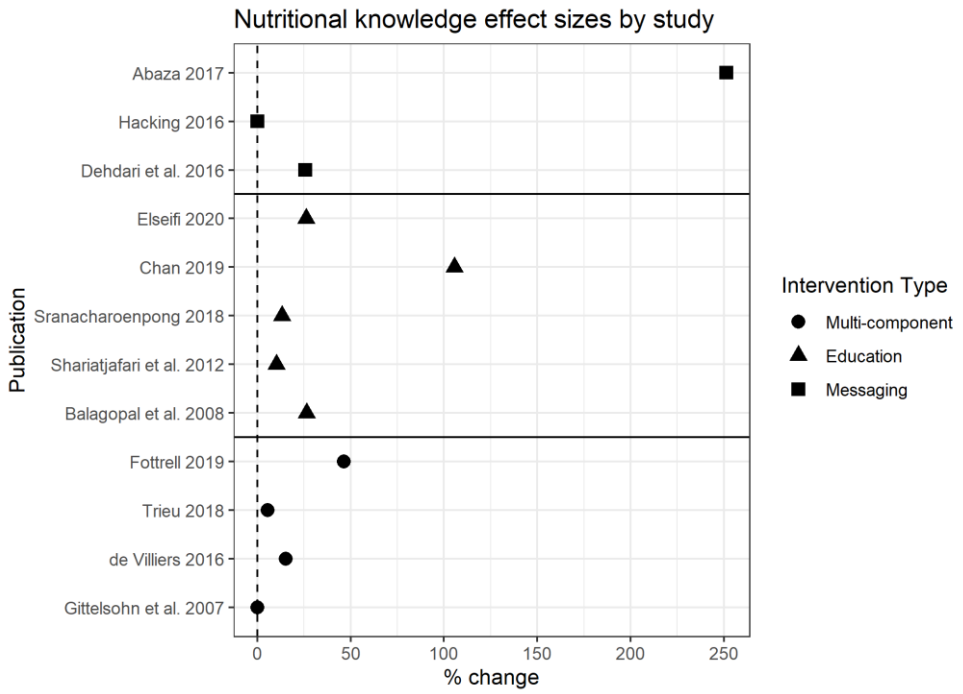


Table 3 shows indicators of study quality. Of the studies in our review, 33 objectively measured at least one outcome. Sample size determinations were based on power calculations in 25 studies. Note that three of the remaining studies used existing datasets and therefore their sample sizes could not be defined by power calculations. More than half the studies did not correct for multiple hypothesis testing despite analyzing several outcomes. Finally, among the 41 studies that provided estimates for attrition over survey rounds, mean attrition was 16 percent. Five studies did not discuss attrition and attrition concerns do not apply to the remaining six since these used cross-sections at different survey rounds or aggregated data. As discussed previously, a few studies examined the outcomes of interest, but effects could not be extracted for these studies since they did not test whether the change in the intervention group was significantly different from changes in the control group.

Table 3: Indicators of study quality (N = 52)

Objectively measured at least one outcome		33
Conducted power calculations[1]		25
Conducted multiple hypothesis testing corrections or designated select outcomes as primary outcomes or studied one or two outcomes		25
Discussed attrition[2]		41
Attrition size		
	Min	0
	Max	63
	Mean	16
	Median	11
Confounders accounted for if not randomized control trial (RCT)[3]		8

Notes: [1]Of the studies that did not conduct power calculations, three studies used existing datasets. Accordingly, their sample sizes were not informed by power calculations. [2]Six studies used several cross-sectional survey rounds or aggregated data. Concerns related to attrition therefore do not apply. [3]21 studies used non-RCT methodologies.

Discussion

Gaining a better understanding of how to improve the quality of people's food consumption has become an important policy goal worldwide. A rise in consumption of unhealthy foods and beverages has taken hold in almost all populations, excepting a handful of countries in East Asia. The shifts in consumption from traditional diets has happened especially fast in middle-income countries, and often among all but the poorest segments of the population. These unhealthy dietary shifts undoubtedly stem from a combination of supply- and demand-side factors. Among the former are intensive farming techniques – such as industrialization and concentration -- that produce greater calories per hectare and verticalization and

ownership concentration in the food system. Demand-side factors include changes in prices, income, and preferences. Around the world, food processing introduces ingredients into the food supply – such as soy fillers, high-fructose corn syrup, salt and fats – that both cheapen the food and offer greater shelf stability. While consumers often flock to ultra-processed and other foods high in those non-nutritious ingredients due to their cheapness and the pleasure in eating, this simultaneously increases the risk of both acute and chronic health problems such as heart attack, stroke, and diabetes.

There is a robust literature on the effectiveness of behavioral interventions – including low-cost nudges that incorporate insights from behavioral economics - to promote a wide range of health behaviors in high-income countries. While there is substantial variation in the effectiveness of such interventions,[32] some of the successful interventions have been adopted by organizations and governments in high-income countries. Similarly, many studies have evaluated behavioral interventions to promote various health behaviors in LMICs,[10] but there has been relatively little focus on interventions to promote healthy diets and address risk factors for NCDs. We reviewed studies conducted in LMICs to assess the evidence available for developing policy and designing programs to prevent NCDs through improvements in dietary behavior. This review reveals the weak foundations upon which NCD prevention policies are being built. The literature is highly concentrated in a handful of LMICs: China, Mexico, Iran, and India. It uses a mix of study designs – including RCTs – but many studies demonstrate design flaws such as absent or poorly explained sampling, insufficient power to test hypotheses, and high attrition.

Of the interventions that have been evaluated, the largest effects of were observed among high-risk populations – either those who have been diagnosed with NCDs and are reached in clinical settings or those with clinically measured risk factors, such as overweight and obese adolescents. Among the various behavioral interventions that have been evaluated, the ones that were most effective in improving health outcomes were multi-component interventions, but several studies found that messaging and education were also effective.

Change in BMI was the most frequently assessed outcome and several studies evaluated interventions that resulted in BMI declines of 0.25 - 2.0 kg/m^2 – effects that would have a

substantial impact on health outcomes if the results were sustained over time and when interventions are scaled up. Blood pressure and cholesterol were the other biometric outcomes measured in many studies. The changes achieved by most interventions were generally not clinically significant but, again, if the interventions were sustained beyond the average 6 months (median) of the studies in the review, real improvement in NCD risk might be achievable. Except for BMI and nutrition knowledge, more than half the studies resulted in zero or non-significant outcomes for some or all their primary outcomes. Nutrition knowledge improved in 10 of 12 studies that measured that outcome.

Limitations

This scoping review has several limitations. One is that it is a scoping review encompassing a broad research area that has been explored in multiple disciplines, with corresponding variation in types of journals where research is published and outcomes that have are typically studied. This implies that our inclusion and exclusion criteria could have caused us to miss some studies that have produced important knowledge about changing people's dietary behavior, such as sociology or marketing.

We also searched only on English-language articles published in journals catalogued in five databases. We drew from multiple bibliographic databases in hopes of casting a wide disciplinary net but we omitted articles published in national and regional journals that are prominent in some LMICs. It is possible that studies of contextually-specific dietary behavioral change would appear in those journals.

We deliberately excluded studies examining impacts of fiscal policies (taxes and subsidies on foods and beverages) as systematic reviews exist that include LMIC experiences. However, we may have missed studies that examine the effects of other kinds of price policies, such as locally-instituted pricing arrangements intended to alter consumer choices.

Finally, the biggest challenge for our review was to collate the different measured outcomes and synthesize conclusions from heterogeneous results. This causes difficulty in comparing specific interventions and whether they will achieve desired results.

Conclusion

There is an urgent need for tailored interventions for healthy diet behaviors based on evidence produced in lower-resource settings. The rising prevalence of NCDs in LMICS creates burdensome effects on health systems and economic progress. This implies that more forceful efforts are needed to redirect the food system in multiple ways that incentivize healthy eating. Achieving this goal will require that healthy food be accessible and affordable to all and that the "healthy choice is the easy choice." Yet, while there is great diversity in LMICs, there is a general scarcity of behavioral interventions being implemented, excepting in China, Mexico, Iran and India.

The diversity of food systems and eating environments argue for more research into the design and implementation of healthy dietary approaches that influence people's behavioral through nudges, better health education, and messages informed by behavioral insights.

Multiple avenues exist to make that possible – from public information and outreach to community-based and targeted programs. Countries at all income levels are still learning how to contend with food and beverage industries that pour substantial sums into influencing people's dietary habits, especially to increase consumption of energy-dense industrially-processed foods. A growing number of LMICs are turning to such population-wide approaches to limit the negative influences of commercial food and beverage companies, yet there has been less experimentation with individual behavioral approaches. More innovation and sharing of best practices will establish norms and a level playing field that help consumers choose healthier diets and reduce their risk of developing NCDs.

References

1. Global Burden of Disease Study 2019; (GBD 2019) Data Resources | GHDx. https://ghdx.healthdata.org/gbd-2019.

2. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380**(9859): 2224-60.

3. Afshin A, Penalvo J, Del Gobbo L, et al. CVD Prevention Through Policy: a Review of Mass Media, Food/Menu Labeling, Taxation/Subsidies, Built Environment, School Procurement, Worksite Wellness, and Marketing Standards to Improve Diet. *Curr Cardiol Rep* 2015; **17**(11): 98.

4. WHO. Obesity and Overweight. 2021.

5. Okunogbe A, Nugent R, Spencer G, Ralston J, Wilding J. Economic impacts of overweight and obesity: current and future estimates for eight countries. *BMJ Glob Health* 2021; **6**(10).

6. Faith MS, Carnell S, Kral TV. Genetics of food intake self-regulation in childhood: literature review and research opportunities. *Hum Hered* 2013; **75**(2-4): 80-9.

7. Vandenbroeck P, Goossens J, Clemens M. Foresight: Tackling Obesities: Future Choices - Building the Obesity System Map: (602972011-001). 2007.

8. Kral TV, Faith MS. Influences on child eating and weight development from a behavioral genetics perspective. *J Pediatr Psychol* 2009; **34**(6): 596-605.

9. Dolan P, Hallsworth M, Halpern D, King D, Metcalfe R, Vlaev I. Influencing behaviour: The mindspace way. *Journal of Economic Psychology* 2012; **33**(1): 264-77.

10. World Development Report 2015: Mind, Society, and Behavior. The World Bank, Washington, DC.

11. Long MW, Tobias DK, Cradock AL, Batchelder H, Gortmaker SL. Systematic review and meta-analysis of the impact of restaurant menu calorie labeling. *Am J Public Health* 2015; **105**(5): e11-24.

12. Bleich SN, Economos CD, Spiker ML, et al. A Systematic Review of Calorie Labeling and Modified Calorie Labeling Interventions: Impact on Consumer and Restaurant Behavior. *Obesity (Silver Spring)* 2017; **25**(12): 2018-44.

13. Ali SH, Luo R, Li Y, Liu X, Tang C, Zhang P. Application of Mobile Health Technologies Aimed at Salt Reduction: Systematic Review. *JMIR Mhealth Uhealth* 2019; **7**(4): e13250.

14. Doak CM, Visscher TL, Renders CM, Seidell JC. The prevention of overweight and obesity in children and adolescents: a review of interventions and programmes. *Obes Rev* 2006; **7**(1): 111-36.

15. French SA, Stables G. Environmental interventions to promote vegetable and fruit consumption among youth in school settings. *Prev Med* 2003; **37**(6 Pt 1): 593-610.

16. Flodmark CE, Marcus C, Britton M. Interventions to prevent obesity in children and adolescents: a systematic literature review. *Int J Obes (Lond)* 2006; **30**(4): 579-89.

17. Ammerman AS, Lindquist CH, Lohr KN, Hersey J. The efficacy of behavioral interventions to modify dietary fat and fruit and vegetable intake: a review of the evidence. *Prev Med* 2002; **35**(1): 25-41.

18. Thomson CA, Ravia J. A systematic review of behavioral interventions to promote intake of fruit and vegetables. *J Am Diet Assoc* 2011; **111**(10): 1523-35.

19. Al-Khudairy L, Uthman OA, Walmsley R, Johnson S, Oyebode O. Choice architecture interventions to improve diet and/or dietary behaviour by healthcare staff in high-income countries: a systematic review. *BMJ Open* 2019; **9**(1): e023687.

20. Niebylski ML, Redburn KA, Duhaney T, Campbell NR. Healthy food subsidies and unhealthy food taxation: A systematic review of the evidence. *Nutrition* 2015; **31**(6): 787-95.

21. Cawley J, Thow AM, Wen K, Frisvold D. The Economics of Taxes on Sugar-Sweetened Beverages: A Review of the Effects on Prices, Sales, Cross-Border Shopping, and Consumption. *Annu Rev Nutr* 2019; **39**: 317-38.

22. Teng AM, Jones AC, Mizdrak A, Signal L, Genç M, Wilson N. Impact of sugar-sweetened beverage taxes on purchases and dietary intake: Systematic review and meta-analysis. *Obes Rev* 2019; **20**(9): 1187-204.

23. Krieger J, Bleich SN, Scarmo S, Ng SW. Sugar-Sweetened Beverage Reduction Policies: Progress and Promise. *Annu Rev Public Health* 2021; **42**: 439-61.

24. Ng SW, Hoerger T, Nugent R. Preventing Non-Communicable Diseases Using Pricing Policies: Lessons for the United States from Global Experiences and Local Pilots. RTI Press Policy Brief. Research Triangle Park (NC): RTI Press
© 2021 Research Triangle Institute. All rights reserved.; 2010.

25. Global SSB Tax Database. The World Bank. https://ssbtax.worldbank.org/.

26. Draft Updated Appendix 3 of the WHO Global Action Plan, 2013-2030. World Health Organization. 2022.

27. Sucharew H, Macaluso M. Methods for Research Evidence Synthesis: The Scoping Review Approach. *Journal of Hospital Medicine* 2019; **14**(7): 416-8.

28. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology* 2005; **8**(1): 19-32.

29. Carl Lachat, Stephen Otchere, Dominique Roberfroid, et al. Diet and Physical Activity for the Prevention of Noncommunicable Diseases in Low- and Middle-Income Countries: A Systematic Policy Review. *PLOS MEDICINE* 2013.

30. Alamnia TT, Tesfaye W, Kelly M. The effectiveness of text message delivered interventions for weight loss in developing countries: A systematic review and meta-analysis. *Obes Rev* 2022; **23**(1): e13339.

31. World Bank Country and Lending Groups Data. The World Bank. 2023.

32. DellaVigna S, Linos E. RCTs to Scale: Comprehensive Evidence From Two Nudge Units. *Econometrica* 2022; **90**(1): 81-116.

APPENDIX A

LMIC country search terms

"Developing Countries"[Mesh] OR "Afghanistan"[Mesh] OR "Bangladesh"[Mesh] OR "Benin"[Mesh] OR "Burkina Faso"[Mesh] OR "Burundi"[Mesh] OR "Cambodia"[Mesh] OR "Central African Republic"[Mesh] OR "Chad"[Mesh] OR "Comoros"[Mesh] OR "Democratic Republic of the Congo"[Mesh] OR "Eritrea"[Mesh] OR "Ethiopia"[Mesh] OR "Gambia"[Mesh] OR "Guinea"[Mesh] OR "Guinea-Bissau"[Mesh] OR “Chile” [Mesh] OR "Haiti"[Mesh] OR "Kenya"[Mesh] OR "Democratic People's Republic of Korea"[Mesh] OR "Liberia"[Mesh] OR "Madagascar"[Mesh] OR "Malawi"[Mesh] OR "Mali"[Mesh] OR "Mozambique"[Mesh] OR "Myanmar"[Mesh] OR "Nepal"[Mesh] OR "Niger"[Mesh] OR "Rwanda"[Mesh] OR "Sierra Leone"[Mesh] OR "Somalia"[Mesh] OR "Tajikistan"[Mesh] OR "Tanzania"[Mesh] OR "Togo"[Mesh] OR "Uganda"[Mesh] OR "Zimbabwe"[Mesh] OR "Armenia"[Mesh] OR "Bhutan"[Mesh] OR "Bolivia"[Mesh] OR "Cameroon"[Mesh] OR "Cabo Verde"[Mesh] OR "Congo"[Mesh] OR "Cote d'Ivoire"[Mesh] OR "Djibouti"[Mesh] OR "Egypt"[Mesh] OR "El Salvador"[Mesh] OR "Georgia (Republic)"[Mesh] OR "Ghana"[Mesh] OR "Guatemala"[Mesh] OR "Guyana"[Mesh] OR "Honduras"[Mesh] OR "Indonesia"[Mesh] OR "India"[Mesh] OR "Kosovo"[Mesh] OR "Kyrgyzstan"[Mesh] OR "Laos"[Mesh] OR "Lesotho"[Mesh] OR "Mauritania"[Mesh] OR "Micronesia"[Mesh] OR "Moldova"[Mesh] OR "Mongolia"[Mesh] OR "Morocco"[Mesh] OR "Nicaragua"[Mesh] OR "Nigeria"[Mesh] OR "Pakistan"[Mesh] OR "Papua New Guinea"[Mesh] OR "Paraguay"[Mesh] OR "Philippines"[Mesh] OR "Independent State of Samoa"[Mesh] OR "Atlantic Islands"[Mesh] OR "Senegal"[Mesh] OR "Melanesia"[Mesh] OR "Sri Lanka"[Mesh] OR "Sudan"[Mesh] OR "Eswatini"[Mesh] OR "Syria"[Mesh] OR "Timor-Leste"[Mesh] OR "Ukraine"[Mesh] OR "Uzbekistan"[Mesh] OR "Vanuatu"[Mesh] OR "Vietnam"[Mesh] OR "Middle East"[Mesh] OR "Yemen"[Mesh] OR "Zambia"[Mesh] OR "Angola"[Mesh] OR "Albania"[Mesh] OR "Algeria"[Mesh] OR "American Samoa"[Mesh] OR "Argentina"[Mesh] OR "Azerbaijan"[Mesh] OR "Republic of Belarus"[Mesh] OR "Belize"[Mesh] OR "Bosnia and Herzegovina"[Mesh] OR "Botswana"[Mesh] OR "Brazil"[Mesh] OR "Bulgaria"[Mesh] OR "China"[Mesh] OR "Colombia"[Mesh] OR "Costa Rica"[Mesh] OR "Cuba"[Mesh] OR "Dominica"[Mesh] OR "Dominican Republic"[Mesh]

OR "Ecuador"[Mesh] OR "Equatorial Guinea"[Mesh] OR "Fiji"[Mesh] OR "Gabon"[Mesh] OR "Grenada"[Mesh] OR "Iran"[Mesh] OR "Iraq"[Mesh] OR "Jamaica"[Mesh] OR "Jordan"[Mesh] OR "Kazakhstan"[Mesh] OR "Lebanon"[Mesh] OR "Libya"[Mesh] OR "Republic of North Macedonia"[Mesh] OR "Malaysia"[Mesh] OR "Indian Ocean Islands"[Mesh] OR "Mexico"[Mesh] OR "Montenegro"[Mesh] OR "Namibia"[Mesh] OR "Palau"[Mesh] OR "Panama"[Mesh] OR "Peru"[Mesh] OR "Romania"[Mesh] OR "Russia"[Mesh] OR "Serbia"[Mesh] OR "Seychelles"[Mesh] OR "South Africa"[Mesh] OR "Saint Lucia"[Mesh] OR "Saint Vincent and the Grenadines"[Mesh] OR "Suriname"[Mesh] OR "Thailand"[Mesh] OR "Tonga"[Mesh] OR "Tunisia"[Mesh] OR "Turkey"[Mesh] OR "Turkmenistan"[Mesh] OR "Venezuela"[Mesh] OR "Afghanistan"[all fields] OR "Bangladesh"[all fields] OR "Benin"[all fields] OR "Burkina Faso"[all fields] OR "Burundi"[all fields] OR "Cambodia"[all fields] OR "cabo verde"[all fields] OR "Central African Republic"[all fields] OR "Chad"[all fields] OR "Comoros"[all fields] OR "Democratic Republic of the Congo"[all fields] OR "Eritrea"[all fields] OR "Ethiopia"[all fields] OR "Gambia"[all fields] OR "Guinea"[all fields] OR "Guinea-Bissau"[all fields] OR "Haiti"[all fields] OR "Kenya"[all fields] OR "Democratic People's Republic of Korea"[all fields] OR "Liberia"[all fields] OR "Madagascar"[all fields] OR "Malawi"[all fields] OR "Mali"[all fields] OR "Mozambique"[all fields] OR "Myanmar"[all fields] OR "Nepal"[all fields] OR "Niger"[all fields] OR "Rwanda"[all fields] OR "Sierra Leone"[all fields] OR "Somalia"[all fields] OR "Tajikistan"[all fields] OR "Tanzania"[all fields] OR "Togo"[all fields] OR "Uganda"[all fields] OR "Zimbabwe"[all fields] OR "Armenia"[all fields] OR "Bhutan"[all fields] OR "Bolivia"[all fields] OR "Cameroon"[all fields] OR "Cape Verde"[all fields] OR "Congo"[all fields] OR "Cote d'Ivoire"[all fields] OR "Djibouti"[all fields] OR "Egypt"[all fields] OR "El Salvador"[all fields] OR "Georgia (Republic)"[all fields] OR "Ghana"[all fields] OR "Guatemala"[all fields] OR "Guyana"[all fields] OR "Honduras"[all fields] OR "Indonesia"[all fields] OR "India"[all fields] OR “Kiribati”[all fields] OR "Kosovo"[all fields] OR "Kyrgyzstan"[all fields] OR "Kyrgyz"[all fields] OR "Laos"[all fields] OR "lao"[all fields] OR "Lesotho"[all fields] OR "Mauritania"[all fields] OR "Micronesia"[all fields] OR "Moldova"[all fields] OR "Mongolia"[all fields] OR "Morocco"[all fields] OR "Nicaragua"[all fields] OR "Nigeria"[all fields] OR "Pakistan"[all fields] OR "Papua New Guinea"[all fields] OR "Paraguay"[all fields] OR "Philippines"[all

fields] OR "Independent State of Samoa"[all fields] OR "Atlantic Islands"[all fields] OR "Sao Tome"[all fields] OR Principe[all fields] OR "Senegal"[all fields] OR "Melanesia"[all fields] OR "Solomon islands"[all fields] OR "Sri Lanka"[all fields] OR "Sudan"[all fields] OR "Swaziland"[all fields] OR "Eswatini"[all fields] OR "Syria"[all fields] OR "East Timor"[all fields] OR "Timor leste"[all fields] OR "Ukraine"[all fields] OR "Uzbekistan"[all fields] OR "Vanuatu"[all fields] OR "Vietnam"[all fields] OR "Middle East"[all fields] OR "west bank"[all fields] OR "Gaza"[all fields] OR "Yemen"[all fields] OR "Zambia"[all fields] OR "Angola"[all fields] OR "Albania"[all fields] OR "Algeria"[all fields] OR "Argentina"[all fields] OR "Samoa"[all fields] OR "Azerbaijan"[all fields] OR "Republic of Belarus"[all fields] OR "Belize"[all fields] OR "Bosnia-Herzegovina"[all fields] OR "Botswana"[all fields] OR "Brazil"[all fields] OR "Bulgaria"[all fields] OR "China"[all fields] OR "Colombia"[all fields] OR "Costa Rica"[all fields] OR "Cuba"[all fields] OR "Dominica"[all fields] OR "Dominican Republic"[all fields] OR "Ecuador"[all fields] OR "Equatorial Guinea"[all fields] OR "Fiji"[all fields] OR "Gabon"[all fields] OR "Grenada"[all fields] OR "Iran"[all fields] OR "Iraq"[all fields] OR "Jamaica"[all fields] OR "Jordan"[all fields] OR "Kazakhstan"[all fields] OR "Lebanon"[all fields] OR "Libya"[all fields] OR "Macedonia"[all fields] OR "Malaysia"[all fields] OR "Indian Ocean Islands"[all fields] OR "Maldives"[all fields] OR “Marshall Islands”[all fields] OR "Mauritius"[all fields] OR "Mexico"[all fields] OR "Montenegro"[all fields] OR "Namibia"[all fields] OR "Palau"[all fields] OR "Panama"[all fields] OR "Peru"[all fields] OR "Romania"[all fields] OR "Russia"[all fields] OR "Russian Federation"[all fields] OR "Serbia"[all fields] OR "Seychelles"[all fields] OR "South Africa"[all fields] OR "Saint Lucia"[all fields] OR "Saint Vincent and the Grenadines"[all fields] OR "Suriname"[all fields] OR "Thailand"[all fields] OR "Tonga"[all fields] OR "Tunisia"[all fields] OR "Turkey"[all fields] OR "Turkmenistan"[all fields] OR "Tuvalu"[all fields] OR "Venezuela"[all fields] OR "low resource"[all fields] OR "under-resourced"[all fields] OR "resource poor"[all fields] OR "under-developed"[all fields] OR "underdeveloped"[all fields] OR "developing country"[all fields] OR "developing countries"[all fields] OR "developing world"[all fields] OR "third world" [all fields] OR lmic[all fields] OR (low[all fields] AND middle[all fields] AND income[all fields])

Table A1: Studies included in review

Authors	Year of publication	Country	Target population	Intervention type	Study design	Types of outcomes studied
Sharma	2017	India	Adults	Multi-component	T vs. C, longitudinal	Biological risk factors, nutritional intake/purchases
Fottrell	2019	Bangladesh	Adults	Multi-component	RCT	Biological risk factors, nutritional intake/purchases, nutrition/health knowledge
Whittemore	2020	Mexico	Adults with Chronic Conditions	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Jensen	2021	Chile	Children	Marketing restrictions	Pre-post	Nutritional intake/purchases
Köse	2021	Turkey	Children with Chronic Conditions	Multi-component	RCT	Biological risk factors
Kim et al.	2020	Peru	Adults with Chronic Conditions	Multi-component	Pre-post	Biological risk factors, nutritional intake/purchases
Gittelsohn et al.	2007	Reublic of the Marshall Islands	Adults	Multi-component	Pre-post	Nutritional intake/purchases, nutrition/health knowledge
Taillie et al.	2020	Chile	Entire population	Multi-component	Fixed-effects modeling	Nutritional intake/purchases
de Villiers	2016	South Africa	Children	Multi-component	RCT	Biological risk factors, nutritional intake/purchases, nutrition/health knowledge
Chan	2019	China	Adults	Education	Pre-post	Nutrition/health knowledge
Karimi-Shahanjarini	2013	Iran	Children	Multi-component	RCT	Nutritional intake/purchases
Souza et al.	2016	Brazil	Adults	Education	Pre-post	Nutrition/health knowledge
Talaei	2013	Iran	Entire population	Multi-component	Pre-post	Nutritional intake/purchases
Chen	2018	China	Adults with Chronic Conditions	Multi-component	Pre-post	Nutritional intake/purchases
Kato-Lin	2020	India	Children	Education	RCT	Nutritional intake/purchases
Abaza	2017	Egypt	Adults with Chronic Conditions	Messaging	RCT	Biological risk factors, nutritional intake/purchases, nutrition/health knowledge
Hacking	2016	South Africa	Adults with Chronic Conditions	Messaging	RCT	Nutrition/health knowledge
Islam	2021	Bangladesh	Adults with Chronic Conditions	Messaging	RCT	Biological risk factors, nutritional intake/purchases
Sandoval	2019	Ecuador	Entire population	Labeling	Modeling	Nutritional intake/purchases
Trieu	2018	Samoa	Entire population	Multi-component	Pre-post	Nutritional intake/purchases, nutrition/health knowledge
Bahreynian	2020	Iran	Children with Chronic Conditions	Messaging	Pre-post	Biological risk factors, nutritional intake/purchases
Kuriyan	2017	India	Adults with Chronic Conditions	Portion controlled ready to-eat meal replacement	RCT	Biological risk factors, nutritional intake/purchases
Gopalan	2019	South Africa	Adults	Multi-component	RCT	Nutritional intake/purchases

Vakili	2015	Iran	Adult women	Messaging	RCT	Nutritional intake/purchases
Pfammatter et al	2016	India	Adults	Messaging	T vs. C, longitudinal	Nutritional intake/purchases
Dehdari et al.	2016	Iran	Adults	Messaging	RCT	Nutritional intake/purchases, nutrition/health knowledge
Souza et al.	2013	Brazil	Adults	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Nanditha et al.	2018	India	Adult men	Messaging	RCT	Biological risk factors, nutritional intake/purchases
Ram	2014	India	Adult men	Messaging	RCT	Biological risk factors, nutritional intake/purchases
Rubinstein et al.	2016	Argentina, Guatemala, Peru	Adults with Chronic Conditions	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Shariatjafari et al.	2012	Iran	Adult women	Education	RCT	Biological risk factors, nutritional intake/purchases, nutrition/health knowledge
Ponce and Ramos-Martin	2017	Ecuador	Households	Multi-component	RCT	Nutritional intake/purchases
Poggio et al.	2019	Argentina	Adults with Chronic Conditions	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Vilchis-Gil et al.	2021	Mexico	Children	Multi-component	T vs. C, longitudinal	Nutritional intake/purchases
Vilchis-Gil	2018	Mexico	Children	Multi-component	T vs. C, longitudinal	Biological risk factors
Ochoa-Aviles et al.	2017	Ecuador	Children	Education	RCT	Biological risk factors, nutritional intake/purchases
Akhu-Zaheya and Shiyab	2017	Jordan	Adults with Chronic Conditions	Messaging	RCT	Nutritional intake/purchases
Gusmao et al.	2019	Brazil	Adults with Chronic Conditions	Messaging	Pre-post	Biological risk factors
Mondal et al.	2019	Bangladesh	Adults	Education	Pre-post	Nutritional intake/purchases
Kanchanachitra et al	2020	Thailand	Adults	Multi-component	RCT	Nutritional intake/purchases
Balagopal et al.	2008	India	Children and Adults	Education	Pre-post	Biological risk factors, nutritional intake/purchases, nutrition/health knowledge
Kaufer et al.	2010	Federated States of Micronesia	Entire population	Multi-component	Pre-post	Nutritional intake/purchases
Sranacharoenpong	2018	Thailand	Adults	Education	RCT	Biological risk factors, nutrition/health knowledge
Kaur	2020	India	Households	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Vilchis-Gil	2016	Mexico	Children	Multi-component	T vs. C, longitudinal	Biological risk factors

Lana	2014	Mexico, Spain	Children	Multi-component	RCT	Biological risk factors, nutritional intake/purchases
Lin	2016	China	Children	Multi-component	RCT	Nutritional intake/purchases
Elseifi	2020	Egypt	Children	Education	T vs. C, longitudinal	Nutritional intake/purchases, nutrition/health knowledge
Shahril	2013	Malaysia	Adults	Multi-component	RCT	Nutritional intake/purchases
Sadanshiv	2020	India	Healthcare workers	Messaging	RCT	Biological risk factors
He	2015	China	Children	Education	RCT	Biological risk factors, nutritional intake/purchases
Armitage	2014	Romania	Children	Implementation intentions	RCT	Nutritional intake/purchases

Notes: RCT = randomized controlled trial; T vs. C, longitudinal = treatment-control comparison leveraging longitudinal data