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Original Research

Fruit and Vegetable Intake and Non-Communicable Diseases among Adults Aged ≥50 Years in Low- and Middle-Income Countries

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Abstract

OBJECTIVES: The relationship between consuming ≥2 servings of fruits and ≥3 servings of vegetables a day, which has been identified as optimal for health (i.e., adequate fruit/vegetable consumption), and non-communicable diseases (NCDs) in low- and middle-income countries (LMICs) is largely unknown. Therefore, using data from six LMICs, we investigated the independent association between inadequate fruit/vegetable consumption and 12 NCDs, and estimated the prevalence of inadequate fruit/vegetable consumption among people with NCDs.

DESIGN AND SETTING: Cross-sectional, nationally representative data from the WHO Study on global AGEing and adult health (SAGE) were analyzed.

PARTICIPANTS: Data on 34129 individuals aged ≥50 years were analyzed [mean (SD) age 62.4 (16.0); maximum age 114 years; 52.1% females].

MEASUREMENTS: Information on the number of servings of fruits and vegetables consumed on a typical day was self-reported. Twelve NCDs were assessed. Multivariable logistic regression analysis was conducted.

RESULTS: Overall, 67.2% had inadequate fruit/vegetable consumption. Inadequate fruit/vegetable consumption was independently associated with significantly higher odds for chronic lung disease (OR=1.25), diabetes (OR=1.45), hearing problems (OR=1.75), and visual impairment (OR=2.50). The prevalence of inadequate fruit/vegetable consumption was particularly high among people with visual impairment (92.5%), depression (90.5%), asthma (79.8%), and hearing problems (78.4%).

CONCLUSION: Promotion of fruit and vegetable consumption (≥2 servings of fruits and ≥3 servings of vegetables a day) in LMICs may lead to prevention of some NCDs (e.g., diabetes, chronic lung disease). Furthermore, people with certain NCDs (e.g., visual impairment, depression) had particularly high prevalence of inadequate fruit/vegetable consumption, and it is thus important to target this population to increase fruit/vegetable consumption.

Key words: Fruit and vegetable, non-communicable disease, low- and middle-income countries, adults, epidemiology.

Introduction

Non-communicable diseases (NCDs) are conditions that do not result from an (acute) infectious process and hence are not "communicable." These conditions have a prolonged cause that do not resolve spontaneously, for which a complete cure is rare. The main types of NCDs are cardiovascular diseases (e.g., heart attacks, stroke), cancers, chronic respiratory diseases (e.g., chronic obstructive pulmonary disease, asthma), and diabetes (1). NCDs are responsible for approximately 71% of global deaths, and 77% of these deaths occur in low- and middle-income countries (LMICs) (1). Moreover, NCDs are most common in older adults, and NCDs are projected to increase substantially in the coming years due to rapid population ageing occurring globally, and in particular, in LMICs, where the United Nation estimates that two-thirds of the world's population aged 60 years and over will live by 2050 (2).

Literature has shown that a higher intake of fruits and vegetables is associated with a significantly lower risk of NCDs. For example, one systematic review (3) found that for hypertension, coronary heart disease, and stroke, there is convincing evidence that increasing the consumption of fruits and vegetables reduces the risk of these diseases. Moreover, there is possible evidence that an increased consumption of fruits and vegetables may prevent body weight gain, and thus, associated conditions such as type II diabetes (4–6). The review of Boeing and colleagues also found possible evidence for a plethora of other NCDs (3). In another recent study which followed 66,719 women from the Nurses' Health Study (1984-2014) and 42,016 men from the Health Professionals Follow-up Study (1986-2014) who were free from cardiovascular diseases, cancer, and diabetes at baseline, it was found that higher intakes of fruits and vegetables were associated with lowest mortality at approximately 5 servings of fruits and vegetables per day, in particular 2 servings of fruits and 3 servings of vegetables, with no additional benefits being observed with higher consumption (7). Importantly, while there is a large body of literature on fruit and vegetable consumption per se and NCDs, there is a scarcity

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of literature that has specifically investigated the independent association between ≥2 servings of fruits and ≥3 servings of vegetables per day and NCDs, especially in the context of LMICs.

Apart from the focus on fruit and vegetable consumption as a risk factor NCDs, it is important to understand the level of fruit and vegetable consumption among people with NCDs, as people with NCDs may have high prevalence of inadequate consumption, while it is possible for adequate consumption to lead to better clinical outcomes in this population. For example, in a meta-analysis of 383 articles, an inverse association between fruit and vegetable consumption and diastolic blood pressure in metabolic syndrome patients was observed (8). In order to develop targeted interventions, information on the prevalence of inadequate fruit and vegetable consumption among those with NCDs is needed, but this is largely unknown in LMIC settings.

Given this background, the aim of the present study was to investigate the independent association of consuming ≥2 servings of fruits and ≥3 servings of vegetables a day with 12 NCDs, as well as to identify the prevalence of consuming this level of fruits and vegetables among people with NCDs, in a large sample of middle-aged to older adults from six LMICs. We hypothesized that those who consume ≥2 servings of fruits and ≥3 servings of vegetables a day will have lower odds for NCDs.

Methods

We analyzed data from the Study on Global Ageing and Adult Health (SAGE), which was a survey undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. Based on the World Bank classification at the time of the survey, Ghana was a low-income country, and China and India were lower middle-income countries although China became an upper middle-income country in 2010. The remainder of the countries were upper middle-income countries. Details of the survey methodology can be found elsewhere (9). Briefly, a multistage clustered sampling design method was employed to obtain nationally representative samples. The sample consisted of adults aged ≥18 years with oversampling of those aged ≥50 years. Trained interviewers conducted face-to-face interviews using a standard questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Fruit and vegetable consumption

Participants were asked the two following questions: "How many servings of fruit do you eat on a typical day?" and "How many servings of vegetables do you eat on a typical day?" Those who consumed at least two servings of fruits and at least three servings of vegetables were considered to have adequate fruit/vegetable consumption based on findings from a recent study that this amount of fruits and vegetables was associated with the lowest risk for mortality (7). The number of servings of fruit/vegetable per day was also used as a continuous measure in some analyses.

Non-communicable diseases

We included all 12 NCDs for which data were available in the SAGE. Chronic back pain was defined as having had back pain every day during the last 30 days. Respondents who answered affirmatively to the question "Have you lost all of your natural teeth?" were considered to have edentulism. The participant was considered to have hearing problems if the interviewer observed this condition during the survey. Hypertension was defined as having at least one of the following: systolic blood pressure ≥140 mmHg; diastolic blood pressure ≥90 mmHg; or self-reported diagnosis. Visual impairment was defined as having extreme difficulty in seeing and recognizing a person that the participant knows across the road (10). Diabetes and stroke were solely based on lifetime self-reported diagnosis. For other conditions, the participant was considered to have the condition in the presence of either one of the following: self-reported diagnosis; or symptom-based diagnosis based on algorithms. We used these algorithms, which have been used in previous studies using the same dataset, to detect undiagnosed cases (11, 12). Specifically, the validated Rose questionnaire was used for angina (13), and other previously validated symptom-based algorithms were used for arthritis, asthma, and chronic lung disease (12). Questions based on the World Mental Health Survey version of the Composite International Diagnostic Interview (14) were used for the endorsement of past 12-month DSM-IV depression. Further details on the definition of NCDs can be found in Table S1 (Appendix).

Control variables

The selection of the control variables was based on past literature (7) and included age, sex, highest level of education achieved (≤primary, secondary, tertiary), country-wise wealth quintiles based on income, setting (urban or rural), body mass index (BMI) based on measured weight and height (<18.5, 18.5–24.9, 25.0–29.9, 30 kg/m^2), alcohol consumption, smoking (never, current, past), and physical activity. Consumers of at least four (females) or five drinks (males) of any alcoholic beverage per day on at least one day in the past week were considered 'heavy' drinkers. Those who had ever consumed alcohol but were not heavy drinkers were categorized as 'non-heavy' drinkers (15). Levels of physical activity were assessed with the Global Physical Activity Questionnaire and were classified as low, moderate, and high based on conventional cut-offs (16).

Table 1. Sample characteristics (overall and by fruit/vegetable consumption status)

Characteristic		Adequate intake			
		Overall	No	Yes	P-value[a]
Age (years)	Mean (SD)	62.4 (16.0)	62.4 (16.4)	62.1 (15.5)	0.260
Sex	Female	52.1	51.9	52.4	0.554
	Male	47.9	48.1	47.6	
Education	≤Primary	57.4	63.5	50.1	<0.001
	Secondary	35.2	30.2	42.0	
	Tertiary	7.4	6.3	7.9	
Wealth	Poorest	17.1	20.1	9.7	<0.001
	Poorer	19.0	20.3	15.8	
	Middle	19.5	18.8	20.9	
	Richer	21.3	19.9	25.1	
	Richest	23.1	20.9	28.5	
Setting	Rural	53.8	61.4	39.3	<0.001
	Urban	46.2	38.6	60.7	
Body mass index (kg/m^2)	<18.5	16.7	23.3	4.8	<0.001
	18.5-24.9	47.6	45.8	52.9	
	25.0-29.9	24.2	19.7	32.1	
	≥30	11.5	11.2	10.2	
Alcohol consumption	Never	67.1	68.0	68.4	0.023
	Non-heavy	28.8	28.5	26.9	
	Heavy	4.1	3.5	4.8	
Smoking	Never	58.6	53.5	67.9	<0.001
	Current	34.9	40.1	25.1	
	Past	6.6	6.5	6.9	
Physical activity	High	49.1	51.6	44.4	<0.001
	Moderate	22.8	20.9	28.3	
	Low	28.1	27.5	27.3	

Abbreviation: SD Standard deviation; Data are % unless otherwise stated; a. P-value was calculated by Chi-squared tests, except for age (Student's t-test).

Statistical analysis

The statistical analysis was performed with Stata 14.2 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged ≥50 years. The difference in sample characteristics by fruit/vegetable intake status was tested by Chi-squared tests and Student's t-tests for categorical and continuous variables, respectively. The association of inadequate fruit/vegetable consumption (exposure) and each of the 12 individual NCDs (outcomes) was estimated by multivariable logistic regression. Country-wise analysis was also conducted. Furthermore, analyses using the continuous variable on fruit/vegetable consumption (i.e., servings/day) as the exposure variable was performed. Models were adjusted for age, sex, education, wealth, setting, body mass index, alcohol consumption, smoking, physical activity, and country, except for the country-wise analysis which was not adjusted for country. Adjustment for country was done by including dummy variables for each country in the model as in previous SAGE publications (17, 18). All variables were included in the models as categorical variables except for age (continuous variable) and fruit/vegetable consumption (servings/day) when used as a continuous variable. The sample weighting and the complex study design were considered in the analyses. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$.

Results

Data on 34129 individuals aged ≥50 years (maximum age 114 years) were analyzed. The sample size of each country was: China n=13175; Ghana n=4305; India n=6560; Mexico n=2313; Russia n=3938; South Africa n=3838. Overall, 67.2% had inadequate fruit/vegetable consumption. The mean (95%CI) servings of fruit/vegetable per day was 6.1 (5.9-6.3). The

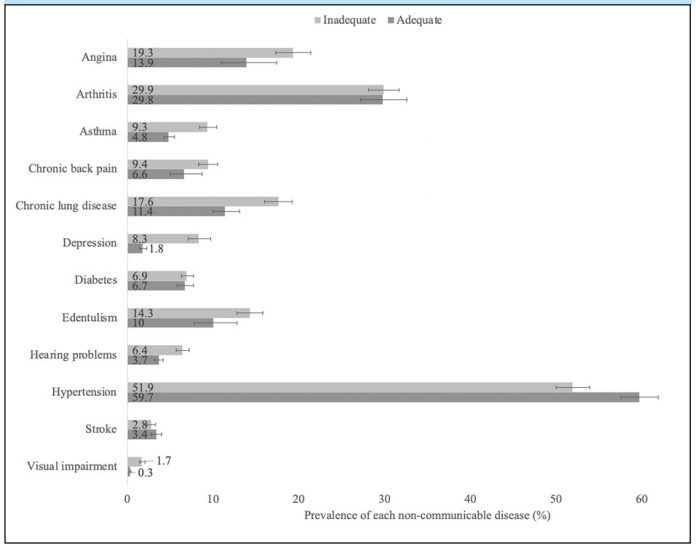
sample characteristics are provided in Table 1. The mean (SD) age was 62.4 (16.0) years and 52.1% were females. Those with adequate intake of fruit/vegetable were significantly more likely to never smoke, drink heavily, exercise moderately, to be of an urban setting, and have higher levels of education and wealth, while they were less likely to be underweight. The prevalence of angina, asthma, chronic lung disease, depression, edentulism, hearing problems, and visual impairment were significantly higher in people with inadequate fruit/vegetable intake (vs. adequate intake), while the prevalence of hypertension was significantly lower in people with inadequate fruit/vegetable intake (Figure 1). Country-wise analysis showed some level of variation between countries (Appendix Table S2). For example, the prevalence of hypertension was higher in inadequate (vs. adequate) intake in China. After adjustment for potential confounders, inadequate vegetable consumption was associated with significantly higher odds for chronic lung disease (OR=1.25; 95%CI=1.08-1.45), diabetes (OR=1.45; 95%CI=1.13-1.87), hearing problems (OR=1.75; 95%CI=1.41-2.17), and visual impairment (OR=2.50; 95%CI=1.46-4.26), while arthritis was significantly associated with lower odds for inadequate fruit/vegetable consumption (Figure 2). Country-wise analysis showed some differences between countries (Table S3 of the Appendix). For example, while hypertension was not significantly associated with inadequate fruit/vegetable consumption in the overall sample, there was a significant positive association observed in China. In addition, the significant association observed for diabetes in the overall sample was mainly driven by the strong association observed in China. Next, a one serving increase in fruit/vegetable per day was associated with significant 2-6% lower odds for depression, hearing problems, and chronic lung disease, while this was associated with a significant 1.02 times higher odds for hypertension (Figure S1 of the Appendix). Finally, the prevalence of inadequate fruit/vegetable consumption and mean servings of fruit/vegetable per day by absence or presence of a NCD are shown in Figure 3 and Figure S2 (Appendix), respectively. The prevalence of inadequate fruit/vegetable consumption was particularly high, and mean consumption of fruit/vegetable per day low, among people with visual impairment (92.5%; 3.2 servings), depression (90.5%; 3.1 servings), asthma (79.8%; 4.6 servings), and hearing problems (78.4%; 5.1 servings). The country-wise prevalence of inadequate fruit/vegetable consumption by NCD status is shown in Table S4 (Appendix). The prevalence of inadequate fruit/vegetable consumption was particularly high for NCDs such as depression, hearing problems, and visual impairment in China.

Discussion

Main findings

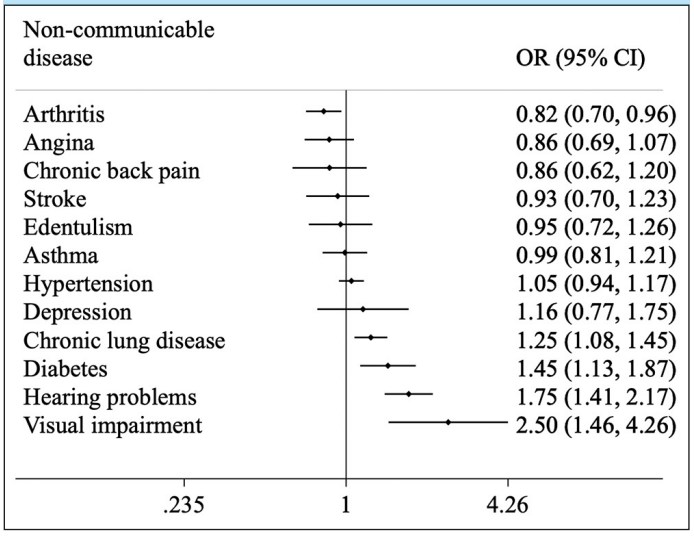
In our study which analyzed a large nationally representative dataset of six LMICs, we found that the prevalence of inadequate fruit/vegetable consumption is very high in the general population (67.2%). Furthermore, we found that inadequate fruit/vegetable consumption is independently associated with significantly higher odds for chronic lung disease, diabetes, hearing problems, and visual impairment, but this was associated with lower odds for arthritis. Finally, when focusing on people with NCDs, conditions such as visual impairment, depression, asthma, and hearing problems were associated with particularly high prevalence of inadequate fruit/vegetable consumption.

Figure 1. Prevalence of each non-communicable disease by fruit/vegetable consumption status



Bars denote 95% confidence interval

Figure 2. Association of inadequate fruit/vegetable consumption (exposure) with non-communicable diseases (outcome) estimated by multivariable logistic regression



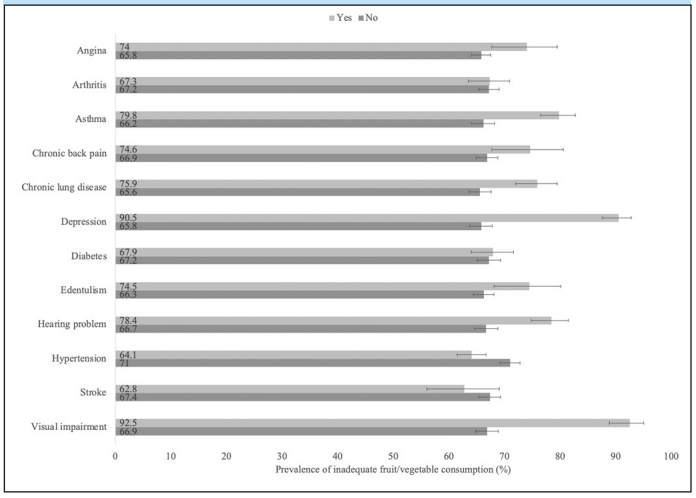
Abbreviation: OR Odds ratio; CI Confidence interval; Models are adjusted for age, sex, education, wealth, setting, body mass index, alcohol consumption, smoking, physical activity, and country.

Interpretation of the findings

In the present study, we found that inadequate fruit/vegetable consumption is independently associated with significantly higher odds for chronic lung disease, diabetes, hearing

problems, and visual impairment. First, in terms of chronic lung disease, previous research has found similar findings (19), and this may be owing to impaired antioxidant status associated with inadequate fruit/vegetable consumption. Indeed, high fruit and vegetable consumption has been associated with reduced levels of oxidative stress and inflammation parameters, as well as with increased levels of antioxidant defense (20, 21). For example, higher plasma lipid peroxidation has been associated with higher risk for progression in patients with chronic obstructive pulmonary disease, while higher catalase and erythrocyte glutathione activities have been found to be associated with decreased risk of progression of this disease (22).

Figure 3. Prevalence of inadequate fruit/vegetable consumption by absence or presence of non-communicable disease



Bars denote 95% confidence interval

Second, the increased risk for diabetes in people with inadequate fruit and vegetable consumption has been shown in a meta-analysis (23). Fiber may be implicated in the potential protective effect of fruit and vegetable consumption against diabetes. Indeed, dietary fiber has been found to be associated with insulin sensitivity, and an improved ability to delay the absorption of carbohydrates and secrete insulin adequately to overcome insulin resistance, resulting in lower postprandial blood glucose and insulin levels (24, 25).

Similar to the present study, previous literature has also demonstrated an association between fruit and vegetable consumption with vision and hearing impairments (26, 27). As mentioned previously, inadequate fruit/vegetable consumption may induce oxidative stress and oxidative damage (20, 21), and these are implicated in age-related macular degeneration and cataracts as well as hearing loss (28).

The finding that inadequate fruit and vegetable consumption was associated with lower odds of arthritis should be noted. Previous research has reported the reverse (29), and it may be that the observed association is owing to reverse causality, where those with arthritis consume greater amounts of fruit and vegetables owing to the known benefits of fruit and vegetable consumption for people with this condition. For example, commonly available fruits such as blueberries, raspberries and strawberries, and pomegranates have shown promising results in reducing pain and inflammation in experimental models and in human clinical studies of arthritis. There is also some evidence on the role of specific fruit polyphenols, such as quercetin and citrus flavonoids, in alleviating arthritic symptoms (30). We also did not find an independent association of inadequate fruit/vegetable consumption with hypertension (except China), angina, and stroke despite a previous review showing that there is convincing evidence that these conditions are associated with low fruit/vegetable intake (3). It is possible that people with these conditions also modified their dietary habits following a doctor's advice etc.

Importantly, it should be noted that some level of reverse causality may exist for all conditions assessed in our study as people with NCDs may be less likely to consume fruits and vegetables owing to factors such as reduced income due to the disease and changes in diet following the diagnosis. Furthermore, people with visual impairment may have difficulties in choosing fruits and vegetables, and this may lead to lower consumption of these food items. Longitudinal studies from LMICs are necessary to minimize reverse causality and to understand the effect of fruit/vegetable consumption on NCDs.

Next, the finding that the prevalence of inadequate fruit and vegetable consumption was very high among those with visual impairment, depression, asthma, and hearing problems is of concern. It is well known that those with chronic conditions are at a higher risk of worse clinical outcomes compared to those without. For example, those with visual impairment or depression are at a much higher risk of cardiovascular disease than those without (31, 32). Given that fruit and vegetable consumption are protective of cardiovascular diseases (33), targeting people with these conditions to promote fruit and vegetable consumption may ultimately lead to better clinical outcomes.

Finally, it is important to note that there was some level of between-country difference in the association between inadequate fruit/vegetable consumption and NCDs. Although the reason for this can only be speculated, it is possible for the content of vegetables and fruits to differ by country. For example, glucosinolates, which are phytochemicals found almost exclusively in cruciferous vegetables, have been identified from preclinical and clinical studies to have a strong protective effect against NCDs (34). It is possible that there is variation in the level of consumption of cruciferous vegetables between countries owing to its availability (35). In addition, there also is the possibility that this reflects the difference in tendency of people to change their diets following a diagnosis of a NCD due to doctor's advice etc.

Implication of study findings

In our study on middle-aged and older adults from six LMICs, we found a high prevalence of inadequate fruit/vegetable consumption in the general population (67.2%), and in particular among those with certain NCDs (e.g., visual impairment, depression). Our study results point to the

importance of promoting fruit and vegetable consumption in the general population to prevent NCDs, while people with some NCDs may be targeted for interventions to increase fruit and vegetable consumption to improve clinical outcomes. It is generally recommended that one should aim to consume at least five portions of fruit and vegetables a day (36), and recent evidence shows that this should consist of at least 2 servings of fruits and at least 3 servings of vegetables a day (7).

Strengths and limitations

The large representative sample of middle-aged and older adults from six LMICs is a clear strength of the present study. However, findings must be interpreted in light of the study's limitations. First, the study was cross-sectional in nature, and therefore, the direction of the observed associations cannot be determined. Second, the majority of questions were self-reported potentially introducing recall and social desirability bias into the findings. We also lacked information on the exact type of fruit or vegetable people consume, despite the fact that some types of vegetables or fruits may be more beneficial for protection against NCD (37). Finally, people who consume greater amounts of fruits and vegetables could be those who are more health-conscious and consume other types of food that may promote good health. In relation to this, we were unable to adjust for other types of food (e,g., foods high in fat) that may increase risk for NCDs due to lack of data.

Conclusion

Given the high prevalence of inadequate fruit and vegetable consumption observed in our study of middle-aged and older adults from LMICs, and the fact that NCDs are increasing in LMICs, interventions to increase fruit and vegetable intake in this population is likely to be of prime importance to tackle NCDs. Furthermore, targeting people with certain NCDs (e.g., visual impairment, depression) to increase fruit and vegetable intake may be important also to improve their health outcomes. Importantly, several global plans have been developed to increase fruit and vegetable intake, and these plans include WHO Global Action Plan for the Prevention and Control of NCDs, and the United Nations (UN) Decade of Action on Nutrition 2016–2025. Moreover, the World Cancer Research Fund International (WCRF) developed the NOURISHING framework to guide national policy to improve public health nutrition. The framework highlights interventions across 10 key policy areas in three key domains: food environment (e.g., food labelling standards), food system (e.g., supply chain actions) and behavioral change communication (e.g., nutrition counselling).

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