Road to a Healthier Mexico

The influence of price signals, information, stress and consciousness on food choices

Marcos Esau Dominguez Viera

Propositions

1. Reduced financial stress improves food choice in lower-income areas.
   (this thesis)

2. Changes in consumer preferences are more effective to radically improve diets than stringent fiscal policies.
   (this thesis)

3. The dissemination of scientific findings moves broader audiences when shared with a sense of empathy.

4. Indigenous health-related wisdom provides plenty of worthy hypotheses yet to be tested.

5. Sometimes a single social interaction with your supervisors has more value than several work-related meetings.

6. A PhD project is experienced with more joy by simultaneously pursuing other goals such as raising a family or doing endurance sports.

7. If you want others to value your work, you should value it yourself first.

Propositions belonging to the thesis, entitled

Road to a Healthier Mexico: The influence of price signals, information, stress and consciousness on food choices

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Thesis

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CHAPTER 1

General Introduction

1.1 PROBLEM STATEMENT

The global burden of obesity and diet-related non-communicable diseases are threatening some of the gains of decades of economic development. If these issues keep growing at the same pace, some benefits of development such as life expectancy and disability free living would be significantly reduced in the future (Popkin & Ng, 2021). The burden of the obesity pandemic has been shifting towards low- and middle-income countries (LMIC) in general, but it is now growing faster among the poor than the rich only in some regions, particularly in Latin America and the Caribbean and in the Middle East and North Africa (Ford et al., 2017; Popkin & Ng, 2021; Popkin & Reardon, 2018). The proliferation of such issues is the direct result of these countries mimicking a Western-type dietary pattern, whereby diets deviate from whole foods and become richer in animal fats, sugars, and processed foods (Giuntella et al., 2020; Popkin & Gordon-Larsen, 2004). Such nutrition transition and resulting public health issues are intertwined with environmental degradation processes, which call for systemic approaches that account for diet-environment connections (Willett et al., 2019). Therefore, a dramatic food system transformation is urgently needed to promote healthier diets that benefit both humans and our planet.

Promoting healthier diets and reducing obesity are intricate tasks, as they are bounded by several factors. While there are diverse approaches, this work departed from the conception that such factors can be divided in traditional factors, which are extensively studied in traditional economic theory, such as affordability, knowledge and availability; and emerging factors, which are increasingly studied in behavioural economics, such as the role of stress in inducing biases and heuristics in individuals decision-making, particularly in contexts of financial strain (Ford et al., 2017; Mancino et al., 2018; van Rongen et al., 2019). Recently, the emerging factors are gaining considerable attention in other fields such as consumer behaviour and among policy makers, because long used strategies such as relying on information to increase knowledge show limited effectiveness on behaviour change (van Kleef & van Trijp, 2018; Wilson et al., 2016). For example, the focus on information measures may influence attitudes and willingness to adopt more sustainable food consumption, but it has been shown to have a limited impact on actual consumption (Vellinga et al., 2022). That being said, we should be cognizant that there is an interplay between both types of factors, which furtherly complicates steering individuals to do healthier food choices (Just & Gabrielyan, 2018).

Dual-decision models provide a practical framework to depict the interactions between the traditional and emerging factors that shape food choice (Loewenstein et al., 2015). Under this framework, every decision is the outcome of the interplay between a deliberate system in the mind that assesses options in a broad, goal-oriented manner and

an affective system, which encompasses emotions and motivational drives. At first sight, a deliberate food decision would be based on aspects such as budget constraints, the available information in terms of nutrition and expected health benefits from consuming certain foods and the existing products in the immediate food environment. Hereafter, affective-based mechanisms in the mind may interfere with a thoughtful food decision. Such affective motivations would rely more on habits, convenience, taste or marketing messaging that triggers consumer impulses (Just & Gabrielyan, 2018). Under cognitive load or stress, individuals would be more prone to affective influences and its associated factors (Ruhm, 2012). All consumers experience such issues to a certain extent, but low-income populations are significantly more affected by them as they persistently experience financial worries in their daily lives (Dalton et al., 2019). Furthermore, affective motivations may bound information uptake among consumers in general and would lead low-income consumers to overly focus on cues about affordability (Carroll et al., 2018; Zhao & Tomm, 2017). Thus, emerging factors such as stress influence consumer behaviour directly, as well as indirectly by interfering with the influence of traditional factors.

There is certain level of consensus that points towards the effectiveness of diversifying the menu of tools to change human behaviour (Duckworth et al., 2018; Just & Gabrielyan, 2016; Marette et al., 2016; Mercer et al., 2003). For instance, self- and other-deployed (e.g., paternalistic policies) strategies may lead to the same objective by distinct means. The former type of strategy (e.g., commitment devices, cognitive therapy, meditation) typically works through bringing conscious awareness about self-control issues top of mind; whereas the latter type of strategy (e.g., taxes, changes in the environment) forces the desired behaviour without the need of such self-awareness. Therefore, this thesis comprises a mix of strategies and barrier linked to traditional and emerging factors driving food choice. For instance, it includes an assessment of the possibilities to attain a healthy and sustainable diet through price incentives (disincentives) and changes in consumer preferences, where the latter aspects are determined by both traditional and emerging factors. Moreover, this thesis examines the role of affordability, information and stress on the demand for healthy foods in low-income communities. Additionally, an intervention is executed at schools to assess the effect of stress-reduction strategies together with information on students' food choices.

This study employes samples of households, adult shoppers and children from Mexico. The direct consequences of the nutrition transition strike Mexico earlier than elsewhere in Latin America and the Caribbean (Popkin & Reardon, 2018). In this country, overweight and obesity affect three and seven out of ten adults and children, respectively (Rivera-Dommarco et al., 2018). Furthermore, Mexico is one of the large LIMC where the poor face increasingly higher prevalence of overweight and obesity than the well-off (Popkin & Ng, 2021). The country is also well-known for the policy efforts to fight obesity and unhealthy

eating; it was the first to establish demand-related solutions via taxation and one of the first in Latin America to establish more stringent marketing controls (Barrientos-Gutiérrez et al., 2018; Popkin & Reardon, 2018). Additional strategies are required in the country, such as dietary guidelines incorporating sustainability interconnections and a stronger support from the food industry. Likewise, more stringent fiscal measures are needed considering the anemic effects of the existing policies, which is expected as small price changes are likely neglected on the consumer side (Colchero et al., 2016; Jaacks, 2019; Just & Gabrielyan, 2016). This research attempts to provide input to design such policies, which are urgently needed, as no country has reached the last stage in the nutrition transition, where a generalized behavioural change unlocks healthy and sustainable diets at population level.

1.2 OBJECTIVE AND RESEARCH QUESTIONS

The goal of this thesis is to gauge the impact of fiscal policies, information, poverty stress and stress reduction strategies on the likelihood of attaining healthy and sustainable diets in Mexico. In particular, we assess the effectiveness of taxes and subsidies to healthy and unhealthy foods, respectively, to reach a healthy and sustainable reference diet (Chapter 2). Hereafter, we aim to measure the effect of providing nutrition and health information and the role of poverty stress, respectively, on the willingness to pay for healthier foods in low-income communities (Chapters 3 and 4). Finally, we determine the impact of stress-reducing meditation practices among school-age children on their food choices (Chapter 5).

The following specific research questions guided this work:

a) Strategies linked to traditional factors driving food choice:
    1. What is the impact of the adoption of a healthy and sustainable diet at population level? Do fiscal policies enable households from different income levels and regions to reach such diet?

(Chapter 2)

    2. What is the potential demand for healthier foods in low-income communities? Does information increase the willingness to pay for healthier foods in such communities?

(Chapters 3)

b) Barrier and strategy linked to emerging factors driving food choice:

3. Does poverty-related stress reduce the potential demand for healthier foods in low-income communities?

(Chapters 4)

4. Do stress reduction strategies improve food choice of school-age children? Do the same strategies reduce the likelihood of dynamically inconsistent food choices?

(Chapter 5)

Fig. 1 below comprises the overall framework of the thesis starting from the main driving factor analysed to the common outcome in all chapters. From a food systems perspective, the aspects addressed by the different chapters focus on the interaction between consumer behavior and the characteristics of the food environment (de Brauw et al., 2019). In this sense, the framework employed revolves around selected positive (i.e., price, information and emotion regulation) and negative (i.e., emotions) incentives within the food system to influence food choice at the country, household and individual levels of analysis.

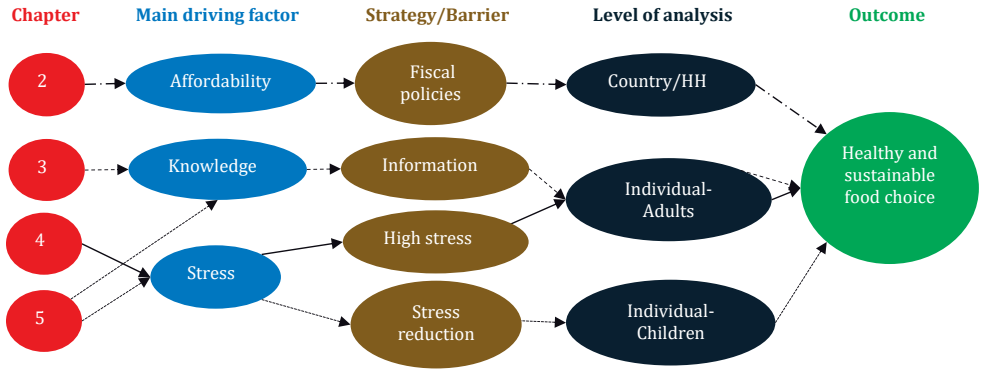

Fig. 1. Overview of this thesis' framework.

Each chapter defines the general outcome of interest differently. The healthy dietary pattern employed in chapter 2 is defined by Willett et al. (2019), based on an assessment of nutrition adequacy and predictions of mortality rates. The sustainability in diets as described in the same chapter, relates to reductions in land pressure, water use and greenhouse emissions, which result from the adoption of such healthy dietary pattern. Healthy diets as defined in chapters 3-5, imply the selection of food products with improved macronutrients, micronutrients and ingredients profile (e.g., lower calories, fat, sodium and sugar; higher protein and fibre content; higher iron and calcium content).

1.3 LITERATURE

This study intends to contribute to three main debates in the academic literature regarding the effectiveness of interventions for improving food choice.

1.3.1 Fiscal policies to promote healthy and sustainable diets

There is a large set of observational and experimental evidence on the impact of food pricing strategies on the improvement of dietary consumption (Afshin et al., 2017; Cornelsen et al., 2015; Green et al., 2013; Thow et al., 2014). Such policies are widely recommended in the literature on promotion and affordability of healthy and sustainable diets, as well as by public health experts (Castellanos-Gutiérrez et al., 2021; Hirvonen et al., 2020; Popkin & Ng, 2021; Raghunathan et al., 2020; Rivera-Dommarco et al., 2018; Willett et al., 2019). The overall consensus in the mentioned literature is that both taxes and subsidies to unhealthy and healthy foods, respectively, can be effective means to improve the quality of food consumption. Yet, the focus of this literature is on specific types of foods (not a dietary pattern as a whole) and does not incorporate the sustainability dimension, which has implications for the type of diet recommended (Caro et al., 2020, 2017a; Guerrero-López et al., 2017).

Studies modelling pricing shocks to attain healthy and sustainable diets usually perform analyses at global scale (Latka et al., 2021). More nuanced approaches at the country-level and for different types of households are scarce. In addition, long-term dynamics are usually missing in the studies on the affordability of diets, which may provide inaccurate conclusions (Batis et al., 2021; Herforth et al., 2020; Raghunathan et al., 2020).

Chapter 2 provides therefore a detailed assessment of the effectiveness of fiscal policies to reach a healthy and sustainable dietary pattern at population level, as well as for different households in a specific middle-income country context (Mexico). Dynamics towards 2050 are analysed through a multidimensional analysis, which includes, nutrition, affordability, economy and environmental outcomes.

1.3.2 Demand for healthier foods in low-income communities

In the desired final stage in the nutrition transition, the availability of healthier processed foods, would require a significant expansion of the retail markets, which to date has only happened for some niche markets in certain high-income countries (Popkin & Reardon, 2018). At the same time, studies on the availability of healthy unprocessed and processed foods shed light on the higher availability of such products in higher-income areas as compared to lower-income areas within the same regions (Cummins et al., 2010; Hamelin et al., 2002; Marrón-Ponce et al., 2020a; Pérez-Ferrer et al., 2019). Food retailers would offer more of these foods if sufficient demand were perceived in lower-income

communities, which opens the door for research showing the possibilities to boost the demand for healthy processed foods in these communities (Andreyeva et al., 2010). Whereas there is substantial evidence on the potential demand for nutritionally enhanced products via biofortification, fortification or composite variants of low-cost staple foods, the existing evidence on demand for healthier variants of more processed foods is limited to consumers in higher-income countries (Birol et al., 2015; Chege et al., 2019; Hellyer et al., 2012; Teuber et al., 2016; Vecchio et al., 2016).

Chapter 3 addresses this gap by examining the potential demand and pathways to facilitate an increased demand for healthier variants of processed foods in low-income communities in the centre of Mexico. In the context of the ongoing nutrition transition, the specific product selection acknowledges a trend in large and sophisticated markets in middle-income countries, where convenience-driven consumers have deviated from traditional grains (i.e., maize) (Dominguez-Viera et al., 2022; Popkin & Reardon, 2018).

Chapter 4 lies in the intersection between the above research and the body of behavioural economics literature on scarcity. The scarcity literature highlights the impact of poverty on individuals' decision-making processes and behaviours (Bruijn, 2021). To date, there is a lack of evidence within this field addressing the impact of such scarcity mindset on healthier food choices. So far, this aspect has been partially tested only in a few studies (Huijsmans et al., 2019; Schofield & Venkataramani, 2021). In this sense, the aim of chapter 4 is to test if poverty-related stress reduces the demand for healthier foods among lower-income shoppers. Additionally, we determined if such source of stress affected the uptake of nutrition information. These findings complement chapter 3's framework, as the healthfulness of the available products in retail markets is influenced by emotionally-driven consumer-behaviours (Ruhm, 2012).

1.3.3 School interventions to influence food choice

There is substantial research on school interventions to improve diets among students, which is mainly centred in high-income countries (DeCosta et al., 2017; Evans et al., 2012; Madden et al., 2017). Schools are a fruitful ground for interventions as they provide easy, continuous and intensive access to children (Dudley et al., 2015). Another advantage of these school settings is that eating behaviours start shaping at school-age, which sets the stage for potential long-lasting effects (Campbell et al., 2014).

Standard school interventions mostly rely on paternalistic strategies such as nudges, incentives and changes in the food environment (Belot et al., 2016; DeCosta et al., 2017; List & Samek, 2015; Loewenstein et al., 2016). There is a research gap on studies electing strategies that empower students to make healthier, conscious food choices in a way that they preserve their personal agency (Duckworth et al., 2018; Reijula & Hertwig, 2022;

Salam et al., 2020). These strategies usually improve emotional self-regulation, which is relevant nowadays that the recent COVID-19 pandemic affected the psychological well-being of adults and children (Kar et al., 2021; Landa-Blanco et al., 2021). A limitation of the few studies that employ these strategies is that their analyses are typically based on limited sample sizes, which compromises the generalization of their results (de Lara Perez & Delgado-Rios, 2022).

Chapter 5 relates to a self-deployed strategy that equips a large sample of primary school children to make more conscious food choices in the south of Mexico. This study also tests the possibilities to influence dynamic inconsistencies in the food choice domain, which is a new concept in economics that has been only tested among adults (Alem et al., 2021).

1.4 MATERIALS AND METHODS

Our research relies on different data sets and uses various research methods that are tailored to the before-outlined research questions.

1.4.1 Macro-microsimulation

The analysis in chapter 2 relies on a neoclassical recursive dynamic, multi-regional, multi-commodity computable general equilibrium (CGE) model. This macro model is linked to a nutritional database, which enables to determine impacts of economic shocks on nutritional outcomes. It allows country-specific assessments, in this case for Mexico, as regional aggregations are customizable. At the household level, this model represents the behavior of a single representative houshold. To enrich the analysis, outcomes from MAGNET are coupled with demand system estimations with disaggregated results for different types of households. The data used in the demand system estimations is based on the Mexican income and expenditure survey, which comprises a sample of around 75 thousand households.

The macro model is well-suited to answer the first part of research question 1, as the link between the economic sectors and the nutritional database enables the imposition of the dietary patterns at hand. Similarly, its modular nature facilitates multidimensional assessments of the desired dietary sock. The second half of research question 1 will be answered with the combined macro-microsimulation approach, which allows to determine heterogenous effects of the dietary scenarios for households from different income and regional levels.

First, a healthy and sustainable diet is imposed in MAGNET via policy measures and changes in consumer preferences to compare its outcomes with a business-as-usual scenario

towards 2050. Then, price effects from a simulation of tax adjustments on MAGNET were used to assess the likelihood to attain two types of healthy and sustainable diets by the lowest-income, highest-income, rural and urban households. The diets modelled are based on the EAT-Lancet framework, one of them was adapted in a previous study to the actual consumption of the Mexican population, while the other is a contribution of this work and is aligned with traditional eating patterns in Mexico (Castellanos-Gutiérrez et al., 2021; Secretaria de Salud, 2020; Willett et al., 2019).

1.4.2 Experimental studies

Chapters 3 and 4 are based on two different samples collected during the same lab-in-the-field experiment in the centre of Mexico. The experiment has a randomized design, where in the case of chapter 3, half of the participants received nutrition information about two healthy packaged bread varieties. For chapter 4, an additional treatment is introduced, which created a 2x2 factorial design, where the two treatments are nutrition information and poverty-related stress. Stress is induced via an induction procedure, where participants engaged in a conversation about a hypothetical scenario regarding an unexpected expenditure to cover a health issue. The outcome of interest for both chapters is the willingness to pay for both breads, which is elicited through the well-known Becker-DeGroot-Marschak (BDM) auction-type mechanism.

BDM's incentive compatible nature increases the likelihood of participants revealing their true preferences, which aids to deal with the demand-related research question 2. Likewise, the priming procedure has been proven to effectively bring pre-existing financial preoccupations top of mind, which combined with the BDM auction serves as a reliable mechanism to address research question 3.

The field experiment in chapter 5 was executed in 27 schools in the south of Mexico. Half of the school classes in the sample are randomly assigned to participate in a meditation program. The program involved six audios with basic relaxation techniques and intuitive messages to guide food choice. The outcome is based on a stated preference food choice experiment, where students had to choose between a traditional bar high in grains and reduced in sugar content (i.e., healthy snack) and a chocolate snack high in calories, saturated fat and sugar (i.e., unhealthy snack). All participants received information signalling that the healthy snack was nutritious. Dynamically inconsistent food choices are measured at the end of the experiment to determine if the meditation program reduced such inconsistencies towards the unhealthy snack.

The experimental treatment involves a proven strategy to reduce stress and is also purposely designed to influence food choice. Likewise, the experiment is set to determine dynamic inconsistencies following the related literature. It involved a shorter gap between

the advance and immediate choice as compared with other studies, as children may show more impulsivity than adults. Therefore, I posit that the experiment in chapter 5 is well-suited to tackle both components of research question 4.

1.5 THESIS OUTLINE

The remainder of the thesis is structured as follows.

Chapter 2 presents a macro-microsimulation analysis to determine the impact and possibilities for Mexico to reach a healthy and sustainable diet in the future. It includes a set of paternalistic policies (i.e., taxes, subsidies) and simulated changes in consumer preferences, thereby including a comprehensive bundle of traditional (and implicitly emerging) strategies to reach the desired dietary shift at population level and by groups of households.

In chapters 3 and 4 we zoom in to examine the behavior of adult shoppers in peri-urban Mexico City. There, the demand for healthier variants of processed foods is elicited and pathways to increase its purchases are detailed, for instance through traditional aspects such as information and sensory improvements of the products.

Chapter 4 starts with the exploration of emerging factors by experimentally estimating the impact of poverty-related stress on the willingness to pay for healthier variants of processed foods. As explained, this experiment complements the findings of chapter 3.

In chapter 5, the focus shifts towards children and alternatives to counteract the negative role of the emerging barrier presented in chapter 4 (i.e., stress). The strategy used here is a softer strategy as compared to the paternalistic tool used in chapter 2 (i.e., taxation), as it focuses on directly solving self-control issues in the individual, rather than reducing the need for it by intervening the food environment.

Chapter 6 provides a summary of our research findings and concludes with an overall discussion on the relevance of our findings for science and policymaking.

CHAPTER 2

2

Economic Pathways to Healthy, Sustainable and Culturally Acceptable Diets

The case of Mexico

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ABSTRACT

A predominantly plant-based diet would aid low- and middle- income countries to deviate from the existing negative trends in health and environmental outcomes. Taking Mexico as case study, we assessed the impact of adopting such diet on multiple food system indicators and identified a menu of fiscal policies to reach the intake targets determined in the EAT-Lancet framework. A macroeconomic model named MAGNET and a Quadratic Almost Ideal Demand System model were employed for the analysis. Two diets were modelled, an adaptation of the EAT diet considering existing intakes in Mexico and a version proposed here based on traditional eating patterns (i.e., Milpa diet). Our results showcased that the magnitude of the changes needed to attain the proposed dietary intakes is such, that fiscal policies alone were found implausible. We thus modelled the change to two thirds of the EAT targets by 2040 (the goal was 100% of the EAT targets by 2050). Still, to keep fiscal policies feasible (up to over +/-80% ad-valorem tax rates) 75% of the required change in consumption would need to come from other strategies. Substantial environmental gains are expected from the adoption of the EAT diet, but at the same time, foods would be more affordable for all but the poorer households. At the household level, subsidies would improve the intakes of fruits, vegetables and added-fats, but the targets would be attained only by the highest income households and closely followed by urban households. Subsidies would be ineffective to reach the intake target for plant-based proteins. Given the projected progress, increased taxes are strongly advised for the foods with targeted intake reductions, particularly for the well-off and urban households. Policy makers should be cautious in the design of taxes to dairy foods, as these could lead to excessive intake reductions among vulnerable populations.

2.1 INTRODUCTION

The global syndemic of malnutrition and climate change is creating compound long-term effects that pose substantial challenges to the health of the world population (Swinburn et al., 2019). As a response to those challenges, there are recent proposals such as the EAT reference diet (EAT), that call for a radical food system transformation that may enable to achieve both healthy eating and sustainability goals (Springmann et al., 2018; Willett et al., 2019). These approaches entail a new dietary pattern composed of a diversity of plant-based foods and very small quantities of animal-source foods. Such pattern would provide complete nutrition adequacy at affordable prices for a large share of the population in some low- and middle income countries (LMIC) (Bai et al., 2020; Hirvonen et al., 2020). However, the long-term effects of this dietary shift in LMIC are uncertain and its attainment competes with the aggressive marketing, taste, convenience, and accessibility of unhealthy foods. Furthermore, healthy and nutritious diets are presumably unaffordable for the world's poorest people (Hirvonen et al., 2020; Raghunathan et al., 2020; Springmann et al., 2021). At the same time, reaching such ambitious goals in LMIC is complicated by high prevalence of malnutrition in all its forms and an ongoing transition towards the Western meat-based dietary pattern (Kim et al., 2020). In this vein, country-specific analyses may aid to assess the impact of reaching the desired dietary targets on the food system and to identify viable strategies to attain them in LMIC (Kim et al., 2020; Springmann et al., 2018).

Transforming dietary patterns at the level envisioned in the EAT-Lancet report will require multiple system-level interventions (Latka et al., 2021; Swinburn et al., 2019). Food choices are shaped by individual and community-level differences in income, prices and preferences about food attributes, which are in turn mediated by multiple factors such as biological conditions, culture, habits and social norms (Finaret & Masters, 2019). Many studies have shown that directly lowering prices of nutrient-rich foods has a higher impact on diet quality than lowering prices of basic staples and would also enable nutrition education and behaviour change to be effective (Cornelsen et al., 2015; Green et al., 2013; Herforth et al., 2020). In this sense, fiscal incentives (disincentives) for healthy (unhealthy) foods may aid to reach healthier diets.

Mexico was one of the first countries worldwide to implement fiscal policies to disincentive the intake of unhealthy sugar-sweetened beverages and non-basic energy-dense foods. Such strategies remain a key component of the set of public policies recommended by Mexican public health experts to achieve healthier dietary intake in the population (Rivera-Dommarco et al., 2018). Furthermore, efforts to promote healthy and sustainable eating as proposed in the EAT diet are currently underway in Mexico. Relative to the EAT diet, food groups consumed in excess among the Mexican population are red and processed meats,

eggs, added sugars, low-fiber grains, and grains with excess added sugar and/or saturated fat; while food groups consumed in lower amounts are nuts, legumes, vegetables, fruits, and whole grains (Castellanos-Gutiérrez et al., 2021). Among the subpopulation groups, the preservation of healthy food traditions makes the food intake of Mexican poor, rural and indigenous populations more consistent with the EAT, whereas the opposite trend is observed among non-poor, urban and non-indigenous populations (Castellanos-Gutiérrez et al., 2021). Thus, one strategy conducted by the Mexican government is to promote traditional nutrient-rich foods to achieve food and nutrition security in low-income communities (Secretaria de Salud, 2020). Some of these foods are relatively underutilized (e.g., amaranth, insects) and have the potential to complement and even substitute common animal-source foods at lower monetary and environmental costs (Arendt & Zannini, 2013; Kim et al., 2020; Weindl et al., 2020). Moreover, the Mexican government is also taking into consideration the traditional diets and the EAT model to develop new food dietary guidelines that are not only healthy, sustainable and affordable, but also culturally acceptable (Castellanos-Gutiérrez et al., 2021). Therefore, it is of our interest to model the expected outcomes and necessary fiscal schemes to attain the EAT recommendations in Mexico, with two dietary approaches, one that incorporates the existing deviations in consumption from the EAT dietary targets and another that emphasizes traditional foods in each of the targets.

Economy-wide methods such as computable general equilibrium (CGE) models are well suited to assess the long-term impact of fiscal policies, because they capture all economic linkages and interactions between all sectors and institutions within the domestic economy and foreign trade (Ecker et al., 2012). These models have been used in the past to do foresight studies focused on food security (Brinkman et al., 2020; Doelman et al., 2019; van Meijl et al., 2020) and to assess the possibilities to transform country-level food systems to promote healthy diets (Kuiper & Cui, 2020; Latka et al., 2021; Smeets-Kristkova et al., 2019). Likewise, coupling CGE models with microsimulations is a potential approach that has been employed to assess food and nutrition outcomes (Breisinger & Ecker, 2014). Among microsimulation models, different variants of demand systems are frequently used to study changes in food consumption (Cornelsen et al., 2015; Finaret & Masters, 2019). The synergy of macro-micro models allows a more nuanced analysis of food system interventions, as general equilibrium models comprise the aggregate economic behaviour of groups such as producers and consumers, and micro models allow more disaggregated sets of commodities and household types.

The goal of this paper is twofold: 1) to assess the impact of adopting the EAT diet at population level on nutrition, affordability, economy and sustainability outcomes; 2) to identify a menu of fiscal policies to enable households from different socioeconomic status and regions to reach the EAT targets. Mexico was chosen among LMIC, given its

pioneer role in the enforcement of fiscal measures to improve diets and its ongoing efforts to incorporate the EAT model in nutrition policies. Two versions of the EAT diets were modelled for this analysis, an adaptation to the Mexican population proposed by Castellanos-Gutiérrez et al. (2021) (EAT-Mx) and a dietary pattern that is consistent with Mexican traditional diets (Milpa-EAT-Mx). We analysed the impact of adopting both diet versions with a dynamic CGE for Mexico. With this model, we ran baseline and EAT diets' imposition scenarios. Based on the results obtained, we undertook a multi-dimensional assessment with several indicators per outcome of interest. To assess the possibilities to attain the desired dietary change, we imposed subsidies and taxes to foods with lower and higher intakes than in the EAT diets, respectively, in the CGE framework. Furthermore, we adopted a top-down procedure where outcomes from the CGE analysis were used in Quadratic Almost Ideal Demand System (QUAIDS) microsimulations to obtain disaggregated results by household income level and urban/rural areas. Our study is the first to use these mixed methods to analyse specific pathways to achieve the EAT diet at country level among LMIC. Another novelty of this research is its regional orientation towards a Mesoamerican diet, which lies outside the overly addressed Mediterranean diet and newly highlighted Nordic diet (Krznarić et al., 2021).

In the next section, we describe the composition of the different EAT propositions, as well as the macro and micro models used to run scenarios towards 2050. The third section provides the results of our simulation exercises. Then, we present the general discussion and policy implications. Finally, we state the main conclusions of the study.

2.2 METHODOLOGY

2.2.1 Addition of Mexican traditional foods to the EAT

The EAT–Lancet Commission recommends a dietary pattern predominately composed of fruits, whole grains, legumes, vegetables, nuts, and unsaturated oils; while it includes a low to moderate amount of seafood and poultry, and contains no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables. Table 1 (column 1) shows the EAT's recommended intakes by food group, adjusted for the mean daily energy intake among Mexican adults of 1,947 kcal/day (Castellanos-Gutiérrez et al., 2021).

The EAT can be adapted to the culture, geography, and demography of the population and individuals in any country. With that in mind, Castellanos-Gutiérrez and co-authors proposed an adaptation of this diet to the context of Mexico (EAT-Mx). To develop their proposition, these authors compared the EAT recommended intakes with the current

Mexican dietary guidelines, and analysed current intakes among a nationally representative sample of adults that completed a 24-hour dietary recall in the Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016. The EAT-Mx differs with respect to the EAT diet by: 1) allowing the intake of small amounts of processed foods with added fat or sugars, and refined grains because the consumption of these foods groups is very high in Mexico and it would be unfeasible to eliminate them; 2) increasing the intake of poultry and eggs to the level of current Mexican intakes to require a less drastic increase of plant-based proteins; 3) increasing the proportion contributed by legumes vs. nuts in the plant-based proteins group, because it is more feasible to increase the consumption of legumes than nuts, as products such as beans are already highly used in the Mexican culinary tradition; 4) allowing a very small intake of processed meats (Table 1, column 2).

To highlight the Mexican traditional foods in the EAT framework, we followed the proposal by Secretaria de Salud (2020). The diet addressed in this report is based on Mesoamerican agroecological production systems (i.e., Milpa) and is consistent with the criteria established in the EAT report. The composition of this diet deviates from the other EAT propositions in the following aspects: 1) it focuses exclusively on maize and amaranth within the whole grains category (i.e., no rice nor wheat); 2) among dairy foods it includes traditional cheeses (especially low-fat), but no yoghurt, milk or dairy products with excess added sugars; 3) animal proteins are mainly comprised by birds (e.g., chicken, turkey), eggs, local fish, other meats (e.g., iguana, deer, rabbit) and edible insects (e.g., grasshoppers, *maguey* worms), but no red meat and processed meats; 4) it avoids processed foods such as refined grains and those with added sugars or saturated fat; 5) added sugars are mainly composed of traditional sweeteners (e.g., agave syrup, *piloncillo*) 6) the composition of the rest food groups not mentioned in points 1-5 (e.g., fruits, vegetables) is based on varieties from the Mexican traditional diet. Based on the previously described framework, we estimated that currently, traditional foods account for 38% of the daily energy intake among Mexican adults (Table 1, column 5). Their contribution is relatively low in most food groups, whereas it is important (50% and above) within the categories of grains, vegetables and protein sources, particularly for chicken, eggs and legumes. The shares are higher in rural areas and among the lowest socioeconomic status groups, where these foods represent almost half of the total energy intake (Appendix 1).

Specific energy intakes by food group were proposed here based on the criteria described above. We modified the EAT-Mx to incorporate new food subgroups (i.e., insects and other meats) and adjusted the caloric intakes for those foods (e.g., refined grains, red meat) not considered in this diet (Table 1, column 3). The intake of corn was increased to the lower-bound of the intake in rural areas, which better resembles traditional eating patterns. The remaining calories to attain the EAT amount of whole grains were complemented with amaranth. The suggested intakes of red meat and processed meat

in the EAT-Mx were partially transferred to insects and other meats, respectively, as they have a similar macronutrient profile (FAO, 2020). The specific energy intakes were based on mean intakes of actual consumers among the Mexican population (Appendix 1).

Table 1
EAT diet proposals, mean Mexican energy intake and contribution from traditional foods by food group.

EAT food groups	Proposals			Mean intake (MI)	Contribution from traditional foods to MI
	EAT**	EAT-Mx	Milpa-EAT-Mx		
	kcal/day				%
	(1)	(2)	(3)	(4)	(5)
Grains					
High-fiber grains	631				
Corn		453	554	453	100.0
Other high-fiber grains (e.g., wheat, rice, amaranth)		41	84	11	0.0
Low-fiber grains					
Refined grains	--	54	--	119	--
Grains with excess added sugar or saturated fat	--	90	--	226	--
Tubers or starchy vegetables					
Potatoes and cassava	30	23	23	23	2.5
Vegetables					
All vegetables	61	61	61	47	49.9
Fruits					
All fruits	98	98	98	73	13.6
Dairy foods					
Whole milk or derivative equivalents (e.g., cheese)	119	91	121	91	33.2
Dairy with excess added sugar	--	30	--	74	--
Protein sources					
Red meat	23	23	--	125	--
Processed meat	--	6	--	30	--
Insects**	--		16	0	--
Other meats (e.g. iguana, rabbit)**	--		5	0	--
Chicken and other poultry	48	78	80	78	100.0
Eggs	15	47	50	47	100.0
Fish	31	31	31	15	42.9
Legumes	221	253	253	77	89.9
Nuts and seeds	226	126	126	7	34.6

Added fats					
Plant oils	322	302	322	161	10.4
Lard or tallow	28	24	28	24	0.0
Added sugars					
All sweeteners	93	5	5	11	32.5
Confectionary and desserts	--	90	90	14	--
Sugar-sweetened beverages	--		--	218	0.5
Others	--	22	--	22	28.5
Total energy	**1,947**	**1,947**	**1,947**	**1,947**	**38.4**

Notes: Symbol "--" in column 5 means that there are no traditional foods classified in the corresponding food group, except for the insects and other meats groups. EAT, EAT-Lancet Commission healthy reference diet; EAT-Mx, adapted version defined by Castellanos-Gutierrez et al. (2021); Milpa-EAT-Mx, EAT version including Mexican traditional foods. *New food subgroups added with respect to EAT-Mx. **Values adjusted to be consistent with the mean daily energy intake of Mexican adults.
Source: Castellanos-Gutierrez et al. (2021) and Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016.

Increased/added with respect to EAT-Mx
Omitted with respect to EAT-Mx
Preserved the EAT recommendation

2.2.2 Macrosimulation of the shift towards the EAT diets

2.2.2.1 Description of the applied CGE model MAGNET

MAGNET (Modular Applied General Equilibrium Tool) is a neoclassical recursive dynamic, multi-regional, multi-commodity computable general equilibrium (CGE) model. It enables exploring food systems dynamics (i.e., scenarios) by capturing the interlinkages among different food industry players (e.g., farmers, processors, suppliers, traders, consumers) in one consistent framework (Fig. 1)[1]. At its core is the Global Trade Analysis Project (GTAP) model and its associated database. This paper applies the GTAP database version 10a with reference year 2014 in which production data is aligned with FAOSTAT (Chepeliev, 2020).

The sectoral aggregation used in this MAGNET version has a particular focus on the food system sectors (Table 2). Out of the total 43 sectors, there are 13 primary agriculture sectors, 3 fisheries sectors and 10 food processing sectors. There are 12 aggregated regions: Mexico, USA, Canada, China, Chile, Brazil, Spain, Rest of East Asia and Pacific, Rest of European Union, Rest of South America, Central America & Caribbean, and the Rest of the World. The main criteria to include individual countries was that they reached a cumulative share of 85% of Mexico's food imports, whereas the definition for the regions was based on existing trade agreements.

1 The description of main modelling features and modules is available at: https://www.magnet-model.eu/model/.

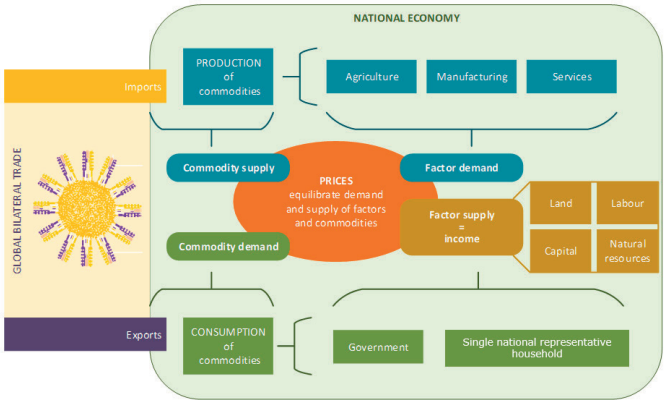

Fig. 1. Schematic representation of circular flow of income and spending in MAGNET.
Source: elaborated by Smeets-Kristkova et al. (2019).

Table 2
Sectoral aggregation in MAGNET.

Group	Sectors
Primary agriculture	paddy rice (rice), wheat (wht), other grains (gro); oilseeds (osd), raw sugar (sug), vegetables, fruits and nuts (hort), other crops (ocr), plant fibres (pfb); beef cattle (bfctl), other grazing animals such as sheep, goats, horses (othctl), wool (wol), pigs (pigpls), poultry (pltry), raw milk (rmk)
Food processing	beef meat (bfcmt), meat from other grazing animals (othcmt), other meat products (othmt), poultry meat (pulmt), dairy (dairy), sugar processing (sugar), vegetable oils and fats (vol), including crude vegetable oil (cvol), other food and beverages (ofd)
Fisheries	wild fishing (wfish); aquaculture (aqcltr), fish processing (fishp)
Supplying food system industries	fertiliser (fert), crude vegetable oil by-product oilcake (oilcake), fish meal (fishm), animal feed (feed), chemicals, rubbers and plastics – pesticides (othcrp), 1st generation bioethanol by-product distillers dried grains and solubles (ddgs)
Other sectors	traditional bio-based sectors, biofuels, Fossil fuels and other energy markets, other manufacturing (manu), transport (trans), accomodation and services (afs), wholesale and retail trade (trd), transport (trans), education (edu), human health and social work (hht), warehousing (whs), other services (svcs)

Notes: MAGNET codes in parentheses.

Among the existing modules in MAGNET, we activated the extension to incorporate the Global Expanded Nutrients Supply (GENUS) database (Smith et al., 2016). GENUS provides data on the supply of macro and micronutrients for 225 products in 175 countries based mainly on the FAO food balance sheets (FBS) for 2011. Edible food supply is obtained from the FBS estimates after considering slaughtering, peeling, etc. As the individual GENUS food items are mapped to MAGNET commodities, changes in household demand modelled in MAGNET can be used to update the nutritional indicators in GENUS. Details

of the adjustments to the GENUS database performed for this research are explained in appendix 2.

In MAGNET, the behaviour of private consumption of a single "representative household" is modelled via a constant difference of elasticity (CDE) function, which is well-suited for CGE models (Hertel, 2013). It is calibrated using the latest consumer elasticities applied in the GTAP model, which are obtained from Reimer & Hertel (2004). However, the application of these elasticities in long-term projections leads to excessive estimations of caloric consumption (>5000Kcal). To bring caloric projections to realistic levels, the MAGNET model uses a PPP-correction equation to endogenize income elasticities to reflect that countries that undergo rapid GDP growth will also see a reduced income elasticities. This is in line with recent global estimates showing that food income elasticities are almost zero or even negative for most countries (Muhammad et al., 2017).

2.2.2.2 Assumptions and drivers for the baseline scenario

The baseline scenario provides a projection of the world without major changes to the main policy instruments (i.e., business-as-usual). Since the base year is 2014, we first updated MAGNET's database for the 12 regions based on key macroeconomic drivers to 2019. GDP and population growth rates for the period 2014-2019 were obtained from historical data (Fricko et al., 2017; INEGI, 2021a). Ad-valorem consumption taxes were updated for the same period based on data from INEGI (2021b). After updating the database to 2019, we ran the model for 3 periods from 2019 to 2050 using indicators from the shared socioeconomic pathways (SSP), which are commonly used in foresight modelling exercises (Kuiper & Cui, 2020; Smeets-Kristkova et al., 2019). The SSP provide long-term projections on GDP, population growth and land productivity. We used the SSP2 projections, as they represent the Middle-of-the-Road scenario (Fricko et al., 2017). By 2050, Mexican GDP is expected to grow by 131%, which is around 2.7% annually. This corresponds to an increase in GDP per capita from 10.8 thousand USD to about 20.9 thousand USD by 2050 (constant prices of 2014). With respect to population, the annual growth rate was close to 1%, but the projections count with slow-down by the end of the period (0.3% during 2040-2050). This corresponds to an increase from 133 million to 159 million inhabitants in 2050. Regarding land productivity, the expected annual productivity rates for Mexico are about 0.7%. A summary of all the assumptions incorporated in the baseline scenario is presented in Table 3.

Diets and nutritional outcomes are the result of complex interlinkages of various food systems drivers. For the purpose of our analysis, we grouped food system indicators into four areas: nutrition, affordability, economy and sustainability. This set of indicators served to make comparisons with the diet shift scenarios detailed below.

Table 3
Baseline drivers and assumptions.

Drivers and MAGNET modules	Description
Macroeconomic drivers	Population growth: SSP2 – Medium Variant
	GDP growth: combination of sources: SSP2, INEGI historical data
Sectoral productivity	Land productivity: about 0.7% p.a. based on SSP2
	Technical change in aquaculture: about 5% per period based on FAO
	Feed efficiency improvements in livestock sectors: 1% - 2% p.a. based on IMAGE model
Tax alignment	Update taxes on domestic consumption based on historical data 2014-2019 from INEGI
Genus Data	Use of GENUS nutritional dataset and an adjustment to 24-hour dietary recall from health and nutrition survey

Sources: Fricko et al. (2017; INEGI (2021a, 2021b); Smith et al. (2016); Stehfest et al. (2014).

2.2.2.3 Definition of diet shift scenarios in MAGNET

The dietary shifts towards the EAT-Mx and Milpa-EAT-Mex were imposed through changes in domestic add-valorem taxes and a consumption preference shift. The latter factor implies altering the demand system such that households consume the imposed EAT diets irrespective of prices or incomes. In practice, such *taste shifters* change the composition of household consumption, without altering total expenditures. We assumed that the dietary shifts occur gradually from 2019 to 2050. In every period, either ad-valorem net taxes are adjusted to the target change in consumption or diet shifters are activated to achieve the same result without direct price intervention. As an alternative pathway, we implemented a combined scenario that imposes simultaneously changes in taste shifters and consumer taxes. Through the combined scenario, we determined the necessary changes in the taste shifter parameter such that the required adjustment in private consumption taxes (i.e., domestic and imported) to reach the diet targets are bounded above/below by +/-100%. Taxes are bounded to be not less than -100%, to keep prices in a positive set of numbers. For simplicity, the trajectories of the caloric intakes over the simulated period for the diets modelled follow a linear trend until 2050 (Figs. 2a and 2b).

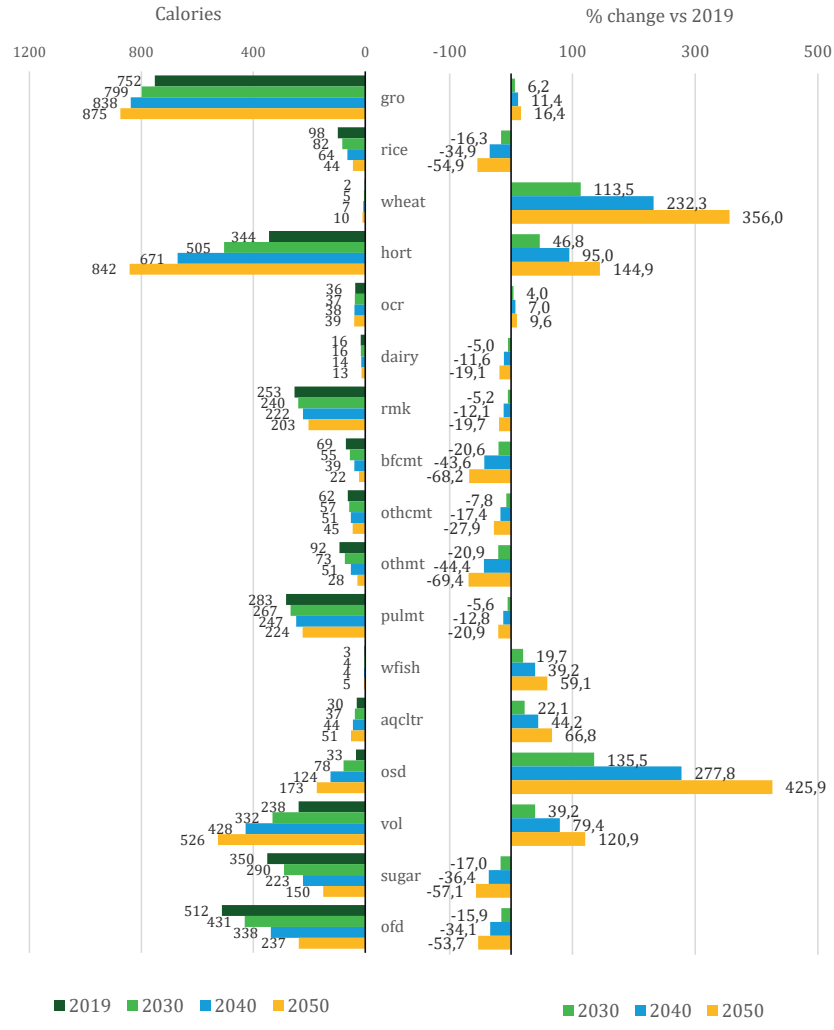

Fig. 2a: EAT-Mx. Simulated diet transition between 2019–2050.

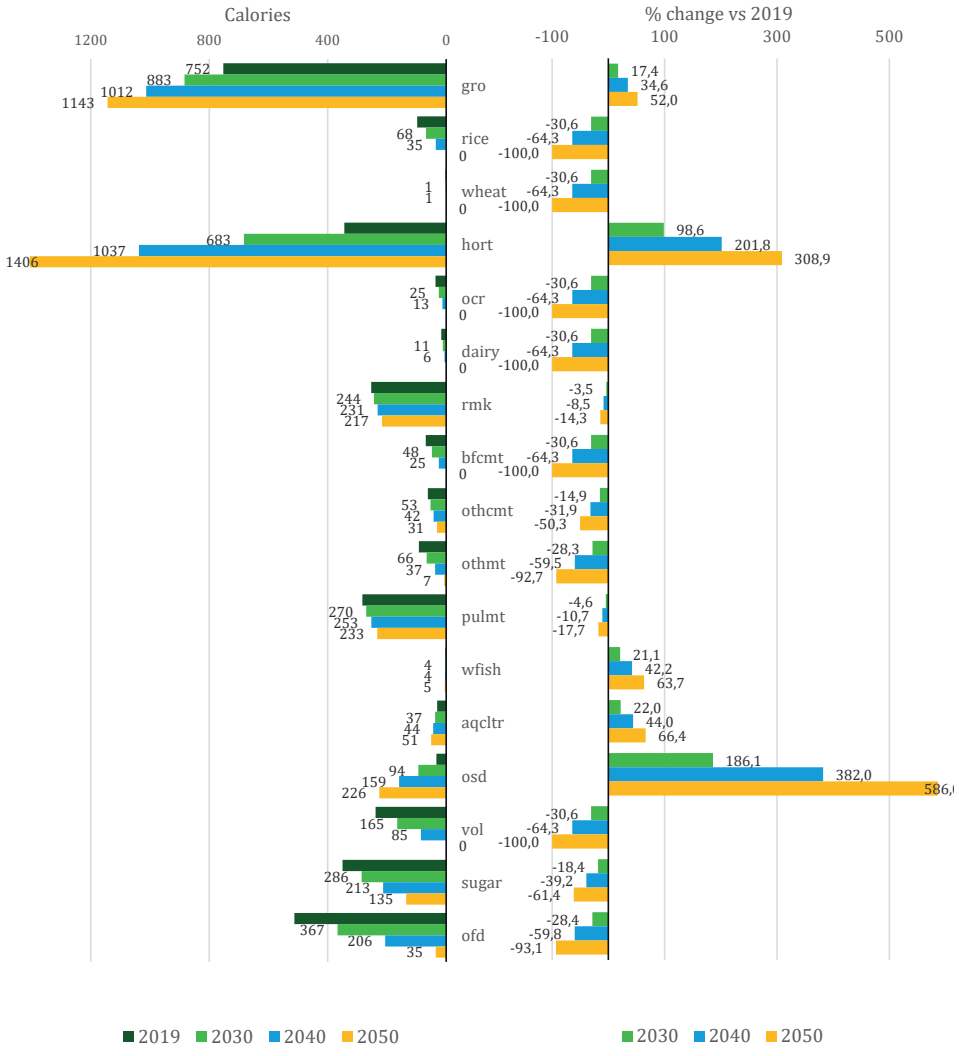

Fig. 2b: Milpa-EAT-Mx. Simulated diet transition between 2019–2050.

2.2.3 Microsimulation model to asses effects by household types

Micro-simulations require different income and price elasticities than those used in CGE models. The demand projections of economy-wide models such as MAGNET-GTAP estimate a long-run adjustment of a representative consumer to price and income changes. To do so, they rely on stylized demand systems for a single consumer and a small number of food groups (3 for MAGNET-GTAP) (Reimer & Hertel, 2004). Micro-simulations intend to calculate immediate responses across various types of households and need to capture the large variation of food expenditure shares between the poorest and the richest households. They therefore use elasticities estimated from detailed cross-sectional

household surveys applying flexible forms such as AIDS, AIDAIDS, and QUAIDS. The income and price elasticities obtained from such micro-modelling are generally higher than those implemented in GTAP or the MAGNET model, with values exceeding one for various food groups (Adekunle et al., 2020). Below, we explain how we estimated the demand system for our microsimulations.

2.2.3.1 Data

We employed the 2018 National Household Income and Expenditure Survey (ENIGH, by its initials in Spanish) for the microsimulation exercise. The ENIGH is a large cross-sectional survey carried out every two years between August and November in Mexican households. This survey has a probabilistic, two-stage stratified clustered design. It is representative at the national and state levels, in both cases with representativeness for urban and rural zones. The 2018 wave collected data for 74,647 households, but after cleaning the data from outliers in terms of sociodemographic variables, the final analytical sample was 74,198 households. Most household heads in the sample are males and at least completed secondary education (Table 4). Also, the majority of households are from urban areas.

Table 4
Summary of household sociodemographics

Variable	Mean	Std. Dev.	Min	Max
	(1)	(2)	(3)	(4)
Household head				
Age (years)	49.72	15.99	14	110
Gender (female=1)	0.27	0.45	0	1
At least completed secondary education (yes=1)	0.55	0.50	0	1
Household size	3.61	1.83	1	20
Zone (urban=1)	0.62	0.49	0	1

Notes: Observations equal to 74,198.
Source: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

2.2.3.2 Variable construction

For our analysis, we considered 247 food, tobacco and beverages items comprised in the ENIGH, as the purchase decisions for these products are jointly determined. These items were classified in the following 11 groups, which resemble the EAT categorization used above: 1) whole grains, 2) low-fiber grains; 3) tubers or starchy vegetables, 4) vegetables, 5) fruits, 6) dairy foods, 7) animal-based proteins, 8) plant-based proteins, 9) added fats, 10) added sugars, 11) others (e.g., foods away from home, condiments, non-sweetened beverages, tobacco). Expenditure shares and municipality level prices by food group were

computed following standard procedures used in similar studies, which are described in appendix 3 (Caro et al., 2017b; Colchero et al., 2015; Segovia et al., 2020). We also calculated adult equivalent units (AE), where a person of 5 years of age or younger equals to 0.77 AE, a person 6 to 12 years of age equals to 0.8 AE, someone 13 to 18 years of age equals to 0.88, and an adult (>18) equals to 1 AE. Lastly, we estimated the calorie availability by food group based on ENIGH data to implement the fiscal policy macro-microsimulations (Appendix 4).

2.2.3.3 Demand system framework and estimation

We employed a Quadratic Almost Ideal Demand System (QUAIDS) to estimate the price and income effects of our simulated fiscal policies across different diets and household types. This is a nonlinear demand system that was introduced by Banks et al. (1997), which provides an accurate depiction of relative price responses and an increased flexibility of the demand system representation. Alternatives would be AIDS and AIDAIDS. The various frameworks are quite similar in terms of functional flexibility and predictability of demands with cross sectional data (Cranfield et al., 2003). We applied standard modelling procedures widely used in the literature (Caro et al., 2017b; Colchero et al., 2015; Segovia et al., 2020). The expenditure share equation system is defined as follows:

$$w_i = \alpha_i + \sum_{k \in K} \rho_{ik} z_k + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{m}{a(\mathbf{p})}\right] + \frac{\lambda_i}{b(\mathbf{p})} \left\{\ln \left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 \quad \forall i \in I \qquad (1)$$

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{j \in I} \alpha_j \ln p_j + \frac{1}{2} \sum_{l \in I} \sum_{j \in I} \gamma_{lj} \ln p_l \ln p_j \qquad (2)$$

$$b(p) = \prod_{j \in I} p_j^{\beta_j} \qquad (3)$$

w_i and p_i represent the budget share $(p_i \times q_i / m)$ and price for each food group *i*, respectively; m is the total expenditure on all food groups included in the demand system. *I* represents the set of food groups, and z_k are the variables used as sociodemographic shifters. Specifically, we controlled for age, gender and education of the household head, the sum of AE within each household, dummy variables for the presence of children below 12 years of age, type of household (single =1, 0 otherwise) and zone (urban=1, 0 otherwise). Equations (2) and (3) are the nonlinear price aggregators. Lowercase Greek letters other than α_0 represent parameters to be estimated. Standard constraints over parameters were imposed, including adding-up of the demand system (i.e., $\alpha_0 = 3.8,$), homogeneity of degree zero on prices (i.e., demand does not change if prices and income change proportionately) and symmetry of the Slutsky matrix (i.e., complementarity or substitution effects between goods are symmetrical in direction and magnitude).

Two particular issues identified in the estimation of this type of demand systems were handled: 1) price endogeneity and 2) expenditure endogeneity, which were corrected

following procedures employed elsewhere, which are described in appendix 3 (Capacci & Mazzocchi, 2011; Caro et al., 2017b; Segovia et al., 2020). For sensitivity analysis, we also addressed censoring in the data through a two-step estimation procedure detailed elsewhere (Caro et al., 2017b; Segovia et al., 2020; Shonkwiler & Yen, 1999). We preferred the uncensored model for our main analysis because the values of the estimated elasticities were more in line with MAGNET-GTAP's values.

The parameters in equation (1) were estimated by iterated linear least-squares estimation, where following Banks et al. (1997) we set $\alpha_0 = 3.8$, which is slightly less than the lowest value of $\ln m$ observed in the data. After estimating the parameters of interest, expenditure, own and cross-price (uncompensated) elasticities were computed at the means of all variables in the model. The estimations of the uncensored and censored models were performed with the commands *aidsills* and *quaidsce*, respectively (Caro et al., 2021; Lecocq & Robin, 2015).

Finally, the elasticity values were used to estimate the effects of the fiscal measures by household income level (highest income vs lowest income) and zone (urban vs rural). To obtain these estimates, price effects were gathered from a macrosimulation of domestic add-valorem taxes shocks in MAGNET (size of taxes' shocks taken from combined scenario in section 2.2.3) and then multiplied by the corresponding (own/cross) price elasticities. With the resulting values and the calorie conversions in Table A.7, we estimated the impact on calorie availability. The same procedure just described was employed with the price effects of the baseline scenario (see section 2.2.2). Our approach differs from similar microsimulations, as we do not assume full pass-through of taxes, but rather the price changes that result when the new equilibrium is achieved in the CGE model.

2.3 RESULTS

2.3.1 Macro-level implications of imposing healthy and sustainable diets in Mexico

2.3.1.1 Baseline projections of diets and food systems

Table 5 shows the outcomes of the business-as-usual scenario. With respect to the nutritional dimension, several indicators are expected to increase by 2050, such as caloric consumption per capita (up to 3,488 Kcal) and protein intake per capita (+12%). Calorie consumption increases due to favourable changes in income and prices (see below) and a growth in services consumption (e.g., foods away from home). There is also some improvement regarding the micronutrient gap (i.e., calcium). The calorie consumption

of plant-based foods (i.e., fruits, vegetables, nuts, legumes) would rise by 11%, but its share in the overall intake remains rather constant over time. While the diet structure would remain unchanged, the affordability of diets is expected to increase substantially. Consumer disposable income is foreseen to grow by 85%, food prices would decline by 10% and the share of unskilled agricultural labour wages (i.e., from poorest households) to cereal price index will improve by 67%. This also leads to a declining share of food expenditures in total expenditures (down to 10% by 2050).

With respect to the economy dimension, a notable change in the direction of the agri-food (primary agriculture and processed food) foreign trade balance is foreseen, with Mexico becoming a net exporter of such commodities by 2050. This is also related to an increase in food systems employment (+23%) that produces the expected surplus in agri-food trade. Nutrient import dependency declines from the already low level of 10% in the 2019 to 9% in 2050. Mexico will further advance in the process of structural transformation with the share of value added from agriculture dropping down to 2%, which is comparable to high income economies. The rapid economic growth, structural transformation and increased food consumption will have negative repercussions on the sustainability dimension. Emissions from agriculture will increase by 25%. This is linked to increases in calorie consumption, as there would be larger increases in meat than plant-based foods demand, which affects the calorie footprint (+5%). On the positive side, the volume of water used in agriculture will be reduced. Similarly, land pressure will be below 80% suggesting that growth of agricultural production will be driven by employment of other production factors and increased productivity.

2.3.1.2 Pathways towards healthy and sustainable diets, and their feasibility

Table 5 displays our selected channels of diet transition by 2030 for the Mexican EAT (EAT-Mx) and EAT traditional (Milpa-EAT-Mx). Through ad-valorem consumption tax rates only, the necessary adjustments to reach the consumption targets are substantial. For the EAT-Mx, some of the rates are as high as 149%, 132% and 127% for rice, beef meat and sugar, respectively (column 1). For fruits, vegetables and nuts, the negative tax rates (i.e., subsidy rate) would need to be on -63% levels. For the Milpa-EAT-Mx, the changes are even more radical, with some tax rates exceeding 400% (column 2). The required tax rates beyond 2030 are not even reported because of their excessive levels. On the other hand, using the taste shifters only, it is feasible, at least from the simulation point of view to achieve a desired diet transition, without intervening in the price system (columns 3 and 4). The results highlight that the required changes in the taste shifter parameter to reach the targets are almost always higher in absolute terms for the Milpa-EAT-Mx than for the EAT-Mx.

Table 5
Multi-dimensional assessment of diets and food systems in the baseline scenario.

Indicator	2019	2030	2040	2050	2050 vs 2019 (%, pp or abs change)
	(1)	(2)	(3)	(4)	(5)
Nutrition					
Caloric consumption per capita	3,175	3,306	3,404	3,488	10%
Protein per capita	122	128	133	137	12%
Share of cereals in calories	41%	41%	40%	40%	-1%
Share of fruits, vegetables, nuts & legumes in calories	9%	9%	9%	9%	0%
Micronutrient gap – Calcium (share MEX/EU)*	0.72	0.73	0.74	0.75	4%
Affordability					
Disposable income	6,495	7,999	9,762	11,994	85%
Share food expenditures	18%	15%	12%	10%	-8%
Food prices index (in agent prices)	1.0	0.9	0.9	0.9	-10%
Unskilled labour wages to cereal price	1.1	1.2	1.5	1.8	67%
Economy					
Agri-food trade balance (Billion USD)	192	1,876	3,447	5,011	4,819
Nutrient import dependency	10%	9%	9%	9%	-1%
Food systems employment (value)	31,304	33,890	36,432	38,612	23%
Structural transformation (share agri VA)	3.0%	2.0%	2.0%	2.0%	-1%
Sustainability					
Emissions from agriculture (mln tons CO2 eq)	105	105	117	126	25%
Diet related carbon footprint (kg CO2eq)	829	829	848	861	5%
Volume of irrigated water (km3)	56.68	57	56	55	-6%
Land pressure	81%	80%	79%	78%	-3%

Notes: *Calculated as a calcium intake in Mexico divided by calcium intake in the best performing country (EU).

Figs. 3a and 3b show that a joint simulation where consumer taxes work together with taste shifters implies lower tax changes than in the scenarios where we only shocked taxes. For this exercise, we determined that a scenario that takes 75% of the original taste shifter changes shown in Table 6, maintains the required adjustments on consumption taxes on acceptable levels. The required ad-valorem rates are below 50% for the EAT-Mx in 2030 and in 2040, they are still below 70% in most of the cases. As for the traditional diets, the combined scenario makes the required changes in 2030 feasible as the ad-valorem tax rates are at least below the +/-100% threshold for all products. In 2040 the required taxes are still quite high for products with radical shifts such as the main cereals other than maize, processed and animal-based foods, but plausible for sugars, fish, fruits, vegetables,

nuts and seeds. Based on the previous analysis, we determined that the EAT dietary shifts will be imposed jointly via taxes and taste shifters.

Table 6
Ad-valorem domestic consumption taxes and taste shifters by 2030 across diet scenarios.

MAGNET food groups	Domestic Ad-valorem taxes		Taste shifters	
	EAT-Mx	Tr-EAT-Mx	EAT-Mx	Tr-EAT-Mx
	(rate %)		(% change)	
	(1)	(2)	(3)	(4)
rice	149	468	-21	-36
wheat	-96	480	104	-35
osd	-97	-99	123	160
hort	-63	-85	37	83
ocr	-6	480	-1	-35
wfish	-31	-30	13	12
aqcltr	-30	-25	13	9
vol	-62	317	31	-36
sugar	127	149	-23	-26
ofd	111	239	-21	-34
dairy	47	194	-13	-38
bfcmt	132	252	-27	-38
ohmt	132	216	-27	-36

Notes: values depict the necessary parameters to achieve the calorie targets by 2030.
Sources: MAGNET analysis.

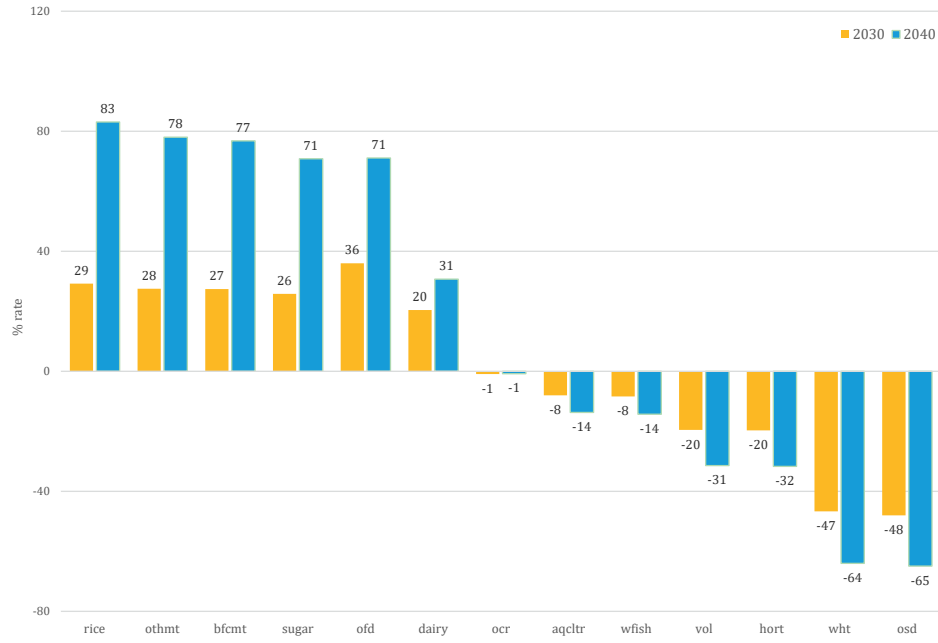

Fig. 3a. Required consumption taxes after changes in the taste shifter to reach the EAT-Mx targets by 2030-2040.

Notes: The values are the necessary ad-valorem private domestic consumption taxes to attain the dietary targets when caping the exogenous shock on the taste shifter parameter at 75% of the necessary shock to reach the targets with taste shifters only.

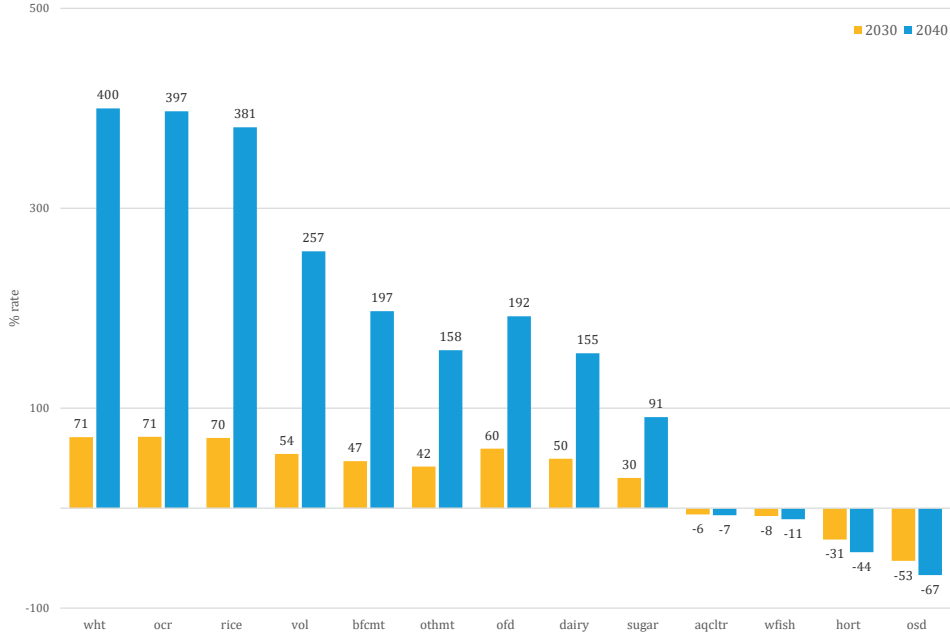

Fig. 3b. Required consumption taxes after changes in the taste shifter to reach the Milpa-EAT-Mx targets by 2030-2040.

Notes: The values are the necessary ad-valorem private domestic consumption taxes to attain the dietary targets when setting the exogenous shock on the taste shifter parameter at 75% of the necessary shock to reach the targets with taste shifters only.

2.3.1.3 Implications of diet transition on food systems

Table 7 shows the impacts of the two diet imposition scenarios on the food systems indicators. Given the feasibility of the scenarios, we report only projections till 2040 because the required changes in tax rates for 2050 are prohibitive. The diet scenarios do not lead to changes in total caloric consumption, only their composition. The share of cereals in caloric consumption declines in both scenarios and the share of plant-based foods (fruits, vegetables, nuts, legumes) increases significantly. In the Milpa-EAT-Mx scenario, the share of fruits and vegetables goes up from 17% to 29%. This brings an increased intake of calcium and a reduction of the calcium intake gap only in this scenario. Likewise, the protein intake remained constant compared to the baseline exclusively in the traditional diet approach.

The findings were mixed for the affordability dimension. The dietary shift would have negative repercussions on household income, food prices and affordability for the poorer households, particularly in the Milpa-EAT-Mx scenario. Yet, for the average household the share of the expenses spent on foods would slightly decrease by 2040. The latter finding is in line with the reallocation of purchases in the dietary shift, from relatively expensive animal-based and processed foods towards plant-based foods (Appendix 5). On the economic implications there are two effects observed – first a reorientation of food systems towards exports in the most affected sectors, as domestic demand is significantly reduced and second, a contraction of the value and volume of agri-food sector in general. This is explained by the reorientation of food system towards plant-based foods, in detriment to the meat, dairy, sugar and other processed food sectors that bring most value added. In addition, the meat sectors require inputs from primary agriculture and the demand for these inputs such as feed also declines. This could have further repercussions for households that are dependent on food systems as income source.

From the environmental point of view, the CO2 emissions generated in primary agriculture drop, particularly in the traditional diet scenario, mainly due to additional reductions in emissions originated from the production of animal-derived foods, rice, sugars, vegetable oils and processed foods (Appendix 5). The same pattern was observed in the diet related carbon footprint, which incorporates the overall emissions from food production, processing, transporting, storing, cooking and disposition. There is also relatively less land pressure on both diet scenarios than in the baseline conditions. On the negative side, the transition towards plant-based foods would result in an intensification in the use of irrigated water, especially for the production of fruits, vegetables, legumes, and nuts (Appendix 5).

Table 7
Multi-dimensional assessment of diets and food systems in the EAT diets imposition scenarios.

Indicator	EAT-Mx		Milpa-EAT-Mx		% change EAT-Mx vs Baseline scenario		% change Milpa-EAT-Mx vs Baseline scenario	
	2030	2040	2030	2040	2030	2040	2030	2040
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nutrition								
Caloric consumption per capita	3,307	3,405	3,306	3,403	0%	0%	0%	0%
Protein per capita	123	123	128	133	-4%	-8%	0%	0%
Share of cereals in calories*	39%	36%	39%	36%	-2%	-5%	-2%	-5%
Share of fruits, vegetables, nuts & legumes in calories*	13%	17%	19%	29%	4%	8%	10%	20%
Micronutrient gap – Calcium (share MEX/EU)	0.73	0.75	0.79	0.87	0%	1%	8%	17%
Affordability								
Disposable income	7,951	9,665	7,920	9,606	-1%	-1%	-1%	-2%
Share food expenditures*	14%	11%	14%	11%	0%	-1%	-1%	-1%
Food prices index (in agent prices)	1.1	1.2	1.3	1.8	11%	26%	26%	82%
Unskilled labour wages to cereal price (incl. taxes)	0.9	0.7	0.9	0.7	-31%	-54%	-30%	-53%
Economy								
Agri-food trade balance (Billion USD)	4,358	8,171	9,344	18,156	132%	137%	398%	427%
Nutrient import dependency*	9%	9%	10%	10%	0%	0%	0%	1%
Food systems employment (value)	31,201	31,083	29,738	28,565	-8%	-15%	-12%	-22%
Structural transformation (share agri VA)*	2.2%	1.8%	2.2%	1.9%	0%	0%	0%	0%
Sustainability								
Emissions from agriculture (mln tons CO2 eq)	112	114	109	109	-5%	-10%	-7%	-13%
Diet related carbon footprint (kg CO2eq)	806	777	787	740	-5%	-10%	-7%	-14%
Volume of irrigated water (km3)	57	59	59	63	3%	7%	7%	16%
Land pressure*	79%	78%	79%	77%	-1%	-1%	-1%	-2%

Notes: *Values in % change columns represent percentage point changes. **Values higher than in the EAT-Mx because avocado consumption increases significantly in the Milpa-EAT-Mx. ***Calculated as a calcium intake in Mexico divided by calcium intake in the best performing country (EU).

2.3.2 Microsimulation of fiscal policies to reach the EAT diets in Mexico

2.3.2.1 Descriptive statistics for food expenditures

On average, the food groups with the highest food expenditure shares among Mexican households are animal-based proteins and the others (includes foods away from home) (Appendix 6). The lowest mean shares are for tubers, added fats, plant-based proteins and fruits. The previously mentioned groups also have the largest proportions (>50%) of households with reported zero expenditures. The lowest income group and rural households spent a larger share of their food budget on high- and low-fiber grains, tubers, plant-based proteins and added sugars than the other two types of households. The highest income and urban households tend to spend more on the groups with the highest food expenditure shares than the other households (e.g. animal-based proteins, others).

2.3.2.2 QUAIDS estimated expenditure and price elasticities of demand for foods

The food groups which are more responsive (values>1) to changes in expenditure (income) are animal-based proteins, fruits and added fats (Appendix 6). This means that they are considered luxury goods (i.e., income-elastic). For instance, if income increases by 10%, the purchases of fruits would increase by 11%. Households with the lowest income and from rural areas are more responsive to income changes than the rest of the households. The values of the expenditure elasticities tend to be higher in the censored model than in the uncensored version (Appendix 6).

Regarding the price elasticities, the food groups that are price-elastic (values<-1) are fruits, vegetables, animal-based proteins and dairy foods (Appendix 6). Again, we discovered that the households with the lowest income and those from rural areas are generally the most responsive to price variations among households analysed. The absolute values of the own-price elasticities are higher than the expenditure elasticities in almost all cases, except for added fats, tubers and plant-based proteins. Additionally, the values of the elasticities have higher magnitudes in the censored than in the uncensored model, particularly for added fats and plant-based proteins, where the latter has an unexpected positive (but small) value in the uncensored specification for all the sample (Appendix 6). In the uncensored model, we estimated a negative own-price elasticity value for plant-based proteins only for households in the lowest income groups and for those living in rural areas. Other than the mentioned variations, the elasticity values in both versions of the model point in the same direction. Table 6.6 in appendix 6 shows the full spectrum of own- and cross-price elasticities, where only a few significant substitutabilities and complementarities among food groups can be observed.

2.3.2.3 Effects of taxes and subsidies to reach the EAT diets by household groups

Fig. 4a assesses the feasibility of reaching the EAT-Mx by 2040 for the different household types with and without the introduction of subsides and taxes. In the case of the food groups with targeted increases in consumption, we estimated that for high-fiber grains and tubers the targets would be met regardless of the introduction of such policies due to the decrease in prices in the baseline scenario. For vegetables, fruits and added fats, the subsidies represent an improvement with respect to the baseline conditions for all households, but the targets would be attained only by the highest income households and closely followed by urban households. The lowest income and rural households would lag in the achievement of these targets, particularly in the case of fruits for both types of households, and in the case of added fats for those in the bottom income categories. Subsidies would not improve the baseline conditions for plant-based proteins, with the estimated intakes being less than 30% of the target. Regarding the food groups with projected reductions in consumption, our results revealed that with the imposition of taxes the rural and lowest-income groups would be the only households to reach and be close to the desired dietary shift for dairy foods and animal-based proteins, respectively. Yet, the intakes for dairy foods among these households would be between 14-25 percentage points lower than the recommended intake, which would be reached anyway in the baseline scenario. The targets for low-fiber grains and added-sugars would be hard to reach for almost all households, only the lowest income groups would be close to reaching the reduction goal for low-fiber grains, followed by rural households.

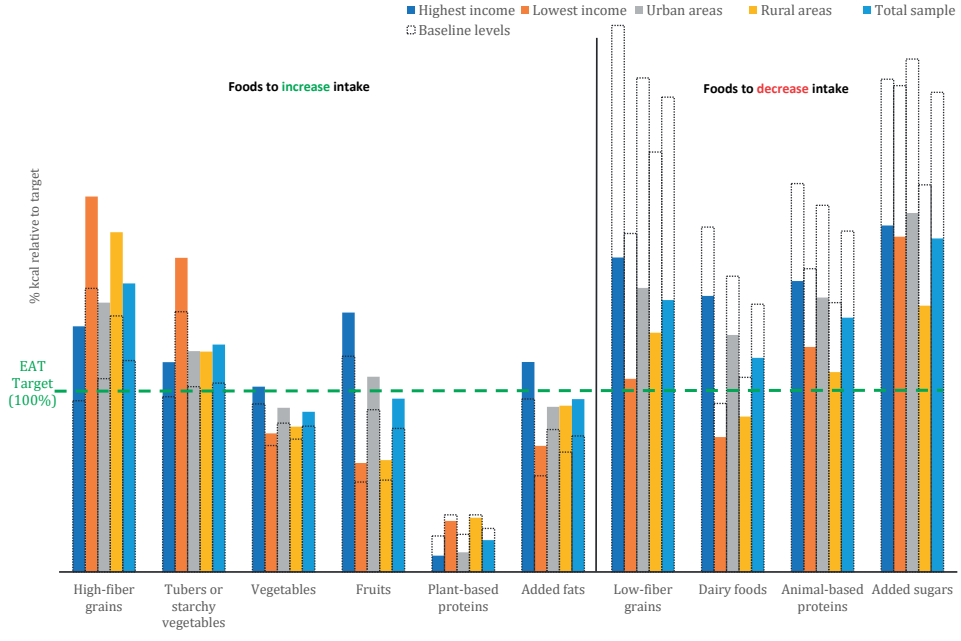

Fig. 4a. Macro-microsimulation of taxes and subsidies to reach the EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by sample subgroup and food group.

Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. Calculations based on elasticities estimated with QUAIDS modelling with corrections for potential price and expenditure endogeneity.
Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

The results were somewhat similar for the Milpa-EAT-Mx (Fig. 4b). Among the differences, we identified that by 2040 the intakes would be considerably closer to the targets with the imposition of fiscal policies for all food groups with targeted intake reductions. As a result, the lowest income and rural households would surpass fully or partially the dietary shifts for dairy foods and animal-based proteins. For animal-based proteins, the intakes among the mentioned households are still around the targets and represent a substantial improvement with respect to the baseline consumption. For low-fiber grains and added sugars, the goals are still far from being reached, except for the former among the lowest-income households and for the latter among rural households. For the traditional diets, the better-off and urban households would fall off the target for the consumption of high-fiber grains in the baseline scenario only.

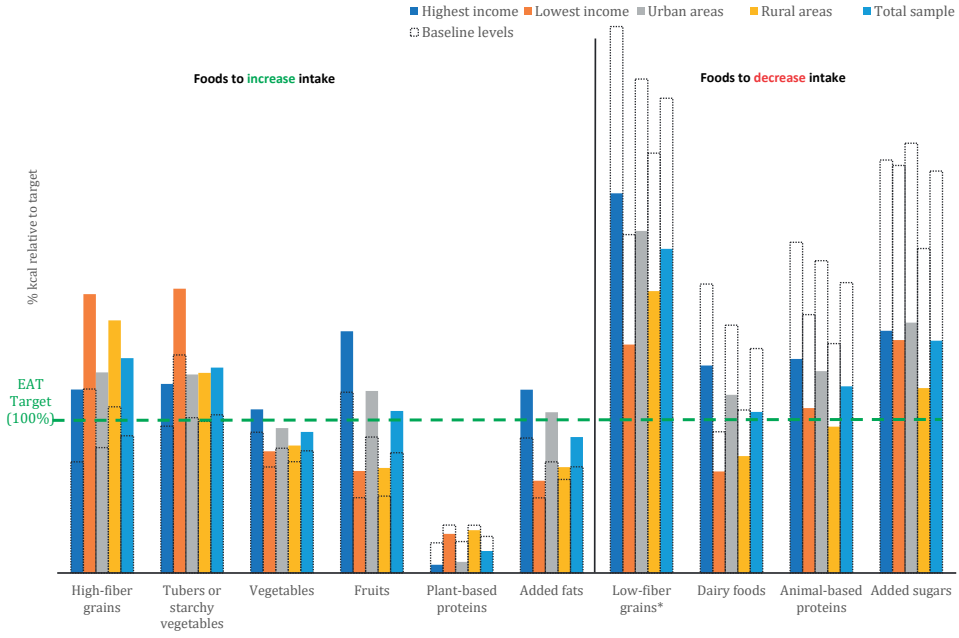

Fig. 4b. Macro-microsimulation of taxes and subsidies to reach the Milpa-EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by sample subgroup and food group.
Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. *For low-fiber grains, the values were re-scaled for representation purposes. Calculations based on elasticities estimated with QUAIDS modelling with corrections for potential price and expenditure endogeneity.
Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

As a sensitivity analysis, we compared the previous results with the outcomes from the MAGNET model (tax shocks only at the levels shown in in Figs. 3a and 3b) and a censored QUAIDS model. For the representative houshold in MAGNET, the percentages of progress with respect to the EAT targets were on average lower (+/-20-25 p.p.) than predicted in the uncensored QUAIDS model (Appendix 7). Yet, the results were roughly similar for 3-5 food groups depending on the diet modelled. Our main findings did not substantially change by using the elasticities from the censored model (Appendix 7). The main difference was with respect to plant-based proteins, where the attainments of the EAT targets would be around 40-50% for the highest income and urban households, and between 69-89% for the other two household types. For the same food group, the attainments would be around 26-28% for the single houshold in MAGNET. The uncensored model was more accurate in terms of the estimated calorie figures than the censored model, as in the latter it was more frequent to see figures disproportionally higher than the EAT targets.

2.4 DISCUSSION

A radical change in diets in low- and middle-income countries as proposed in the EAT Lancet report may aid to shift the existing trajectory of health and environmental outcomes. Taking Mexico as a case study, a macrosimulation with the MAGNET model showed that the desired shift will not be achieved without external intervention. It was apparent that under baseline conditions there is a high inertia in the structure of diets – the shares of calories from plant-based foods favoured in the EAT diets, such as fruits, vegetables, legumes and nuts remain rather constant by 2050. At the same time, greenhouse gas emissions related to intensified meat consumption are expected to increase in the same business-as-usual scenario.

The macrosimulation of alternative dietary pathways for Mexico revealed that the referred shift is only partially possible, regardless of the introduction of strong fiscal incentives and radical behavioural changes. For the EAT-Mx, a major shift in consumer preferences together with feasible tax adjustments would close the gap towards the targeted consumption only until 2040 (2/3 of the full change). In fact, the required taxes in such combined scenario are similar in magnitude to those simulated in observational and experimental studies in the body of literature on food pricing strategies, as well as to those actually implemented to reduce tobacco consumption in the United States (Afshin et al., 2017; Schwartz et al., 2017; Thow et al., 2014). For the Milpa-EAT-Mx, the same combined scenario would be only plausible until 2030 considering the size of the required tax adjustments (1/3 of the full change). Hence, the full attainment of the EAT diets by 2050 is contingent on more stringent changes in consumer preferences than modelled in this study, otherwise, consumption taxes must adjust in prohibitive levels. Similar

conclusions have been reached in past research performed with the same models for developed countries (Latka et al., 2021). Such changes in consumer behaviour would be viable through a bundle of behavioural interventions not specifically modelled by us, such as educational campaigns, marketing restrictions, product labelling, restricting/eliminating choice, changes in the food environment (e.g., at schools) (Castellanos-Gutiérrez et al., 2021; Rivera-Dommarco et al., 2018).

A more nuanced macro-microsimulation exercise showed that the fiscal measures imposed in the combined macro scenario described above would have heterogenous effects at the household level. Among the lowest income and rural households: a) in addition to subsidies, other policy instruments may be needed to fully attain the targets for fruits, vegetables and added fats; b) specific attention shall be placed to determine the size of the taxes to reduce the likelihood of insufficient dairy foods' intakes; c) the intakes for low-fiber grains and added sugars are likely reachable with EAT-Mx and Milpa-EAT-Mx's scenarios, respectively, with the caveat that the traditional diet scenario relies on implausible taxes beyond 2030. For the highest income and urban households: a) in addition to subsidies, other tactics are particularly needed to reach the targets for all foods with restricted consumption in the EAT diets; b) without subsidies, the desired targets to reach the traditional dietary pattern seemed to be implausible for high-fiber grains. Other strategies are hardly needed to reach the recommended dietary intakes for plant-based proteins among all households.

In terms of the impact of attaining the EAT diets through fiscal measures and consumer preference shifts, our analysis revealed potential future gains and losses with respect to the baseline conditions. From a nutritional perspective, the two diets modelled would result in increased micronutrient intake, and in the case of traditional diets, constant protein intake levels. Regardless of the negative effect on income and food prices, the adoption of both diets would result in slightly cheaper diets for the average household. Yet, for poorer consumers affordability would be compromised by 2040. These findings are consistent with recent evidence on the affordability at current prices of the EAT diet in Mexico, which has shown that the savings from a lower consumption of animal-derived and processed foods surpass the extra costs of consuming more plant-based foods (Batis et al., 2021). On the other hand, given the expected reduction in the consumption of animal-based foods in the dietary scenarios, the value of food systems is expected to decline in this process of diet transition. Yet, nutrient import dependency would not change, which means that reliance on increased imports to attain sustainable and healthy consumption would not be necessary. From a sustainability perspective, we estimated substantial gains in terms of greenhouse gas emissions from agriculture, particularly in the scenario where the traditional diet is adopted. The estimated reductions in emissions are higher than those estimated for Latin America in previous studies modelling the EAT diets (Philippidis

et al., 2021). The overall emissions generated in the path of foods from *farm* to *fork* are also reduced, as well as land pressure, which is expected in the adoption of a plant-based diet (Willett et al., 2019). An unwanted consequence would be an intensification in the use of irrigated water to produce plant foods. Altogether, we did not provide a specific assessment of the attainment of the environmental targets in the EAT report, as it lies outside of the scope of this work.

Compared to other macrosimulations of the EAT diets that are performed for a single representative household, we contribute with a detailed analysis at the household level, which to our knowledge, represents the first application for a single country (Latka et al., 2021; Philippidis et al., 2021). We also add to country-level and regional assessments of the affordability of the EAT diets by providing a dynamic analysis of the future outcomes in this indicator (Hirvonen et al., 2020; Raghunathan et al., 2020). The microsimulation results are akin to the findings of other cross-sectional and experimental studies regarding the reinforcing effects of combining taxes and subsidies to reach determined dietary patterns (Afshin et al., 2017; Cornelsen et al., 2015). With respect to similar microsimulations, our research differed in the mechanism to determine the pass-through of taxes by estimating the effective changes in prices based on a CGE model, which accounts for the adjustments of supply and demand after the fiscal shocks are imposed (Caro et al., 2020; Segovia et al., 2020). Such aspects are particularly relevant for the analysis of add-valorem taxes, which unlike excise taxes, tend to reflect less on consumer prices (Gračner et al., 2022).

Our research presents some limitations. The simulation work performed here does not necessarily depict real consumer behaviour. Whereas from a methods perspective the demand functions employed in the macroeconomic modelling are well suited to represent large changes in indicators such as income, the microsimulations are likely less accurate to assess large changes in taxes/subsides as the ones simulated in our study, as compared to small changes (Cornelsen et al., 2015). At the same time, our microsimulations should not be interpreted as causal evidence, as price responses are estimated by exploiting price variations across different locations. Unlike experimental evidence, our results provide evidence of the potential behaviour of different types of households, which may complement causal future research (Afshin et al., 2017). Similarly, the tax adjustments estimated in the CGE model may be interpreted in terms of their order of magnitude, rather than exact values (Latka et al., 2021). Moreover, the values of the income and price elasticities used in the macro and micro simulations differed substantially. We avoided further adjustments to avoid consumption infeasibilities and regional disparities in the macro model. As a result, our micro modelling exercise presented a more positive story than in the CGE modelling. In this sense, our findings may provide input to determine whom to prioritize in terms of the fiscal incentives/disincentives needed and for which foods. Although our preferred demand system framework presented some biases in the

elasticities' estimations for the least consumed food groups (e.g., plant-based proteins), its estimated values pointed in the same direction and the policy microsimulations depicted more stable estimations than the alternative (i.e., censored model). There are other aspects not considered by us, which may constraint the actual effectiveness of adjustments in taxes and consumer preferences, such as the availability of public resources to introduce subsidies and the capacity of the food systems to supply healthy and sustainable foods (Mason-D'Croz et al., 2019).

2.5 POLICY IMPLICATIONS

Four key policy recommendations emerged from our findings, which are interlinked in nature. First, on top of stringent fiscal measures, additional courses of action are of primary importance to steer consumer preferences to fully reach healthy and sustainable diets. Monetary instruments may serve as price signals, while behavioural tactics may aid to rise consumer awareness, acceptance and willingness to adopt such diets (Latka et al., 2021). For instance, a mix of price incentives and information nudges has been shown to effectively reduce meat consumption (Vellinga et al., 2022). There are likely reinforcing effects between fiscal policies and widespread strategies to change consumer behaviour, which may result in larger effects than estimated in here (Mason-D'Croz et al., 2019; Thow et al., 2014). Thus, it is plausible that the size of the required fiscal measures may be lower than calculated in our work. Second, our results call for a comprehensive redesign and reinforcement of the existing food policies in countries like Mexico. So far, the country has focused on the fight against obesity and thereby establishing taxes on sugar-sweetened beverages and non-essential calorie dense foods (i.e., low-fiber grains and added sugars) and new front-of-package labelling to shed light on processed foods' nutrient composition (Basto-Abreu et al., 2020; Gračner et al., 2022). Due to their limited size and resulting impact, more radical price signals are needed to reduce the consumption of low-fiber grains and added sugars (Colchero et al., 2016; Jaacks, 2019). To be coherent with healthy and sustainable dietary patterns, fiscal disincentives to dairy and animal-based proteins shall be introduced and packaging would need to incorporate sustainability claims. This is not only relevant for Mexico, but also for other regions in the world, as forceful initiatives to increase plant-based and reduce animal-source foods consumption are minimal and rather focus on information schemes only (Mason-D'Croz et al., 2019; Vellinga et al., 2022). Third, the design of fiscal policies and complementary schemes should consider the heterogeneity in the existing intakes and economic preferences for foods. In this sense, fiscal incentives (disincentives) may differ within each food group, for instance, taxes on dairy may be focused on products with excess added sugars, while taxes on animal protein sources may target some non-traditional foods (e.g., red and processed meats) to avoid lowering the intakes of animal-derived foods excessively. Considering

their high income responsiveness, cash transfers or vouchers to vulnerable populations may be recommended to increase the intakes of vegetables, fruits, plant-based proteins and added fats. Fourth, the challenge of transforming food systems at the level envisioned here requires substantial support from the private sector. This aspect has been proven to be particularly hard to enforce, as the existing efforts to implement anti-obesity policies have faced strong opposition from the food industry (Barquera & Rivera, 2020).

2.6 CONCLUSION

Policy interventions to attain healthy and sustainable food systems in developing countries like Mexico are still in a gestational stage. A multicomponent, integrated governmental scheme that includes strong price incentives (disincentives), and behavioural interventions is much needed to move the existing diets in the right direction. A combination of both types of strategies that relies mostly on changes in consumer preferences, may aid to partially reach the EAT dietary targets, at least by 2040 in the case of the EAT-Mx. By reaching this dietary pattern via these strategies, the affordability of foods may be compromised in the future only for poorer households, but at the same time, the nutritional and environmental benefits are notable, particularly if diets are more in line with traditional eating patterns. Further research efforts are warranted to do an overall assessment of the environmental dimension in terms of closing the gap towards the corresponding EAT targets.

For the most healthy and sustainable foods from the EAT perspective, subsidies have an added value in reaching the EAT targets for vegetables, fruits and added fats. Yet, other policy instruments, such as income transfers, may be needed to fully attain the latter foods' targets for the lowest income and rural households, as well as for plant-based proteins among all households. Likewise, complementary instruments are required to aid the highest income and urban households to reduce intakes of the least healthy and sustainable foods in the EAT model. Whereas taxes to such foods are particularly effective to attain the targeted intakes in lower income and rural settings, they are still harder to attain at population level for low-fiber grains and added sugars. A careful design of the fiscal measures addressed in this study is needed to avoid unintended outcomes on the intakes of foods such as dairy, among the most vulnerable households. Furthermore, an adaptation of the EAT diet that considers the existing intakes in Mexico (i.e., that includes limited amounts of unhealthy and unsustainable foods) is more feasible to attain with fiscal schemes, with respect to the strictest version of the Mexican traditional diet (e.g., zero intakes of low-fiber grains, red meat, sugar-sweetened beverages). Yet, fiscal and consumer efforts to include some traditional foods may be worthwhile from environmental and cultural points of view.

APPENDICES

Appendix 1. Additional tables for Mexican energy intakes

Table 1.1
Mean Mexican energy intake and contribution from traditional foods by food group and area.

Food groups	Urban area			Rural area		
	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI
	kcal/day		%	kcal/day		%
	(1)	(2)	(3)	(4)	(5)	(6)
Grains						
High-fiber grains						
Corn	406	406	100.0	580	580	100.0
Other high-fiber grains (e.g., wheat, rice, amaranth)	11	0	0.0	9	0	0.0
Low-fiber grains						
Refined grains	123	0	0.0	109	0	0.0
Grains with excess added sugar or saturated fat	232	0	0.0	209	0	0.0
Tubers or starchy vegetables						
Potatoes and cassava	23	0	2.0	23	1	3.9
Vegetables						
All vegetables	47	23	48.4	45	25	55.5
Fruits						
All fruits	82	12	14.5	48	5	9.5
Dairy foods						
Whole milk or derivative equivalents (e.g., cheese)	97	31	32.3	76	27	35.5
Dairy with excess added sugar	83	0	0.0	49	0	0.0

Table 1.1 (Continued)

Food groups	Urban area			Rural area		
	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI
	kcal/day		%	kcal/day		%
	(1)	(2)	(3)	(4)	(5)	(6)
Protein sources						
Red meat	139	0	0.0	87	0	0.0
Processed meat	32	0	0.0	24	0	0.0
Insects	0	0	--	0	0	--
Other meats (e.g. iguana, rabbit)	0	0	100.0	0	0	100.0
Chicken and other poultry	82	82	99.9	68	68	100.0
Eggs	46	46	99.7	50	50	99.7
Fish	15	5	35.3	13	9	70.3
Legumes	66	58	87.3	106	100	94.4
Nuts and seeds	8	2	26.7	5	3	67.2
Added fats						
Plant oils	167	10	6.1	144	34	23.9
Lard or tallow	23	0	0.0	27	0	0.0
Added sugars						
All sweeteners	13	4	31.1	7	2	34.5
Confectionary and desserts	16	0	0.0	8	0	0.0
Sugar-sweetened beverages	229	0	0.0	188	0	0.0
Others	20	5	25.5	26	10	37.3
Total energy	**1,964**	**686**	**34.9**	**1,899**	**914**	**48.1**

Source: Castellanos-Gutiérrez et al. (2021) and Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016.

Table 1.2
Mean Mexican energy intake and contribution from traditional foods by food group and socioeconomic status.

Food groups	SES tertile 1			SES tertile 2			SES tertile 3		
	Mean intake (MI)**	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)**	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)**	Mean intake of traditional foods	Contribution from traditional foods to MI
	kcal/day		%	kcal/day		%	kcal/day		%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Grains									
High-fiber grains									
Corn	620	620	100.0	490	490	100.0	335	335	100.0
Other high-fiber grains (e.g., wheat, rice, amaranth)	9	0	0.0	9	0	0.0	13	0	0.0
Low-fiber grains									
Refined grains	99	0	0.0	122	0	0.0	130	0	0.0
Grains with excess added sugar or saturated fat	148	0	0.0	269	0	0.0	242	0	0.0
Tubers or starchy vegetables									
Potatoes and cassava	32	1	2.7	19	1	4.8	20	0	1.0
Vegetables									
All vegetables	41	21	51.6	46	23	50.9	51	25	49.2
Fruits									
All fruits	46	6	12.0	49	6	11.6	103	15	14.6
Dairy foods									
Whole milk or derivative equivalents (e.g., cheese)	53	18	33.5	92	30	32.4	113	37	33.2
Dairy with excess added sugar	51	0	0.0	75	0	0.0	86	0	0.0

Table 1.2 (Continued)

Food groups	SES tertile 1			SES tertile 2			SES tertile 3		
	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI	Mean intake (MI)	Mean intake of traditional foods	Contribution from traditional foods to MI
	kcal/day		%	kcal/day		%	kcal/day		%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Protein sources									
Red meat	94	0	0.0	116	0	0.0	147	0	0.0
Processed meat	20	0	0.0	34	0	0.0	33	0	0.0
Insects	0	0	--	0	0	--	0	0	--
Other meats (e.g. iguana, rabbit)	0	0	100.0	0	0	100.0	0	0	100.0
Chicken and other poultry	70	70	100.0	86	86	99.7	78	78	100.0
Eggs	64	64	99.9	44	44	99.1	40	40	99.9
Fish	15	6	42.7	11	7	62.1	17	6	37.2
Legumes	104	99	94.8	82	69	83.9	58	52	90.4
Nuts and seeds	4	2	57.7	6	1	25.6	10	3	31.2
Added fats									
Plant oils	111	6	5.4	143	32	22.4	201	13	6.6
Lard or tallow	22	0	0.0	36	0	0.0	18	0	0.0
Added sugars									
All sweeteners	7	2	30.8	11	6	53.0	14	3	20.6
Confectionary and desserts	7	0	0.0	13	0	0.0	18	0	0.0
Sugar-sweetened beverages	233	0	0.0	229	0	0.0	203	0	0.0
Others	34	21	63.0	19	2	12.4	16	0	2.2
Total energy	**1,885**	**937**	**49.7**	**2,002**	**797**	**39.8**	**1,947**	**608**	**31.2**

Notes: SES Socioeconomic status.
Source: Castellanos-Gutiérrez et al. (2021) and Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016.

Table 1.3
Mean Mexican energy intake and contribution from traditional foods among actual consumers by food group.

Food groups	Percentage of consumers	Mean intake in consumers	Average intake of traditional foods in consumers
	%	kcal/day	
	(1)	(2)	(3)
Grains			
High-fiber grains			
Corn	88.8	510	510
Other high-fiber grains (e.g., wheat, rice, amaranth)	5.8	183	0
Low-fiber grains			
Refined grains	61.2	195	0
Grains with excess added sugar or saturated fat	57.4	393	0
Tubers or starchy vegetables			
Potatoes and cassava	28.2	81	2
Vegetables			
All vegetables	95.1	49	25
Fruits			
All fruits	52.3	139	19
Dairy foods			
Whole milk or derivative equivalents (e.g., cheese)	50.8	180	59
Dairy with excess added sugar	34.3	216	0
Protein sources			
Red meat	49.5	252	0
Processed meat	23.8	125	0
Insects	0.0	11	11
Other meats (e.g. iguana, rabbit)	0.1	141	141
Chicken and other poultry	33.4	234	234
Eggs	42.6	111	111
Fish	14.4	102	45
Legumes	57.5	134	120
Nuts and seeds	7.2	100	34
Added fats			
Plant oils	84.4	190	20
Lard or tallow	13.3	183	0
Added sugars			
All sweeteners	11.6	97	31
Confectionary and desserts	16.4	86	0
Sugar-sweetened beverages	78.9	276	0
Others	55.6	38	11

Source: Castellanos-Gutiérrez et al. (2021) and Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016.

Appendix 2. GENUS database adjustments

In this research, the GENUS database was updated from 2011 to 2014 based on FBS to be in line with MAGNET's reference year (FAO, 2021). Then, we mapped the food items in GENUS with the EAT Lancet food groups to compare GENUS's supply of calories in 2014 with the mean intakes from the ENSANUTs 24-hour dietary recalls shown above in Table 1. Total estimated caloric supply in GENUS is 3,167 kcal/capita/day for Mexico, equivalent to 1.6-fold the mean intake in ENSANUT (1,947). The shares of calories by food group from both sources are shown in Table 2.1. Most of the values are quite similar, except for high- and low-fiber grains, dairy foods, animal-based proteins and added sugars. The shares in GENUS were adjusted to resemble the structure of caloric consumption in the 24-hour dietary recall surveys, which makes it easier to interpret the EAT dietary shift.

Table 2.1
Share of calories in GENUS and ENSANUT by food group.

EAT food groups	GENUS 2014	ENSANUTs 2012/2016
	%	
High-fiber grains	37.4	23.8
Low-fiber grains	10.1	17.7
Tubers or starchy vegetables	1.0	1.2
Vegetables	1.1	2.4
Fruits	3.2	3.8
Dairy foods	4.6	8.5
Animal-based proteins	8.9	15.2
Plant-based proteins	3.8	4.3
Added fats	11.5	9.5
Added sugars	18.1	12.5
Others	0.3	1.1
Total	**100.0**	**100.0**
Estimated calories (kcal/capita/day)	**3,167**	**1,947**

Sources: GENUS database, FAO (2021) and Mexican National Health and Nutrition Surveys (ENSANUTs) in 2012 and 2016.

Appendix 3. Variable construction for microsimulations

To obtain expenditure shares, quarterly monetary expenses by food group were calculated and then divided by the total expenditure in the 11 groups. Quantities are expressed in kilograms, where food items originally measured in litres were converted to kilograms based on densities (kg/lts) obtained from ENSANUT's food composition table. Items in concentrate and powdered form were rehydrated following Crovetto M. & Uauy (2014) and then converted to kilograms using the same densities. As proxies for prices, we calculated unitary values, which are equal to the ratio of total expenses over total quantities by food group. Standard procedures were applied to make the unitary values of the others (i.e., numeraire) group equal to 1. To avoid outliers affecting our estimations, when household level expenses, quantities and unitary values differed from the mean value at the municipal level +/- 2.5 standard deviations, we replaced it with the mean value at the municipal level +/- 2.5 standard deviations. If a household reported no expenses for a particular food group, their unitary value was imputed with the mean value at the municipality level (total 1,090 municipalities) or from neighbour municipalities when there were no data in a given municipality. In our demand system estimations, we used prices averaged at the municipality level.

Further adjustments to the prices and an additional covariate were computed to handle two issues typically identified on demand systems estimations. First, the indirect estimation of prices through unitary values may pose measurement errors and hide household preferences for food product quality (i.e., price endogeneity). To correct this issue, we followed the procedure described in Capacci & Mazzocchi (2011) and Caro et al. (2017b), where we ran two-stage least squares regressions to obtain adjusted price estimates at the municipality level. Second, endogeneity in expenditures arises as we used total food expenditures as an explanatory variable for budget shares by food group, which are mutually determined in practice. This aspect was managed by adding a residual term in the demand system obtained by regressing total expenditures on basic sociodemographics (see Caro et al., 2017b; Segovia et al., 2020).

Appendix 4. Calorie availability calculations based on microdata

Data on calories per 100 g. for 224 out of the 247 food items in the ENIGH were obtained from the database of nutritional values compiled by Mexican National Institute of Public Health (INSP, 2012). To estimate the household calorie intakes, the available conversions were multiplied by the quantities reported as expenditures. From the food items with no calorie conversions available, we excluded 7 items that are not meant for human intake (e.g., tobacco, animal foods) from the calorie calculations; for foods consumed at home, we estimated the calorie conversions per 100 g. based on the average from the rest of food items in their corresponding EAT food group; for foods away from home, we used an estimate of the calorie intake per MXN peso from the rest of the data and multiplied the resulting number by 2/3 to reflect processing margins (Subramanian & Deaton, 1996; Valero-Gil & Valero, 2018). The resulting calorie availability by food group is shown below in Table 4.1.

Table 4.1
Calorie content by food group.

EAT Food groups	Kcal per 100 g.
High-fiber grains	261.6
Low-fiber grains	359.7
Tubers or starchy vegetables	215.0
Vegetables	45.4
Fruits	70.4
Dairy foods	280.9
Animal-based proteins	223.4
Plant-based proteins	337.4
Added fats	674.9
Added sugars	232.3
Others	135.7

Notes: Values computed as the average calories in the ENIGH's food items classified in each food group.
Source: Own calculations based on INSP (2012).

Appendix 5. Additional tables MAGNET simulations

Table 5.1
Percentage change in private consumption by food group, 2019-2040.

MAGNET food groups	Scenario		
	Baseline	EAT-Mx	Milpa-EAT-Mx
		%	
	(1)	(2)	(3)
rice	22.2	-23.9	-58.2
wht	19.0	284.1	-58.6
gro	19.7	29.1	56.0
osd	21.9	335.9	456.4
hort	25.5	125.2	248.2
sug	20.8	-27.4	-58.3
ocr	19.3	23.6	-58.7
rmk	26.1	1.6	5.7
bfctl	22.1	30.9	39.6
othctl	21.8	30.1	38.8
pigpls	23.4	30.2	36.6
pltry	24.0	30.8	37.3
wfish	23.6	60.6	64.2
aqcltr	28.3	66.5	66.2
vol	24.7	109.0	-58.1
sugar	24.8	-26.4	-29.8
ofd	22.9	-23.8	-53.5
dairy	27.7	1.9	-58.7
bfcmt	27.7	-34.8	-58.7
othcmt	27.7	-4.3	-21.1
othmt	29.7	-34.7	-52.6
pulmt	30.1	1.4	3.7
fishp	24.0	29.3	37.0

Source: Own calculations based on MAGNET model.

Table 5.2
Percentage change in C02 emissions from agriculture relative to baseline scenario by food group.

MAGNET food groups	EAT-Mx		Milpa-EAT-Mx	
	2030	2040	2030	2040
	%			
	(1)	(2)	(3)	(4)
dairy	-10.1	-19.9	-32.9	-65.3
vol	26.5	53.8	-30.9	-62.9
rmk	-10.0	-19.7	-31.3	-62.0
rice	-15.0	-31.8	-27.4	-57.7
ofd	-16.0	-32.2	-26.3	-52.9
othmt	-18.8	-36.8	-25.4	-50.2
sug	-16.1	-33.4	-22.6	-46.4
bfcmt	-16.0	-30.8	-22.0	-42.7
cvol	-0.6	1.7	-19.1	-37.8
sugar	-13.1	-27.8	-15.6	-33.4
othcmt	-9.3	-17.9	-14.3	-27.8
pulmt	-11.0	-21.4	-10.6	-20.7
pigpls	-6.6	-13.5	-8.6	-17.6
bfctl	-6.2	-12.2	-7.8	-15.3
gro	-5.4	-11.9	-6.7	-15.3
osd	15.0	32.5	-2.6	-13.5
othctl	-3.8	-7.5	-5.3	-10.3
pltry	-4.1	-8.1	-3.5	-6.6
fishp	0.2	0.7	1.9	5.1
ocr	2.9	6.2	5.2	11.4
pfb	2.6	5.4	5.0	11.6
wht	6.9	14.0	7.2	15.4
wfish	11.0	22.3	11.8	24.2
hort	6.0	13.0	13.1	29.6
All food groups	**-4.9**	**-9.6**	**-7.1**	**-13.8**

Source: Own calculations based on MAGNET model.

Table 5.3

Percentage change in irrigated water volume relative to baseline scenario by food group, 2040.

MAGNET food groups	EAT-Mx	Milpa-EAT-Mx
	%	
	(1)	(2)
rice	-22.9	-43.3
wht	16.1	24.2
gro	-5.8	-2.8
osd	31.8	-2.2
hort	11.0	26.4
sug	-24.3	-32.1
ocr	6.4	14.2
pfb	5.7	13.9
All food groups	**7.1**	**15.7**

Appendix 6. Tables for demand system estimations

Table 6.1
Selected food expenditure indicators in the sample by sample subgroup and food group.

Indicator/Food groups	Highest income[1]	Lowest income[2]	Urban	Rural	Total sample
	(1)	(2)	(3)	(4)	(5)
Mean expenditure share (%)					
High-fiber grains	7.22	11.68	8.88	11.07	9.72
Low-fiber grains	7.78	10.06	8.17	10.18	8.94
Tubers or starchy vegetables	1.23	1.77	1.27	1.94	1.52
Vegetables	5.81	8.32	6.45	8.32	7.17
Fruits	3.35	2.77	3.18	2.78	3.03
Dairy foods	7.97	8.54	8.35	8.36	8.35
Animal-based proteins	25.11	23.81	25.51	23.53	24.75
Plant-based proteins	1.49	3.58	1.98	3.47	2.55
Added fats	1.67	2.55	1.69	2.80	2.12
Added sugars	8.68	10.03	8.66	10.58	9.39
Others	29.67	16.89	25.85	16.97	22.45
Share of households with expenditure>0 (%)					
High-fiber grains	87.97	81.23	89.29	79.28	85.46
Low-fiber grains	85.47	86.06	85.49	87.06	86.09
Tubers or starchy vegetables	44.56	40.42	41.57	44.85	42.83
Vegetables	78.28	77.88	77.44	80.39	78.57
Fruits	56.78	40.83	51.98	42.78	48.46
Dairy foods	81.88	71.21	79.68	72.80	77.05
Animal-based proteins	91.59	87.78	90.98	88.58	90.06
Plant-based proteins	43.40	51.34	46.10	51.60	48.20
Added fats	44.23	42.25	40.83	47.42	43.35
Added sugars	83.01	76.45	79.94	80.21	80.04
Others	89.61	77.99	86.08	79.54	83.58
Observations	26,435	32,535	45,822	28,376	74,198

Notes: [1]Households in the top 40% income percentile. [2]Households in the bottom 40% income percentile.
Source: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Table 6.2
Uncensored model. Expenditure elasticities by sample subgroup and food group.

EAT food groups	Highest income[1]	Lowest income[2]	Urban areas	Rural areas	Total sample
	(1)	(2)	(3)	(4)	(5)
High-fiber grains	0.318***	0.547***	0.402***	0.538***	0.461***
	(0.010)	(0.005)	(0.008)	(0.006)	(0.007)
Low-fiber grains	0.774***	0.798***	0.775***	0.805***	0.788***
	(0.007)	(0.005)	(0.007)	(0.005)	(0.006)
Tubers or starchy vegetables	0.786***	0.826***	0.771***	0.853***	0.811***
	(0.013)	(0.010)	(0.014)	(0.009)	(0.011)
Vegetables	0.887***	0.919***	0.892***	0.924***	0.906***
	(0.008)	(0.006)	(0.007)	(0.005)	(0.007)
Fruits	1.091***	1.129***	1.099***	1.134***	1.111***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Dairy foods	0.870***	0.903***	0.881***	0.900***	0.888***
	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)
Animal-based proteins	1.106***	1.131***	1.111***	1.130***	1.118***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Plant-based proteins	0.586***	0.736***	0.610***	0.757***	0.685***
	(0.016)	(0.008)	(0.014)	(0.008)	(0.011)
Added fats	1.038***	1.020***	1.039***	1.017***	1.028***
	(0.014)	(0.010)	(0.015)	(0.008)	(0.011)
Added sugars	0.734***	0.782***	0.743***	0.787***	0.762***
	(0.009)	(0.006)	(0.008)	(0.006)	(0.007)
Others	1.406***	1.539***	1.418***	1.606***	1.472***
	(0.007)	(0.010)	(0.007)	(0.011)	(0.008)
N	26,435	32,535	45,822	28,376	74,198

Notes: Estimations based on QUAIDS modelling with corrections for potential price and expenditure endogeneity. [1]Households in the top 40% income percentile. [2]Households in the bottom 40% income percentile.* p<0.1, ** p<0.05, *** p<0.01.
Sources: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Table 6.3
Censored model. Expenditure elasticities by sample subgroup and food group.

EAT food groups	Highest income[1]	Lowest income[2]	Urban areas	Rural areas	Total sample
	(1)	(2)	(3)	(4)	(5)
High-fiber grains	0.545***	0.945***	0.701***	0.952***	0.665***
	(0.008)	(005)	(0.004)	(0.007)	(0.007)
Low-fiber grains	0.854***	0.896***	0.760***	0.916***	0.684***
	(0.014)	(0.012)	(0.011)	(0.013)	(0.007)
Tubers or starchy vegetables	1.565***	0.835***	0.889***	0.881***	0.880***
	(0.098)	(0.029)	(0.013)	(0.021)	(0.015)
Vegetables	0.623***	0.900***	0.898***	0.807***	0.443***
	(0.045)	(0.012)	(0.017)	(0.018)	(0.037)
Fruits	1.033***	0.737***	1.040***	0.778***	1.191***
	(0.016)	(0.060)	(0.008)	(0.035)	(0.023)
Dairy foods	1.172***	1.035***	0.987***	0.997***	1.790***
	(0.128)	(0.019)	(0.027)	(0.021)	(0.093)
Animal-based proteins	1.321***	1.236***	1.352***	1.257***	1.220***
	(0.022)	(0.006)	(0.009)	(0.006)	(0.009)
Plant-based proteins	2.149***	1.234***	1.088***	1.135***	1.150***
	(0.067)	(0.016)	(0.004)	(0.011)	(0.007)
Added fats	0.998***	0.133**	1.035***	-0.054	1.132***
	(0.026)	(0.059)	(0.010)	(0.071)	(0.025)
Added sugars	0.802***	0.705***	0.841***	0.735***	0.861***
	(0.020)	(0.012)	(0.010)	(0.010)	(0.013)
Others	1.133***	1.206***	1.152***	1.196***	1.112***
	(0.004)	(0.013)	(0.003)	(0.015)	(0.004)
N	26,435	32,535	45,822	28,376	74,198

Notes: Estimations based on censored QUAIDS model with corrections for potential price and expenditure endogeneity. [1]Households in the top 40% income percentile. [2]Households in the bottom 40% income percentile.* p<0.1, ** p<0.05, *** p<0.01.
Sources: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Table 6.4

Uncensored model. Uncompensated own-price elasticities by sample subgroup and food group.

EAT food groups	Highest income[1]	Lowest income[2]	Urban areas	Rural areas	Total sample
	(1)	(2)	(3)	(4)	(5)
High-fiber grains	-0.872***	-0.919***	-0.888***	-0.918***	-0.901***
	(0.025)	(0.018)	(0.023)	(0.019)	(0.021)
Low-fiber grains	-0.965***	-0.969***	-0.966***	-0.970***	-0.968***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tubers or starchy vegetables	-0.189***	-0.305***	-0.122***	-0.413***	-0.262***
	(0.018)	(0.016)	(0.020)	(0.014)	(0.016)
Vegetables	-1.272***	-1.224***	-1.270***	-1.210***	-1.243***
	(0.039)	(0.032)	(0.038)	(0.030)	(0.034)
Fruits	-1.371***	-1.406***	-1.374***	-1.424***	-1.391***
	(0.040)	(0.043)	(0.040)	(0.045)	(0.042)
Dairy foods	-1.235***	-1.225***	-1.228***	-1.230***	-1.229***
	(0.020)	(0.019)	(0.019)	(0.019)	(0.019)
Animal-based proteins	-1.309***	-1.342***	-1.314***	-1.340***	-1.323***
	(0.010)	(0.011)	(0.010)	(0.011)	(0.010)
Plant-based proteins	0.512***	-0.098***	0.401***	-0.168***	0.112***
	(0.055)	(0.031)	(0.050)	(0.029)	(0.039)
Added fats	-0.099*	-0.266***	0.004	-0.395***	-0.198***
	(0.057)	(0.047)	(0.064)	(0.039)	(0.051)
Added sugars	-0.777***	-0.816***	-0.785***	-0.820***	-0.799***
	(0.014)	(0.011)	(0.013)	(0.011)	(0.012)
Others	-1.777***	-2.146***	-1.823***	-2.272***	-1.951***
	(0.034)	(0.053)	(0.037)	(0.059)	(0.043)
N	26,435	32,535	45,822	28,376	74,198

Notes: Estimations based on QUAIDS modelling with corrections for potential price and expenditure endogeneity. [1]Households in the top 40% income percentile. [2]Households in the bottom 40% income percentile.* p<0.1, ** p<0.05, *** p<0.01.

Sources: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Table 6.5
Censored model. Uncompensated own-price elasticities by sample subgroup and food group.

EAT food groups	Highest income[1]	Lowest income[2]	Urban areas	Rural areas	Total sample
	(1)	(2)	(3)	(4)	(5)
High-fiber grains	-1.056***	-0.936***	-0.973***	-0.943***	-0.947***
	(0.025)	(0.004)	(0.017)	(0.005)	(0.007)
Low-fiber grains	-0.972***	-0.973***	-0.961***	-0.970***	-0.986***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Tubers or starchy vegetables	-1.429***	-0.660***	-0.868***	-0.825***	-0.849***
	(0.042)	(0.011)	(0.006)	(0.008)	(0.005)
Vegetables	-1.028***	-1.195***	-1.276***	-1.218***	-1.775***
	(0.057)	(0.009)	(0.020)	(0.014)	(0.030)
Fruits	-0.878***	-1.449***	-0.914***	-1.207***	-0.912***
	(0.015)	(0.034)	(0.007	(0.018)	(0.013)
Dairy foods	0.791***	-1.095***	-0.111***	-1.043***	-2.228***
	(0.098)	(0.011)	(0.020)	(0.013)	(0.049)
Animal-based proteins	-1.179***	-1.123***	-1.090***	-1.104***	-1.104***
	(0.023)	(0.004)	(0.008)	(0.004)	(0.005)
Plant-based proteins	-0.880***	-1.015***	-0.940***	-0.908***	-0.999***
	(0.068)	(0.014)	(0.004)	(0.009)	(0.005)
Added fats	-1.096***	-0.275***	-1.044***	-0.033	-1.249***
	(0.041)	(0.076)	(0.016)	(0.094)	(0.030)
Added sugars	-0.819***	-1.059***	-0.952***	-1.067***	-0.976***
	(0.013)	(0.006)	(0.005)	(0.005)	(0.006)
Others	-0.960***	-1.121***	-0.976***	-1.102***	-0.923***
	(0.002)	(0.012)	(0.002)	(0.013)	(0.003)
N	26,435	32,535	45,822	28,376	74,198

Notes: Estimations based on censored QUAIDS model with corrections for potential price and expenditure endogeneity. [1]Households in the top 40% income percentile. [2]Households in the bottom 40% income percentile.* p<0.1, ** p<0.05, *** p<0.01.
Sources: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Table 6.6 shows the full set of own- and cross-price elasticities in the uncensored model. Regarding the food groups with projected increases in the EAT diets, we highlighted the following complementarities: 1) a reduction on the price of high-fiber grains would increase the purchases of vegetables, fruits, plant-based proteins and added fats; 2) fruit consumption is particularly complementary to vegetables' prices; 3) if prices of plant-based proteins fall, the consumption of added fats increases. On the contrary, the purchases of plant-based proteins and added-fats would be reduced if vegetables and fruits are cheaper, respectively (i.e., substitution effects). Nevertheless, substitution effects between foods with targeted reductions and increases in consumption may result in positive outcomes for the adoption of the EAT diets: 1) if the prices of dairy products rise, the purchases of vegetables would benefit; 2) a reduction in animal-based proteins' prices may result in increased consumption of fruits and added fats; 3) fruit consumption would increase if added sugars are more expensive. On the negative side, a rise in the price of dairy foods would decrease the purchases of plant-based proteins and added fats, while the same goes for the purchases of plant-based proteins when the price of added sugars rises (i.e., complementary effects).

Table 6.6

Uncensored model. Uncompensated own- and cross-price elasticities by food group.

EAT food groups	High-fiber grains	Low-fiber grains	Tubers or starchy vegetables	Vegetables	Fruits	Dairy foods	Animal-based proteins	Plant-based proteins	Added fats	Added sugars	Others
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
High-fiber grains	-0.901***	-0.023***	-0.017**	-0.345***	-0.056***	0.156***	-0.137***	-0.191***	-0.089***	0.128***	1.014***
	(0.021)	(0.001)	(0.008)	(0.031)	(0.021)	(0.017)	(0.013)	(0.021)	(0.027)	(0.010)	(0.037)
Low-fiber grains	-0.063***	-0.968***	0.001	0.006	0.010	0.010	0.077***	0.001	0.009	0.001	0.128***
	(0.021)	(0.001)	(0.009)	(0.033)	(0.022)	(0.018)	(0.014)	(0.022)	(0.028)	(0.011)	(0.039)
Tubers or starchy vegetables	-0.154***	0.001	-0.262***	-0.103*	0.268***	0.127***	0.033	-0.219***	0.045	0.134***	-0.679***
	(0.040)	(0.001)	(0.016)	(0.060)	(0.041)	(0.032)	(0.026)	(0.040)	(0.052)	(0.019)	(0.071)
Vegetables	-0.562***	-0.003***	-0.024***	-1.243***	-0.294***	0.270***	0.099***	0.175***	-0.006	0.039***	0.642***
	(0.023)	(0.001)	(0.009)	(0.034)	(0.024)	(0.019)	(0.015)	(0.023)	(0.030)	(0.011)	(0.041)
Fruits	-0.272***	0.002	0.134***	-0.725***	-1.391***	0.171***	0.253***	0.152***	0.208***	0.203***	0.155**
	(0.041)	(0.001)	(0.016)	(0.061)	(0.042)	(0.033)	(0.026)	(0.040)	(0.052)	(0.020)	(0.072)
Dairy foods	0.150***	0.001	0.022**	0.230***	0.067***	-1.229***	0.171***	-0.076***	-0.066**	0.040***	-0.198***
	(0.024)	(0.001)	(0.009)	(0.036)	(0.024)	(0.019)	(0.015)	(0.024)	(0.031)	(0.011)	(0.042)
Animal-based proteins	-0.133***	-0.002***	-0.003	0.014	0.031*	0.040***	-1.323***	0.007	0.015	-0.037***	0.272***
	(0.016)	(0.001)	(0.006)	(0.023)	(0.016)	(0.012)	(0.010)	(0.015)	(0.020)	(0.007)	(0.027)
Plant-based proteins	-0.815***	0.012***	-0.129***	0.502***	0.188***	-0.231***	0.169***	0.112***	-0.255***	-0.240***	0.003
	(0.039)	(0.001)	(0.015)	(0.057)	(0.039)	(0.031)	(0.024)	(0.039)	(0.049)	(0.019)	(0.068)
Added fats	-0.525***	0.019***	0.030*	-0.031	0.303***	-0.284***	0.201***	-0.331***	-0.198***	-0.105***	-0.109
	(0.040)	(0.001)	(0.016)	(0.059)	(0.040)	(0.032)	(0.025)	(0.039)	(0.051)	(0.019)	(0.070)
Added sugars	0.111***	0.003***	0.022**	0.040	0.074***	0.046**	-0.006	-0.067***	-0.017	-0.799***	-0.169***
	(0.026)	(0.001)	(0.010)	(0.038)	(0.026)	(0.021)	(0.016)	(0.025)	(0.033)	(0.012)	(0.045)
Others	0.431***	-0.005***	-0.063***	0.189***	0.012	-0.134***	0.240***	-0.020	-0.020	-0.150***	-1.951***
	(0.025)	(0.001)	(0.010)	(0.037)	(0.025)	(0.020)	(0.016)	(0.024)	(0.031)	(0.012)	(0.043)

Notes: Estimations based on QUAIDS modelling with corrections for potential price and expenditure endogeneity. * p<0.1, ** p<0.05, *** p<0.01.
Sources: 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

Appendix 7. Sensitivity analysis

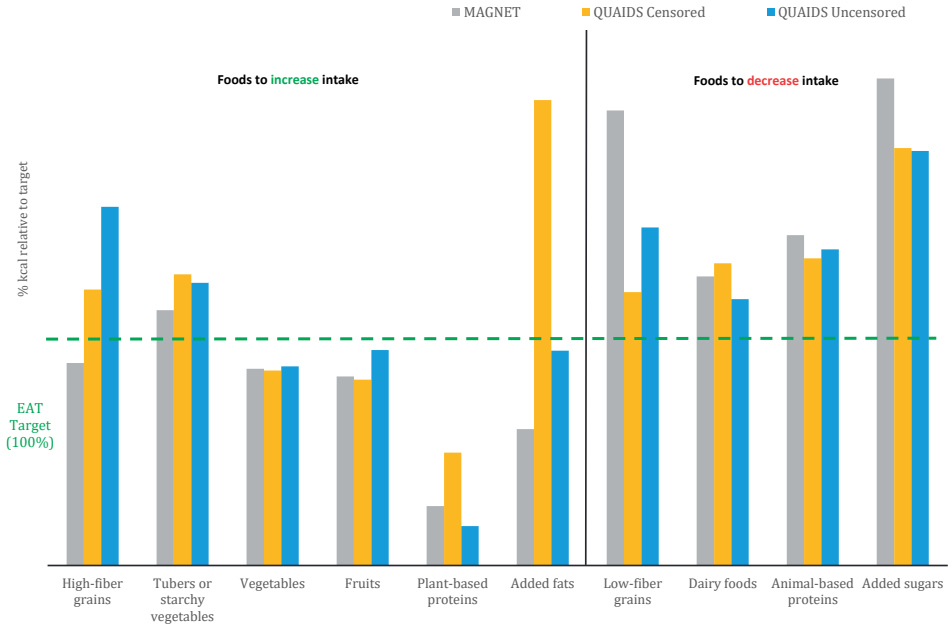

Fig. 7.1. Comparison of models. Macro-microsimulation of taxes and subsidies to reach the EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by model and food group.

Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. QUAIDS modelling based on calculations with corrections for potential price and expenditure endogeneity (with and without censoring corrections).

Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

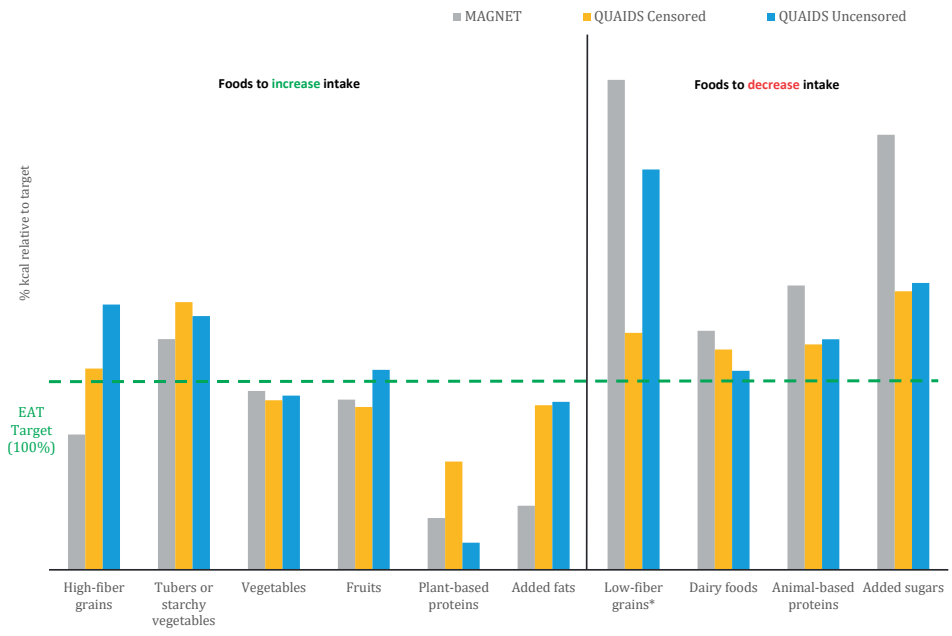

Fig. 7.2. Comparison of models. Macro-microsimulation of taxes and subsidies to reach the Milpa-EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by model and food group.
Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. QUAIDS modelling based on calculations with corrections for potential price and expenditure endogeneity (with and without censoring corrections). *Percentage values downscaled for visualization purposes.
Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

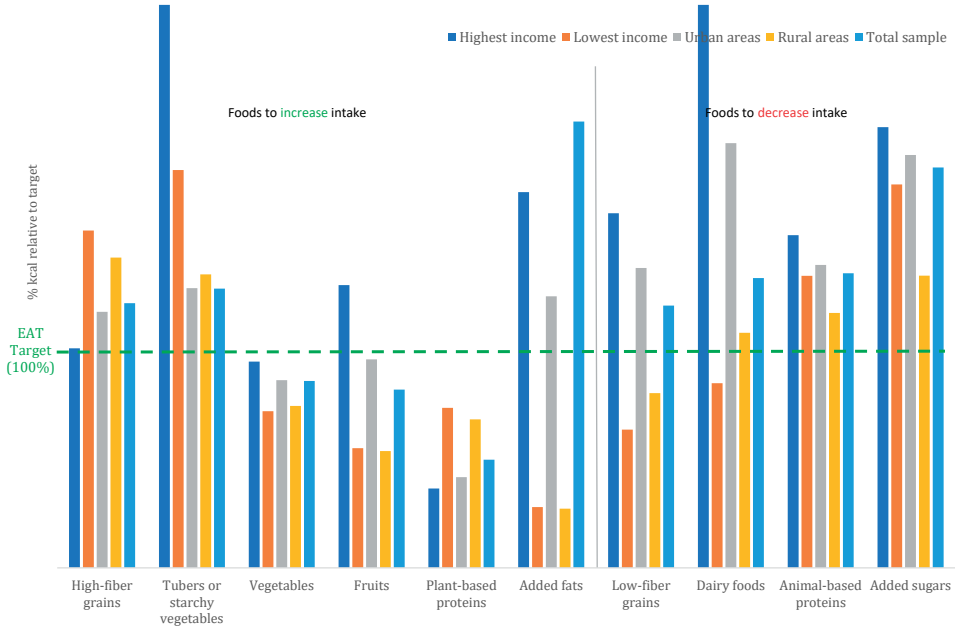

Fig. 7.3. Censored model. Macro-microsimulation of taxes and subsidies to reach the EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by sample subgroup and food group.
Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. Calculations based on QUAIDS modelling with corrections for censoring in the data, potential price and expenditure endogeneity.
Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

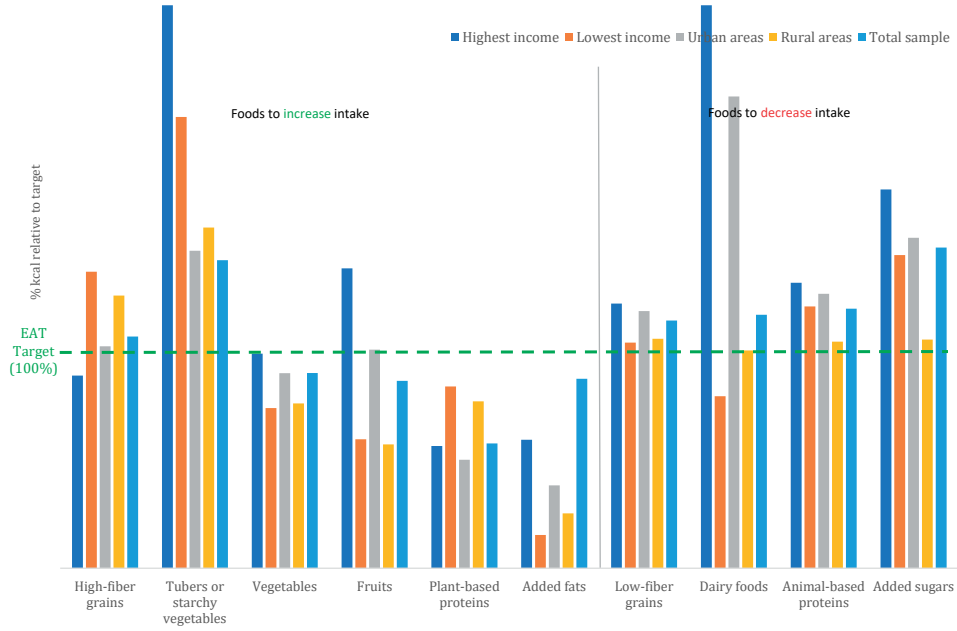

Fig. 7.4. Censored model. Macro-microsimulation of taxes and subsidies to reach the Milpa-EAT-Mx. Percentage of progress by 2040 with respect to the dietary targets by sample subgroup and food group.

Notes: The distribution of calorie values before the simulation was adjusted to be consistent with the ENSANUT structure of shares by food group. The dietary target corresponds to the goal by 2050. Calculations based on QUAIDS modelling with corrections for censoring in the data, potential price and expenditure endogeneity.

Source: Own calculations with data from 2018 Mexican National Household Income and Expenditure Survey (INEGI, 2019).

CHAPTER 3

3

Demand for Healthier and Higher-Priced Processed Foods in Low-Income Communities

Experimental evidence from Mexico City

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ABSTRACT

Diets in Mexico, like many countries, have changed dramatically in recent decades, with increased consumption of processed foods being a major factor. Research suggests that unhealthy diets in low-income communities reflect limited access to healthy foods, combined with high costs and limited knowledge. Weak demand signals from these communities likely disincentivise the food industry from delivering healthier, often costlier, options. This paper explores the potential to market healthy processed foods to these areas. We elicited willingness to pay (WTP) for healthier but relatively more expensive processed foods in low-income communities of Mexico City. We implemented a BDM mechanism to elicit WTP, with half of the participants randomly receiving information regarding nutritional content and health benefits. Results suggested that WTP was considerable among low-income groups but higher among higher-income groups within these communities. While, in general, providing nutrition and health information did not influence WTP, it was effective for those with strong preferences for the processed food category used in the study. WTP was highest among females and younger consumers, those who had a small family and children below 12 years in the household.

3.1 INTRODUCTION

Over the past decades, much of the world has experienced a nutrition transition characterised by strong shifts from traditional diets composed of whole foods (e.g., legumes, fruits and vegetables, whole grains) to a "Western diet" rich in saturated fats (especially from animal sources), added sugars and salt, and processed foods (Ford et al., 2017; Popkin & Gordon-Larsen, 2004). The associated public health challenges are rising rapidly in developing countries (Popkin, 2014, 2015), with Latin America and the Middle East and North Africa being the most obese regions (Popkin & Reardon, 2018). Factors influencing the growth of overweight and obesity are linked to food systems transformations, which were facilitated by five major drivers: income growth, policy liberalisation, infrastructure improvement, urbanisation and the rise of rural nonfarm employment (Popkin & Reardon, 2018). Despite these challenges, research on urban consumer food preferences in these countries remains relatively scarce (Blare et al., 2017).

The food industry has been challenged to become more involved in the promotion of healthier diets worldwide (WHO, 2018). Voluntary efforts by food companies to enhance processed foods' quality and reduce caloric content seem to be focused on high-income rather than in low- and middle-income countries (Popkin et al., 2012). As a result, healthy processed food alternatives are mainly available in higher-income small niche markets in certain countries (Popkin & Reardon, 2018). At the same time, low-income communities tend to have easy access to unhealthy food products and limited access to healthy alternatives as compared to richer areas in the same regions (Cummins et al., 2010; Hamelin et al., 2002; Pérez-Ferrer et al., 2019). Additionally, budget constraints (Bai et al., 2020; Waterlander et al., 2018), limited knowledge (Sandvik et al., 2018) and the overvaluation of sensory attributes like taste (Mancino et al., 2018) discourage healthy choices among disadvantaged groups. These barriers disincentivise local retailers to offer healthy foods in these areas, as they would provide them if sufficient demand were perceived from low-income consumers (Andreyeva et al., 2010).

Access to understandable information may support healthy food uptake (Mancino et al., 2018), as disadvantaged consumers may find it easier to identify healthy alternatives (Sandvik et al., 2018). Well-designed information strategies have guided behaviour changes in other domains like energy conservation (Delmas et al., 2013) and public health (Stead et al., 2019). Recent evidence in developing countries has shown that low-income consumers are willing to pay a premium for quality and nutritious foods, wherein nutrition information about the product positively influenced its valuation (Chege et al., 2019). In light of such evidence, consumers in low-income areas that are willing to purchase healthier foods may be negatively affected by lack of availability in their residential neighbourhood (van Ham et al., 2018).

Mexico represents a remarkable case in the nutrition transition (Popkin et al., 2012), where greater availability of relatively low-cost unhealthy processed foods has significantly contributed to aggravate its associated health problems (Giuntella et al., 2020). Over the last three decades the purchases of these foods have doubled, while those for healthier and less processed options have gradually declined (Marrón-Ponce et al., 2019). Likely factors that have contributed to the increase in uptake of these foods are the rise of advertisement by large processing companies, particularly for ultra-processed foods; volume discounts and promotions from these companies to retailers, and women increasingly working outside home, which has reduced cooking time and has made convenience foods (e.g., ready-to-heat, ready-to-eat) more appealing (Popkin & Reardon, 2018).

Processed wheat and maize products (e.g., pasta, flours, breads, cookies, tortillas, breakfast cereals) are the most prominent category in the Mexican food retail. Altogether, these products represent 33% of the production of processed foods (PROMEXICO, 2018) and contribute to 40% of the total energy intake of the population (Marrón-Ponce et al., 2019). They are not only major sources of energy, but also of essential proteins and micronutrients, and diverse non-nutrient bioactive food components (Poole et al., 2020). Their susbstantial contribution to acheiving nutrient adequacy comes at a relatively low-cost (Bai et al., 2020). Traditionally, the Mexican diet has included high consumption levels of maize tortillas and other types of maize-based products (Dunn et al., 2008; INEGI, 2017). However, several factors like gains in consumer purchasing power and rising maize prices, have led to a gradual transition towards processed wheat products, including bread (Afeiche et al., 2017; Juarez & Harrison, 2018; Popkin & Reardon, 2018). Products like baguette and packaged breads are substitute goods for tortillas in low- and middle-income groups (Retes-Mantilla et al., 2013)[2]. Nonetheless, the most popular varieties within these breads exhibit low fibre content, while at the same time, the Mexican population consumes a limited diversity (Rivera-Dommarco et al., 2018) and likely insufficient amount of high-fibre whole grains (Popkin & Reardon, 2018). Therefore, the intake of high-fibre bread varieties will support improved nutrition, and offer positive metabolic and health effects (CIMMYT, 2017; Poole et al., 2020).

The transition towards processed wheat products is more evident in large metropolitan areas such as Mexico City (Torres, 2007). Mexico City has a sophisticated food processing and retail environment with the presence of multinationals, and the continuous expansion of large supermarket chains and convenience stores (Pérez-Ferrer et al., 2019). Accordingly, 66% of its population's food consumption comes from processed and packaged sources (Popkin, 2017). A recent study found that only 1 out of 10 processed

2 Baguette refers to a minimally processed white bread that is low in fibre content and called bolillo in Mexico. In their estimations, the cited authors grouped bolillo with other traditional white breads (e.g., telera).

wheat and maize products available in food retail outlets in Mexico City were healthy, while this proportion was lower in the low- than in high-socioeconomic status areas analysed (Marrón-Ponce et al., 2020b). In low-income peri-urban areas, nearly half of the healthy processed wheat and maize portfolio was unavailable, whereas the usage of nutrition and health information in the packaging was less frequent (Fernández-Gaxiola et al., 2022). Processed wheat retailers have a limited scope particularly in the peri-urban neighbourhoods where lower-income households tend to locate (Torres, 2007).

This research examines willingness to pay (WTP) for healthy and higher-priced variants of processed foods in peri-urban Mexico City. Our case study focused on the demand for packaged bread. We employed non-hypothetical methods to elicit consumers monetary valuations, a common tool to analyse the potential uptake of healthy foods (Batte et al., 2007; Janssen & Hamm, 2012; Sriwaranun et al., 2019). In addition, we tested the effect of providing consumers with nutrition and health information on product valuations. This work complements a supply-side analysis of the diversity of processed foods in Mexico City, conducted together with the International Maize and Wheat Improvement Centre (CIMMYT) (Fernández-Gaxiola et al., 2022; Marrón-Ponce et al., 2020b). Our goal was to shed light on potential demand and pathways that could facilitate the purchases of an expanded availability of healthy products in low-income communities.

The next section presents the hypotheses of the research. Section 3 describes our methodology and empirical approach. Then, we analyse the main findings regarding the potential uptake of healthy processed foods in the study area. Section 5 discusses the main results and implications for the food industry. The last section provides concluding remarks.

3.2 HYPOTHESES

Three overarching hypotheses guided this research, which are laid out below.

*Hypothesis 1. Low-income consumers are willing to pay market prices for healthy variants of processed foods (**H1**).*

The standard perception is that price limits the purchase of healthier food items, especially for low-income consumers (Waterlander et al., 2018). Yet, evidence from Africa, Asia and Latin America has shown that lower-income rural and urban consumers are willing to pay for nutritious foods at market prices (Birol et al., 2015; Chege et al., 2019; de Groote et al., 2017). However, these studies framed the development problem in terms of micronutrient deficiencies, and thus, they focused on WTP for enhanced nutritional quality through

biofortication, fortification or composite products of lower-cost staple foods. In this paper, we attempt to deepen our understanding of market engagement by lower-income consumers to processed foods with a better nutritional profile in terms of macronutrients and ingredients (e.g., lower calories, fat, sodium and sugar; higher in protein and fibre) and a relatively higher price. As dietary choices are related to household-level characteristics like education and income (Allcott et al., 2019; Mancino et al., 2018; ver Ploeg & Wilde, 2018), it is plausible that this hypothesis may particularly hold in wealthier developing country's urban areas such as Mexico City.

*Hypothesis 2. In low-income peri-urban communities, higher-income consumers have a higher WTP for healthy variants of processed foods than lower-income consumers (**H2**).*

There is a high degree of social mix in the periphery landscape of developing countries' metropolitan areas (Monkkonen et al., 2018) that needs to be acknowledged to shed more light on potential business opportunities. It is common that peri-urban areas include predominately low-income groups, often engaged in the informal sector, but also higher-income groups working in formal jobs, typically commuting to the main urban centres. In addition to the potential demand among low-income consumers, we anticipated a substantial demand from those with higher income. Higher disposable income among the latter group may imply a more diverse diet, including healthier processed foods, thus leading to potentially higher WTP. Assuming the latter argument holds, social-interactive mechanisms (e.g., social contagion, collective socialisation) at the neighbourhood level (Duncan et al., 1997; Galster, 2012; Leventhal & Brooks-Gunn, 2000) may incentivise lower-income consumers to mimic their higher-income and own group neighbours' behaviour. Causal evidence within this literature has revealed that even after controlling for neighbourhood selection, place of residence still influences individuals' outcomes (van Ham et al., 2018).

*Hypothesis 3. The provision of nutrition and health information increases consumers' WTP (**H3**).*

Economic theory predicts that information aids agents to make rational choices aligned with their preferences and needs. Hence, individuals with a knowledge deficit will increase their valuation of healthy processed foods when receiving the signal that these products are favourable for their diet and overall health. Based on a meta-analysis of the existing literature on WTP for unprocessed and processed foods that are beneficial for health (i.e. functional foods), Dolgopolova & Teuber (2018) estimated that health claims generally resulted in positive marginal valuations. Similar results were found in WTP experiments for products bearing nutritional claims (De-Magistris & López-Galán, 2016). As nearly all

this literature related to processed products is concentrated in developed regions, we attempted to provide evidence to see if this holds in a developing country context.

3.3 MATERIALS AND METHODS

Fieldwork was conducted in the north-eastern Mexico City from September 2nd to October 4th, 2019. We selected six data collection sites (see Fig. 1), as detailed below. In five out of six locations, we collected data for up to three days to reduce the risk of spillover effects. For logistics and safety reasons, however, we collected data in one of the locations for a total of eleven days in three different weeks. Data collection took place between 9 am and 4 pm during twenty weekdays. Participants who engaged in the study signed consent forms, and the project's protocol was approved by CIMMYT's Institutional Research Ethics Committee.

3.3.1 Data collection sites

To determine the research locations, we used venue-based sampling. In order to target low-income segments, we selected densely populated municipalities that were considered to have high or very high levels of marginalisation according to the Index of Urban Marginalisation elaborated by the National Population Council (CONAPO). This index includes ten indicators covering four dimensions: education, health, housing conditions, and asset ownership. Within these municipalities, we purposely selected six sites where we were likely to encounter many primary shoppers. All sites were in areas with high levels of marginalisation, but to ensure encountering both poor and less poor people, we made sure to include sites in areas surrounded by areas with medium-level marginalisation. The selected sites were in a central square, a shopping mall, and locations in streets close to schools in the municipalities of Chimalhuacan, Chicoloapan and Texcoco.

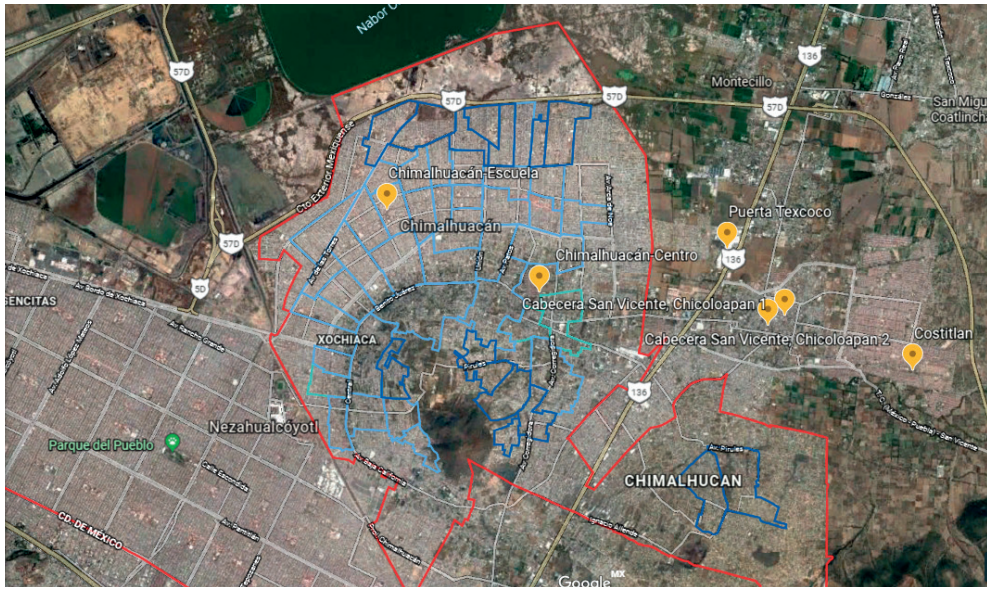

Fig. 1. Data collection sites shown as yellow spots.

3.3.2 Participants

Our sample consisted of 472 persons who purchased household grocery on a regular basis. A team of seven researchers approached passers-by to participate in the study. Female respondents comprised roughly 69% of the sample (Table 1). While women were more prevalent in our sample than in the population, this reflects that they are typically the primary grocery shoppers. Likewise, average age (41) was higher than in the general population as we only interviewed adults. Although interviews occurred during working hours, a high percentage of interviewees (68%) had engaged in a remunerated activity in the previous month. Perhaps an important share were informally employed given that they were outside during these hours. This does not necessarily suggest a biased sample, as the rate of informal employment is high at around 50% in Mexico City. The majority of respondents (86%) were classified in the lower-income categories (see Table 2). Based on Table 2 data and information on household sizes, we found that at least 76% of the interviewees lived in a household with an income below the urban poverty line (MXN 3,091/USD 158 per person).

68% of the participants had consumed packaged bread in the previous week. The majority of participants (60%) had consumed both packaged bread and its substitute baguette. It was more common to consume baguette but not packaged bread (28%) than the other way around (8%). Packaged bread was purchased at least every other week by nearly 80% of the sample.

Table 1
Descriptive statistics in the sample and selected Mexico's areas

Variable	Sample				Mean in selected areas		
	Mean	Std. Dev.	Min	Max	National	Mexico City[5]	Municipalities in the sample[6]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Basic demographics							
Female	0.69	0.46	0	1	0.51	0.52	0.52
Age (years)[1]	41.22	14.94	18	85	28.92	30.55	27.00
Remunerated activity[2]	0.68	0.47	0	1	0.63	0.64	0.65
HH size	4.19	2.01	1	15	3.93	3.83	4.06
Children<12 yr.[3]	0.99	1.19	0	8	0.59	0.54	0.65
In partnership[4]	0.65	0.48	0	1	0.65	0.61	0.67
Education							
None	0.02	0.14	0	1	0.08	0.04	0.04
Primary	0.49	0.50	0	1	0.56	0.49	0.58
Secondary	0.33	0.47	0	1	0.18	0.23	0.23
Tertiary	0.15	0.36	0	1	0.18	0.24	0.15

Notes: [1] Weighted average in columns 5 and 6; and median values' average in column 7. [2] Includes the unemployed in columns 5, 6 and 7. [3] Includes households with children until 14 years in columns 5, 6 and 7. [4] Includes married and living together. [5] 2010 Average in Mexico City and the State of Mexico. [6] 2015 Average in *Chicoloapan*, *Chimalhuacan* and *Texcoco*. Source: Columns 5, 6 and 7 are own elaboration with data from National Census 2010 and Intercensal Survey 2015, National Institute of Statistics and Geography (INEGI).

Table 2
Sample size by household monthly income level

Category	Income level (MXN)		Freq.	Percent	Cum.
	Min	Max			
Very low	0	2,500 (128)	91	19.28	19.28
Low and middle-low	2,501	11,000 (562)	317	67.16	86.44
Middle-high and above	11,001	More	64	13.56	100.00
		Total	472	100.00	

Notes: Amounts in USD in parentheses (Ex. Rate 19.6 MXN/USD).

3.3.3 Products

We selected two high-fibre bread products based on information provided by Marrón-Ponce et al. (2020b). These authors calculated nutrition scores for processed wheat and maize products in retail outlets in selected parts of Mexico City, following the Pan American Health Organization's Nutrient Profile Model (PAHO, 2016). They classified the products in five levels of healthiness based on their calories, sugar, saturated fat, sodium, protein and fibre content. We focused on products in the healthiest category, that had a cost above the conventional options, and were unavailable and likely unknown in the researched zones. According to the classification 17 out of 53 packaged breads were rated in the desired category. From the shortlisted options we selected two that: a) had the traditional sandwich-like slice; b) had a colour that was appealing to consumers in the area (not black) and signalling healthiness (not white); c) were not readily available in the research zones; and d) were not of the same brand. Focus groups and visits to supermarkets in well-off districts informed this decision-making process.

The selected breads were (see Fig. 2): 1) Canadian Bagels and 2) Oroweat 12 Grains. To focus less on brands and more on a set of products chosen to test our hypotheses, we will refer to them by their package colours as green and red, respectively. These breads were richer in protein and fibre and had less sodium content than a standard and highly consumed white packaged bread, which translated into a higher nutrition score (see Table 3, last column). Switching consumption from white bread to the selected breads would thus contribute to healthier diets.

Bread prices collected from different retail outlets (e.g., supermarkets, independently owned grocery stores, corner stores and convenience stores) were obtained from Marrón-Ponce et al. (2020b) to compute mean values. The green bread fetched an average price of MXN 44 (USD 2.25) and tended to be sold only in supermarkets in higher-income areas of Mexico City. The red bread had an average price of MXN 49 (USD 2.51) and was available in most types of retailers including supermarkets, even in a couple of these in the periphery of the study area. However, only a few participants in focus groups and during data collection were aware of its existence. The costs of these products were at least 35% above the mean cost of the most frequently consumed bread products (i.e., white bread MXN 33 (USD 1.66)).

Table 3
Nutrition profile of the study's packaged breads and the conventional option.

Packaged bread	Protein	Fibre	Kcal	Sat. fat (per 100 gr.)	Carbs	Sugar	Sodium	Nutrition score*
Green	8.8	9.6	252.0	0.4	56.4	4.4	404.0	3
Red	11.8	4.7	287.1	0.9	49.4	7.1	376.5	2
Conventional (white)	6.8	0.0	246.6	0.3	50.7	6.8	439.2	-4

Notes: * Values shown with opposite sign with respect to standard methodology to reflect that a higher score means that the product is healthier. It is the weighted sum of the nutrition indicators shown in the table, where protein and fibre are favourable components that increase the score; while total fat, saturated fat, carbohydrates, sugar and sodium are unfavourable components that reduce the score. Source: own estimations based on data from Marrón-Ponce et al. (2020b).

Fig 2. Packaged bread varieties.

3.3.4 Experimental design

We used a Becker-DeGroot-Marschak (BDM) auction-type mechanism to estimate WTP, where half of the participants were randomly selected to receive information about the positive health aspects of the selected food items. BDM auctions are relatively easy to implement and incentive-compatible, which increases the chance of respondents revealing their true WTP, thus potentially reducing hypothetical bias (Skuza et al., 2015). They do not require gathering groups of people, as opposed to other commonly used methods such as Vickery second price auctions. While BDM auctions have been shown to generate less accurate results than more complex alternatives (Lusk & Rousu, 2006), a recent study suggests they yield similar results when participants are experienced in making market purchases of the product (Banerji et al., 2018).

Three focus groups were organised in the area to inform and validate our research design. These provided insights on the local context and helped to refine the survey

modules and BDM protocol. The final design of the survey tools had the following elements and order:

1. *Background information:* Participants provided information on basic demographics, family food consumption behaviours regarding bread and maize tortilla products, and stated the time of their last meal, which helped to control for level of hunger.

2. *Nutrition and health information* (treatment group only): The enumerators explained to treated participants that both breads were high in fibre, low in fat, and high in whole grains content; and that a diet rich in fibre and whole grains reduces the risk of constipation and colon cancer (see exact wording and materials in appendix 2). We employed succinct non-technical wording, as suggested in the literature (Hellyer et al., 2012).

3. *Sensory evaluation:* Participants tasted a piece of each bread variety and rated seven attributes using a visual scale (see materials and protocol in appendix 2), where the tasting order was random.

4. *Mood:* Participants responded to questions about their levels of hurriedness, tiredness and stress.

5. *Training:* Before the auction, participants engaged in a practice round, where we used didactic charts that outlined the auction implementation process. Contrary to the actual auction in which participants received real money, we gave participants toy coins in the practice round to avoid cash-in-hand effects (Morawetz et al., 2011). The practice round was designed to ensure that individuals were aware of the implications of overbidding or underbidding, thus making it more plausible that they bided equal to their real valuation of the product.

6. *Grocery expenses:* Question about weekly grocery expenses.

7. *Auction fee:* An endowment of MXN 60 (USD 3.06) was given to each auction participant, which was enough to cover the market price of either of the breads used.

8. *Bidding:* Each participant was asked to bid for a package of each of the two bread options, and their bids were recorded.

9. *Selection of binding option:* One of the bread options was randomly selected for the auction.

10. *Auction result:* A random sale price was drawn from a bag with a set of five values distributed around market prices of the study's products. The distribution was unknown to

participants. If the biding price was greater than or equal to the sale price, the participant got the product and the change after paying the sales price; otherwise, the participant did not get the product and kept the auction fee (see materials and protocol in appendix 3).

11. *Knowledge acquisition questions* (treatment group only): After the experiment, we asked information recipients two questions to test knowledge acquisition. These questions were multi-select multiple choice, where the first was about the breads' nutritional content, and the second covered the health risks mentioned in point two.

12. *Income sources:* At the end of the interview, respondents provided information about their household's monthly income, and whether their family received remittances and government financial support.

We asked all questions, with the exception of those related to knowledge acquisition and income sources, before the auction in anticipation that respondents might lose interest in continuing the interview after the auction. We did not foresee significant bias in the experiment due to these questions as they were unrelated to WTP.

3.3.5 Estimation strategy

We treated our data as a panel with two observations per subject, one for each bread. Hausman tests indicated that the random-effects estimator was preferred over the fixed-effects estimator. The full specification used for the estimations of the WTP of person *i* for bread variety *j* is therefore as follows:

$$\mathrm{WTP_{ij}} = \alpha + \beta Info_i + \sum_{\mathrm{k}=1}^{\mathrm{K}} \delta_{\mathrm{k}} X_i^k + \sum_{m=1}^{M} \gamma_m Sen_{ij}^m + \sum_{n=1}^{N} \varphi_n Bread_i^n + \vartheta Red_{ij} + \theta\left(Info_i \times Red_{ij}\right) + \sum_{\mathrm{o}=1}^{\mathrm{O}} \omega_{\mathrm{o}} Z_i^o + c_s + m_e + \eta_i + \epsilon_{ij}$$

Where:

- $Info_i$: dummy variable that takes the value of 1 if the individual is treated with the nutrition and health information, 0 otherwise.

- X_i^k: sociodemographic covariates. 1) Demographics: female, dummy variable equal to 1 if female, 0 otherwise; age in years; partnership status, dummy variable equal to 1 if the participant has a partner (e.g., married or living together), 0 otherwise; secondary education, dummy variable equal to 1 if completed secondary school or a higher level, 0 otherwise; remunerated activity, a dummy variable equal to 1 if the individual generated an income in the previous month, 0 otherwise; children dependency ratio, equal to the number of children below 12 years of age divided by household size; and household size. 2) Income categories: low and middle-low, equal to 1 if monthly household income

between MXN 2,501-11,000, 0 otherwise; and middle-high and above, equal to 1 if monthly household income above MXN 11,000, 0 otherwise.

- Sen_{ij}^{m}: sensory attributes with scores ranging from 1 to 7, which were (i) taste (ii) appearance and (iii) size. We only selected three out of seven attributes to avoid multicollinearity problems.

- $Bread_{i}^{n}$: bread consumption variables, which included: (i) existence of dietary restrictions related to bread, dummy variable equal to 1 if bread purchases are restricted due to the health condition of a respondents' family member, 0 otherwise; (ii) frequency of consumption of packaged bread, dummy variable equal to 1 if packaged bread is purchased on a weekly basis, 0 otherwise; and whether baguette, a common substitute of packaged bread, was consumed (dummy variable equal to 1 if consumer had a baguette on the previous week, 0 otherwise).

- Red_{ij}: Red bread variety, dummy variable equal to 1 if referring to the red bread, 0 if referring to the green bread.

- Z_{i}^{o}: set of additional control variables, which included: (i) level of hunger, dummy variable equal to 1 if time from last meal is less than three hours, 0 otherwise; (ii) level of rush, dummy variable equal to 1 if not in a hurry, 0 otherwise; (iii) level of tiredness, dummy variable equal to 1 if not tired, 0 otherwise; (iv) stress level past month, equal to 1 if very worried about affording grocery expenses in the past month, 0 otherwise; (v) other income sources, to include remittances (dummy variable equal to 1 if received remittances from other region or abroad, 0 otherwise) and government benefits, (equal to 1 if received a benefit from the government, 0 otherwise); and (vi) bid in the practice round to capture revealed preferences information. Variables i-iv were measured as median splits of continuous variables and typically influence WTP (Morawetz et al., 2011).

- m_e: enumerator fixed-effects.

- c_s: data collection site fixed-effects.

- η_i: individual random-effects in the residual term.

- ϵ_{ij}: random error term.

In contrast with similar WTP studies (Chege et al., 2019; Hellyer et al., 2012; Teuber et al., 2016), we did not choose a Tobit specification, as did not have bids with a value of zero. As

packaged bread and baguette tend to be substitute goods, we employed a heterogeneity analysis based on the consumption preferences for these two products.

3.4 RESULTS

3.4.1 Balance checks and enumerator bias

There were a few imbalances between the treatment groups at 5% (i.e., female, level of hunger) and 10% (i.e., in partnership, income low and middle-low) levels of significance (Appendix 1). As an additional balance check, we performed a joint test of orthogonality, by estimating a probit regression of the treatment variable against the sociodemographics, bread preferences, mood and hunger level, and other income sources. Through this test we could not reject the null hypothesis that all the regression coefficients are simultaneously equal to zero (Prob>χ^2=0.187), which suggests that both treatment groups are comparable in terms of a large set of characteristics.

The team of enumerators was relatively homogeneous: five out of seven were between 24 and 26 years old. In addition, the eldest enumerator (i.e., the supervisor, aged 34) interviewed only two respondents. The key difference was their gender with four female and three male enumerators. Female interviewers were somewhat more likely to interview respondents that were older, had a higher-income, were not in a hurry and under less stress (Appendix 1). Through a joint test of orthogonality estimated as above, we rejected the null hypothesis of equal participant pools (Prob>χ^2=0.032). Hence, enumerators' sex influenced the sample composition.

In our regression analyses, we provide specifications that control for sociodemographics, bread preferences, mood and hunger level, and other income sources of the respondents, and enumerator fixed effects.

3.4.2 Sensory analysis

Both breads were generally well-liked, with scores around 5 and above in all categories, based on a 1-7 scale (Table 4). The red bread was significantly preferred across all the measured attributes. Especially taste and texture were rated higher, mainly due to the green bread regularly judged as tougher and drier. This may be driven by the fact that the red bread has three times more ingredients than the green bread (27 vs 10), including taste enhancers and a higher sugar content (7.1 vs 4.4. gr/100gr). Additionally, as reflected by its highest scores, this bread possessed visual attributes that consumers found attractive, such as whole grains sprinkled on the top of the loaf. The information treatment did not affect the sensory evaluations (Appendix 1).

Table 4
Sensory attributes' descriptive statistics by bread type

Attribute	Bread type				Means diff.†
	Red		Green		
	Mean	Std. Dev.	Mean	Std. Dev.	
Smell	5.88	1.05	5.13	1.23	0.75***
Taste	6.11	1.02	4.98	1.38	1.13***
Texture	5.96	1.07	4.86	1.46	1.09***
Appearance	6.22	0.94	5.36	1.30	0.86***
Colour	6.14	1.00	5.51	1.21	0.63***
Size	6.39	0.86	5.76	1.22	0.63***
Thickness	6.29	0.95	5.61	1.28	0.68***

Notes: † Paired t-test on equality of means. * p<0.1, ** p<0.05, *** p<0.01.

3.4.3 Willingness to pay

The average valuations for the green and red products were 27% and 23% below their respective market prices (see Table 5). Our data also revealed that 14% and 18% of the participants were willing to pay the market prices or above for the green and red breads, respectively. In Fig. 3, we observe that a substantial share of participants had a WTP around MXN 40, which is just below market prices. The most frequently offered bids were close to the price of the conventional white packaged bread (MXN 33).

Table 5
Bids by income level and bread type

Category	Bread type			
	Red		Green	
	Mean	Std. Dev.	Mean	Std. Dev.
Very low	35.79	10.12	30.31	9.89
Low and middle-low	37.30	10.34	31.78	9.87
Middle-high and above	43.75	9.59	35.50	10.46
All sample	37.89	10.46	32.00	10.04

Notes: Amounts in MXN (Ex. Rate 19.6 MXN/USD).

3.4.3.1 Demand among low-income consumers

The distribution of bids for the lower-income categories (i.e., very low, low and middle-low) exhibits a similar pattern to the whole sample (Fig. 3). The average bid for these categories was below the cost of the green and red products between 28-31% and 24-27%, respectively (Table 5). Furthermore, the proportions of valuations at least at market

prices were 10-14% for the green bread and 12-17% for the red bread (see Fig. 4a and 4b). Half of these participants were willing to pay a premium with respect to the cost of the conventional option, particularly for the red variety for which the average premiums were between 10-15%. Thus, we found evidence to partially support H1: A non-negligible part of low-income consumers were willing to pay market prices for healthy variants of processed foods.

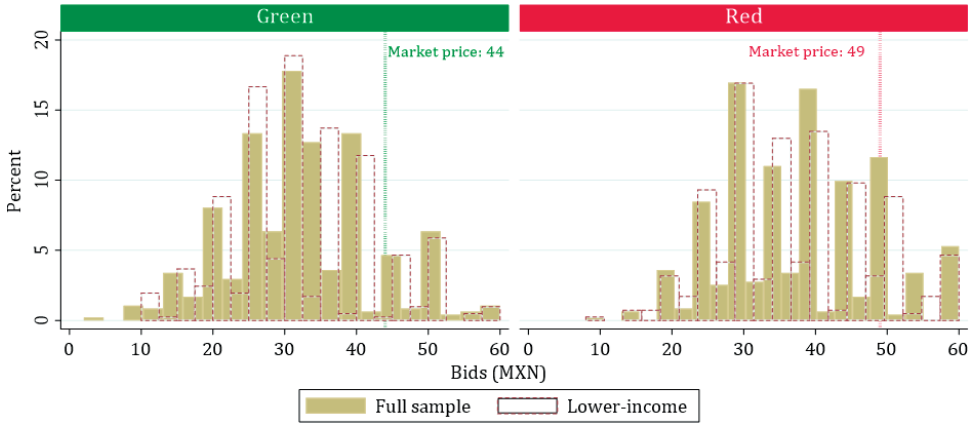

Fig. 3. Distribution of bids for the full sample and lower-income categories by bread type.

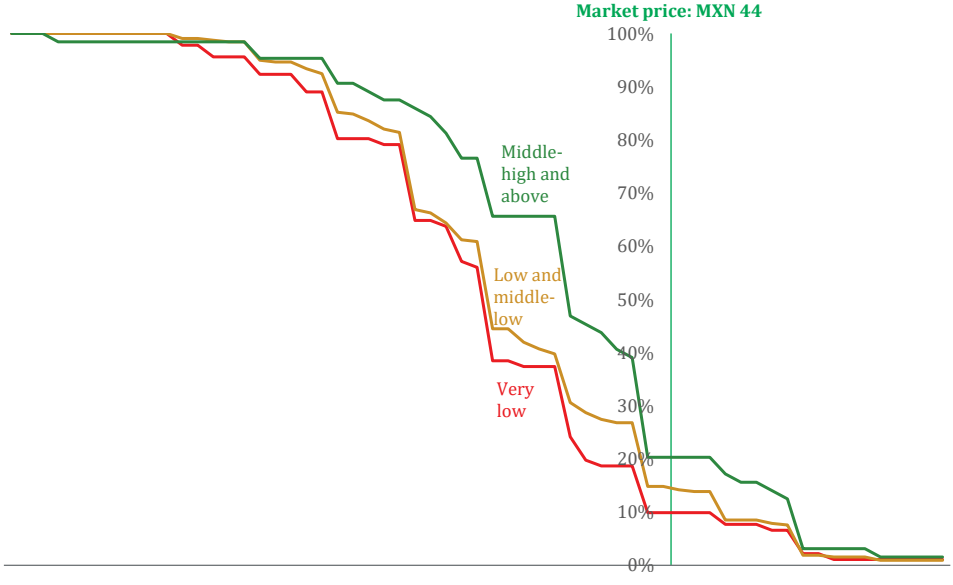

Fig. 4a. Cumulative distribution of bids by income level for the green bread.

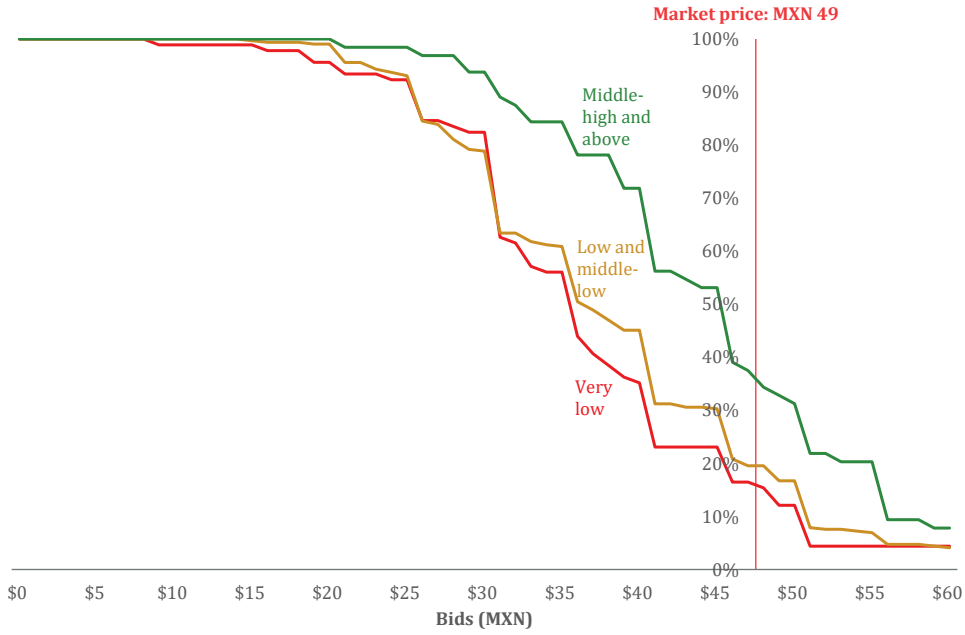

Fig. 4b. Cumulative distribution of bids by income level for the red bread.

3.4.3.2 Incorporating higher-income consumers

Ceteris paribus, consumers who formed part of households in the middle-high and above income category were willing to pay MXN 5.5 more than those with very low income (see Table 7). They were also willing to pay more than the low- and middle low group (Prob>χ^2=0.028). Within this category, 20% and 33% of the bids were equal or greater than the market prices of the green and red breads, respectively (see Figs. 4a and 4b). This provides evidence in favour of H2: Higher-income consumers in low-income communities have a higher WTP for healthy variants of processed foods than lower-income consumers.

3.4.3.3 The role of nutrition and health information provision

Before eliciting WTP, we provided a random selection of participants with facts about fat, sugar and whole grains content, as well as about prevention of health risks. This information did not influence their valuations of healthy packaged bread for the whole sample, nor by bread type (see Table 6, columns 9 and 10; and Table 7). This result is robust to the inclusion of a large set of individual controls and location and enumerator fixed effects. Most of the respondents (75%) remembered at least one component in the information provided, especially fibre content. We did an explorative analysis to test for sub-group differences based on bread preferences. We divided our sample in three groups: those that did not consume packaged bread, those that consumed packaged bread and its close substitute baguette, and those that consumed packaged bread but

not baguettes[3]. We found that information effectively increased WTP for the latter group, which we expect to have the highest consumption of packaged bread (see Table 8). The increase was equivalent to 0.82 SD and did not differ between the two bread types. The coefficient remained significant even after controlling for multiple hypothesis testing using the false discovery rate adjustment (Anderson, 2008). This result needs to be interpreted with caution as it is based in a relatively small sample[4]. Hence, H3 partially holds in our study: the provision of nutrition and health information increases WTP only for specific consumer segments.

The lack of observed impact for the whole sample could in theory have been caused by diffusion of treatment if early participants in the treatment group shared their new knowledge with acquaintances who later became untreated participants. This was especially a risk for the area where we spent eleven days in total, compared to two or three in the others. As a robustness check, we re-estimated WTP excluding observations from the location where we stayed for longer. The treatment effect remained statistically insignificant. We therefore do not think that the lack of impact is caused by diffusion of treatment.

Table 6
Summary statistics of bids by treatment group and bread type

Sample	Treatment				Control				*p*-value†	
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
All	34.80	10.70	8	60	35.08	10.63	2	60	0.681	0.565
Green bread	31.60	9.75	10	60	32.39	10.33	2	60	0.395	0.379
Red bread	38.00	10.68	8	60	37.78	10.26	14	60	0.822	0.924

Notes: †*p*-value in column 9 is based on *t*-test on equality of means between groups; while *p*-value in column 10 is based on Wilcoxon ranksum test for equality of distributions.

3 17 participants that did not consume any of the breads were excluded from this analysis given the small sample.

4 We confirmed this result with a larger sample (156) by adding the same group of consumers from another study that we ran simultaneously. The latter had the same research design, the only difference was an additional treatment that was expected to decrease WTP but did not alter the effect of information.

Table 7
Regression analysis on willingness to pay

Dependent variable	Willingness to pay (MXN)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Information	0.038	-0.228	-0.228	-0.035	0.043	-0.389	0.009
	(0.862)	(0.852)	(0.840)	(0.825)	(0.854)	(0.892)	(0.862)
Demographics							
Female		2.776***	3.178***	3.147***	3.013***	3.013***	2.912***
		(0.953)	(0.949)	(0.929)	(0.946)	(0.946)	(0.918)
Age		-0.066**	-0.059*	-0.080***	-0.069**	-0.069**	-0.073**
		(0.032)	(0.031)	(0.030)	(0.031)	(0.031)	(0.030)
In partnership		1.684*	1.478*	1.235	1.460*	1.460*	1.097
		(0.905)	(0.890)	(0.886)	(0.884)	(0.884)	(0.861)
Above secondary education		0.618	-0.283	-0.152	-0.106	-0.107	-0.029
		(0.937)	(0.981)	(0.970)	(0.978)	(0.979)	(0.936)
Remunerated activity		0.902	0.631	0.598	0.789	0.790	0.519
		(0.915)	(0.896)	(0.884)	(0.895)	(0.895)	(0.901)
Children <12 yr. dependency ratio		1.084	0.904	1.848	2.296*	2.296*	2.427*
		(1.666)	(1.519)	(1.430)	(1.380)	(1.381)	(1.362)
Household size		-0.629***	-0.605***	-0.626***	-0.502**	-0.502**	-0.464**
		(0.228)	(0.222)	(0.223)	(0.214)	(0.214)	(0.209)
Income level							
Low and middle-low			1.453	1.834*	1.891*	1.889*	2.806***
			(1.097)	(1.074)	(1.067)	(1.068)	(1.085)
Middle-high and above			5.970***	6.001***	5.534***	5.534***	5.548***
			(1.560)	(1.506)	(1.579)	(1.580)	(1.543)
Sensory analysis							
Taste				1.468***	1.458***	1.448***	1.440***
				(0.215)	(0.214)	(0.214)	(0.213)
Appearance				0.771***	0.796***	0.801***	0.768***
				(0.247)	(0.247)	(0.247)	(0.249)
Size				0.461*	0.461*	0.464*	0.549**
				(0.273)	(0.274)	(0.276)	(0.274)
Bread preferences							
Bread dietary restrictions					1.414	1.414	0.912
					(1.093)	(1.093)	(1.093)
Purchases pack. bread frequently					-1.002	-1.002	-0.976
					(0.847)	(0.847)	(0.843)
Consumed baguette last week					-2.813**	-2.813**	-2.602**
					(1.171)	(1.172)	(1.144)
Red bread variety		5.886***	5.886***	3.269***	3.259***	2.839***	3.248***
		(0.358)	(0.358)	(0.368)	(0.369)	(0.473)	(0.372)
Information*Red bread variety						0.867	
						(0.655)	
Constant	33.120***	31.249***	29.502***	15.335***	15.155***	15.379***	16.524***
	(1.381)	(2.721)	(2.789)	(3.026)	(3.405)	(3.396)	(3.988)
Controls							
Location fixed effects	yes	yes	yes	yes	yes	yes	yes
Mood and hunger level	no	no	no	no	yes	yes	yes
Others[†]	no	no	no	no	yes	yes	yes
Enumerator fixed effects	no	no	no	no	no	no	yes

Notes: GLS random-effects estimations and observations equal to 944 in all columns. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [†] Include other income sources and bids in the auction's practice round.

Table 8
Regression analysis on willingness to pay by bread consumption preferences

Dependent variable	Willingness to pay (MXN)					
	Consumption in the previous week:					
	Baguette & packaged bread		No packaged bread		Only packaged bread	
	(1)	(2)	(3)	(4)	(5)	(6)
Information	0.138	-0.435	0.301	0.059	8.788***	8.073**
	(1.081)	(1.130)	(1.778)	(1.883)	(3.154)	(3.655)
p-value	0.898	0.700	0.866	0.975	0.005	0.027
FDR q-value	1.000	1.000	1.000	1.000	0.016	0.089
Red bread variety	3.666***	3.098***	2.301***	2.066**	4.280**	3.755*
	(0.504)	(0.652)	(0.664)	(0.874)	(1.728)	(2.131)
Information*Red bread variety		1.145		0.475		1.390
		(0.834)		(1.193)		(3.738)
Constant	14.284***	14.449***	5.263	5.525	-12.452	-11.514
	(4.298)	(4.296)	(7.024)	(6.986)	(23.234)	(23.161)
Covariates[†]	yes	yes	yes	yes	yes	yes
N	570	570	266	266	74	74

Notes: GLS random-effects estimations in all columns. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. FDR q-values calculated according to Anderson (2008). [†] Include variables for demographics, income level, sensory attributes, bread preferences, location fixed effects, mood and hunger level, other income sources and bids in the auction's practice round.

3.4.3.4 Main characteristics that explain willingness to pay

Women were willing to pay more than men for healthy packaged bread, on average MXN 2.9 more (see column 7, Table 7). Older people had a lower WTP. On average, a person 20 years younger would pay MXN 1.4 more. Households with more family members exhibited significantly lower WTP. Although only significant at 10% level, individuals living in households with a higher share of children had a higher WTP. A higher score in terms of taste increased WTP, on average, MXN 1.4 more per additional point provided. Its magnitude was larger than the coefficients for appearance (Prob>χ^2=0.070) and size (Prob>χ^2=0.018), which yielded a higher WTP too: MXN 0.8 and MXN 0.6, respectively. As mentioned above, the red bread was especially well rated by its taste, which goes hand in hand with participants willing to pay MXN 3.3 more than for the green variety on average. Participants who had consumed baguette in the previous week were willing to pay nearly MXN 2.6 less than those who had not

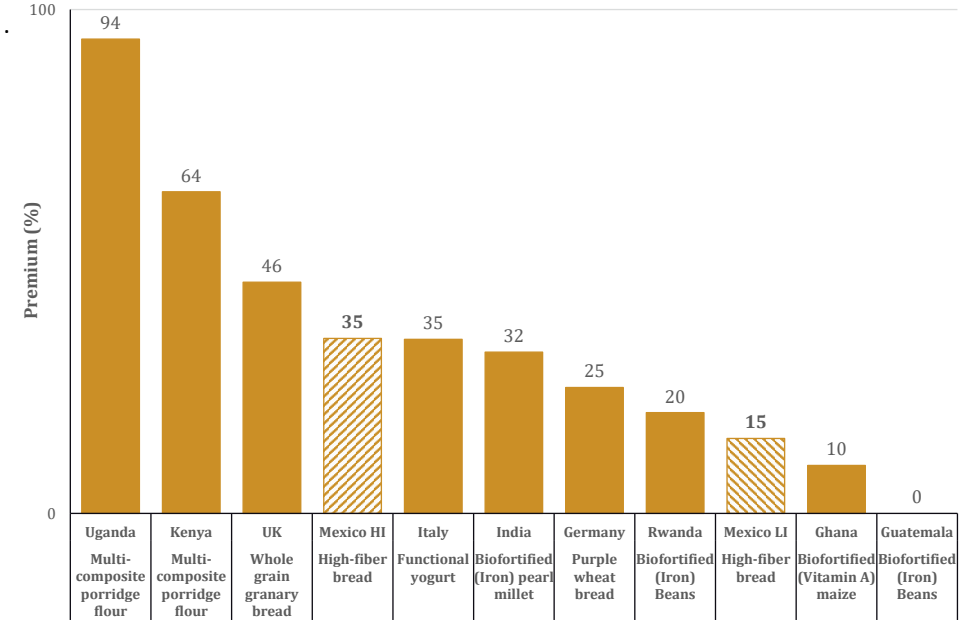

Fig. 5. Estimated premium for selected food items in developing and developed countries.
Notes: LI means lower-income, which corresponds to the low and middle-low income category. HI means higher-income, which corresponds to the middle-high and above income category. Premiums correspond to the percentage change of the product's WTP with respect to the valuation (cost) of the conventional alternative in the same food category. For each country, we took the highest estimated premium for the treated group in studies eliciting WTP with auctions. For Italy, organic yogurt had the highest premium, but we excluded it as its main feature mainly concerned attributes other than health (e.g., ethics, environmental). Source: Birol et al. (2015); Chege et al. (2019); Hellyer et al. (2012); Teuber et al. (2016); Vecchio et al. (2016).

3.5 DISCUSSION

The portfolio of healthy processed foods is limited in low-income urban communities of developing countries (Fernández-Gaxiola et al., 2022; Pérez-Ferrer et al., 2019). From the private sector perspective, reluctance to sell healthier, but more expensive, foods in these areas likely reflects a perception of there being insufficient demand. However, this paper shows that a considerable share of low-income consumers in our sample from three peri-urban municipalities of Mexico City were willing to pay market prices for such foods, after they had the opportunity to feel, smell, and taste them. Half of these consumers valued the products at a price higher than the most popular and unhealthier alternative in the market. While the average overvaluation ranks below the premiums in similar studies in developing and developed regions (see Fig. 5), it points towards an interest in paying more for healthier varieties. Furthermore, we showed that peri-urban areas comprised higher-income shoppers with their associated higher demand for these healthy foods.

Their premium with respect to the cost of conventional breads is comparable to premiums for similar processed foods in developed countries (see Fig. 5). Over time, demand is likely to increase further through the influence of neighbour peers that purchase these products, as well as the diffusion of social norms and higher-income neighbours serving as role models (Galster, 2012). Therefore, combining consumers across all income categories, there is enough potential demand in these communities to justify making such healthy varieties available.

We tested whether nutrition and health messaging increased WTP for healthier processed foods. In general, we found no effects of this type of information. As pointed out in focus groups, perhaps people already identified the products used in our study as healthy, so the information provided had no additional effect. This interpretation was previously mentioned in similar WTP studies elsewhere (Chege et al., 2019; Mialon et al., 2002). Nonetheless, we discovered that health and nutrition messages were effective for participants with stronger preferences for the processed food used in our experiment. This result echoes recent consumer behaviour research, which states that information is useful only for those who have certain motivations for the product that is being promoted (van Kleef & van Trijp, 2018). Nutrition information tends to be effective for enriched staple foods that are highly consumed by low-income populations (Chege et al., 2019). This may apply to upgraded versions of traditional products in Mexico that are cheap and less processed, but lower in fibre content (e.g., baguette). Thus, for relatively less consumed products personalized information for specific consumer segments is a potential business strategy (Delmas et al., 2013; Stead et al., 2019).

In general, we can explain WTP along the following lines: it tends to be higher for consumers who are female, younger, form part of a family with fewer members, and are members of households with a higher share of children below 12 years. Women in particular are a potential target group for businesses, a finding consistent with the WTP literature (Szakály, Kovács, Pető, Huszka, & Kiss, 2019). Predominantly younger participants in focus groups showed a high level of dissatisfaction with conventional white packaged breads and were willing to save money to buy healthier options at least every other week. On the sensory side, participants substantially valued the product more if they liked its taste, appearance and size. Taste in particular is a key feature influencing food choices and preferences (Bruschi et al., 2015; Teuber et al., 2016) especially for low-income consumers who usually face greater cognitive and affective burdens (Just & Gabrielyan, 2018; Mancino et al., 2018). Therefore, taste offerings and an attractive appearance may aid substantially to raise awareness about new healthy varieties and those already offered that are relatively unknown to shoppers in low-income areas (e.g., red bread).

The study presents some important limitations. First, our sample was non-random. We have no reason to believe that this biased our results, but this can only be tested by replicating the experiment in more locations and with different selection procedures. Second, auction fees may have had an upward influence on bidding behaviours, if they were perceived as windfall gains (Skuza et al., 2015). However, these effects have been shown to be small, especially among knowledgeable subjects (Banerji et al., 2018) like primary shoppers. Third, although we substantially limit overstating of WTP by using non-hypothetical methods (List & Gallet, 2001) we cannot rule out that our respondents showed higher WTP than they would in a real-life situation to create a favourable impression on the enumerators. However, we expect this social desirability bias to be specifically relevant for respondents in the information treatment, and in general we do not find this treatment to have a significant effect on WTP. This suggests that overstating of WTP may have been limited. Fourth, diffusion of treatment is a potential concern. We think this risk is limited, as the research took place in very busy locations with a lot of environmental noise, and we told participants to avoid sharing details of the interview. In addition, we stayed only a few days in all but one location, and the results hold also when excluding the latter location from the sample.

3.6 CONCLUSIONS

This research unveiled potential for healthy foods demand within a vast processed food category, in low-income communities of one of the largest metropolitan areas in the world. Altogether, the joint valuations of low- and high-socioeconomic status shoppers from the area account for a sizable business opportunity for processors and food retailers of expanding their menu of healthy products to these zones. In this context, the interplay of social and sensory aspects may facilitate the uptake of these foods. Our results are based on an upper-middle income country and a specific processed food category. Hence, replications of our concept in different developing regions and with other processed food categories are warranted. At the same time, providing information is an effective strategy to promote healthier product purchases among specific market segments.

APPENDICES

Appendix 1. Additional tables

Table 1.1
Balance of participants' characteristics by treatment group

Variable	Treatment (1)	Control (2)	*p*-value† (3)
Demographics			
Female	0.74	0.64	0.019
Age	40.82	41.61	0.565
In partnership	0.61	0.69	0.069
Above secondary education	0.48	0.49	0.774
Remunerated activity	0.66	0.70	0.345
Children <12 yr. dependency ratio	0.21	0.21	0.856
Household size	4.11	4.28	0.379
Income level			
Low and middle-low	0.63	0.71	0.054
Middle-high and above	0.14	0.13	0.884
Bread preferences			
Bread dietary restrictions	0.18	0.14	0.196
Purchases pack. bread frequently	0.46	0.53	0.116
Consumed baguette last week	0.90	0.87	0.306
Mood and hunger level			
Level of hunger	0.51	0.42	0.036
Level of rush	0.41	0.42	0.874
Level of tiredness	0.46	0.50	0.350
Stress level past month	0.50	0.43	0.102
Other income sources			
Remittances	0.06	0.04	0.469
Government benefits	0.11	0.12	0.759
N	232	240	

Notes: Means reported in columns 1 and 2. [1] Includes married and living together. †*p*-value based on Pearson χ^2 test for the independence between categorical variables, except for the continuous variables age, children <12 yr. dependency ratio and household size, where the *p*-value is based on a *t*-test on equality of means between groups.

Table 1.2
Comparison of participants' characteristics across enumerators' sex

Variable	Enumerators' sex		*p*-value[†]
	Male	Female	
	(1)	(2)	(3)
Demographics			
Female	0.71	0.68	0.468
Age	39.38	42.29	0.042
In partnership	0.61	0.68	0.167
Above secondary education	0.51	0.47	0.333
Remunerated activity	0.70	0.66	0.405
Children <12 yr. dependency ratio	0.22	0.20	0.434
Household size	4.23	4.18	0.802
Income level			
Low and middle-low	0.75	0.63	0.005
Middle-high and above	0.09	0.16	0.018
Bread preferences			
Bread dietary restrictions	0.13	0.18	0.151
Purchases pack. bread frequently	0.49	0.49	0.939
Consumed baguette last week	0.90	0.88	0.402
Mood and hunger level			
Level of hunger	0.47	0.46	0.740
Level of rush	0.35	0.45	0.042
Level of tiredness	0.45	0.51	0.209
Stress level past month	0.53	0.43	0.047
Other income sources			
Remittances	0.06	0.04	0.254
Government benefits	0.13	0.10	0.436
N	173	299	

Notes: Means reported in columns 1 and 2. [1] Includes married and living together. [†]*p*-value based on Pearson χ^2 test for the independence between categorical variables, except for the continuous variables age, children <12 yr. dependency ratio and household size, where the *p*-value is based on a *t*-test on equality of means between groups.

Table 1.3
Regression analysis on sensory attributes

Dependent variable	Attribute (Scale 1-7)						
	Smell	Taste	Texture	Appearance	Colour	Size	Thickness
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Information	-0.010	-0.071	-0.181	-0.171	-0.030	-0.055	-0.114
	(0.113)	(0.127)	(0.135)	(0.118)	(0.111)	(0.113)	(0.117)
Demographics							
Female	0.089	0.023	0.094	0.126	-0.005	-0.107	0.013
	(0.091)	(0.105)	(0.108)	(0.095)	(0.090)	(0.089)	(0.093)
Age	0.008***	0.009***	0.009**	0.007**	0.010***	0.003	0.007**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
In partnership	0.170*	0.084	0.052	0.018	0.065	0.142	0.172*
	(0.091)	(0.106)	(0.103)	(0.089)	(0.090)	(0.088)	(0.097)
Above secondary education	-0.107	-0.090	-0.121	-0.044	-0.037	0.025	-0.014
	(0.091)	(0.106)	(0.111)	(0.090)	(0.095)	(0.093)	(0.100)
Remunerated activity	-0.097	0.026	-0.052	0.057	0.013	-0.033	0.038
	(0.090)	(0.100)	(0.099)	(0.088)	(0.091)	(0.089)	(0.095)
Children <12 yr. dependency ratio	-0.299	-0.370**	-0.331	-0.390**	-0.318*	-0.448**	-0.250
	(0.184)	(0.174)	(0.202)	(0.189)	(0.168)	(0.179)	(0.156)
Household size	-0.012	0.006	0.009	-0.017	0.012	0.017	0.007
	(0.023)	(0.025)	(0.026)	(0.023)	(0.020)	(0.020)	(0.022)
Income level							
Low and middle-low	0.055	-0.184	-0.054	-0.093	0.028	-0.080	-0.048
	(0.120)	(0.126)	(0.129)	(0.114)	(0.118)	(0.106)	(0.114)
Middle-high and above	0.136	0.028	0.035	0.056	0.153	-0.043	0.120
	(0.164)	(0.170)	(0.179)	(0.163)	(0.167)	(0.148)	(0.161)
Bread preferences							
Bread dietary restrictions	-0.140	-0.124	-0.215*	-0.214**	-0.142	-0.102	-0.169
	(0.102)	(0.108)	(0.121)	(0.102)	(0.101)	(0.100)	(0.111)
Purchases pack. bread frequently	0.165*	0.136	0.110	0.176**	0.123	0.041	0.091
	(0.084)	(0.092)	(0.093)	(0.082)	(0.081)	(0.082)	(0.086)
Consumed baguette last week	-0.036	-0.039	-0.056	-0.040	-0.157	-0.083	-0.108
	(0.129)	(0.134)	(0.139)	(0.116)	(0.129)	(0.116)	(0.123)
Red bread variety	0.821***	1.083***	1.021***	0.862***	0.671***	0.633***	0.683***
	(0.092)	(0.106)	(0.110)	(0.091)	(0.089)	(0.081)	(0.087)
Information*Red bread variety	-0.135	0.098	0.143	-0.005	-0.089	0.000	-0.002
	(0.131)	(0.139)	(0.153)	(0.130)	(0.124)	(0.114)	(0.122)
Constant	4.168***	4.840***	4.182***	5.104***	4.780***	5.626***	4.924***
	(0.470)	(0.515)	(0.524)	(0.432)	(0.422)	(0.434)	(0.456)
Controls[†]	yes	yes	yes	yes	yes	yes	yes

Notes: GLS random-effects estimations and observations equal to 944 in all columns. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [†] Include location fixed effects, mood and hunger level, other income sources, bids in the auction's practice round and enumerator fixed effects.

Appendix 2. Sensory evaluations protocol

At the beginning of the survey we asked them if they had allergies or any other reason that could prevent them from tasting bread. The exact wording (translated from Spanish) and visual material are shown below. Upper-case words were instructions for the enumerators and were not read out loud. Bolded words in brackets are additional details for the reader.

Instructions

Now we will do a tasting to evaluate your perception about smell, taste, texture in the mouth, appearance, colour, size and thickness of two different types of bread.

[TREATED GROUP ONLY:] The breads that you will taste have a high nutritional value and the following characteristics **[See Fig. 2.1]**.

ENUMERATOR: SHOW THE NUTRITIONAL CHART TO THE PARTICIPANT.

Fig. 2.1 Nutrition and health Information

Randomly draw the first bread to taste from this bag **[participant drew the bread's name and showed it to the enumerator].**

ENUMERATOR: THE BREAD DRWAN, WILL BE THE SAME TO BE AUCTIONED LATER.

ENUMERATOR: OFFER WATER **[in aplastic cup]**.

[A slice of bread in a sealed plastic bag was offered to each participant]

In a scale from 1 to 7, where 1 is I dislike it very much and 7 is I love it. Please evaluate this bread according to the following characteristics **[participant selected a score from the scale shown in Fig. 2.2, for each attribute]:**

1. Smell
2. Taste
3. Texture in the mouth
4. Appearance
5. Colour
6. Slice size
7. Thickness

Fig. 2.2 Sensory evaluation's visual scale

[Participant repeated the procedure with the second bread]

Appendix 3. Auction protocol

The exact wording (translated from Spanish) and visual materials of the auction are shown below. Upper-case words were instructions for the enumerators and were not read out loud. Bolded words in brackets are additional details for the reader.

Instructions

Practice round

Now, you will participate in a bread auction. First, we will do a practice with a soap.

ENUMERATOR: APPLY THE PROCEDURE STEP BY STEP AS IT IS SHOWN IN THE GUIDING CHART **[see Fig. 3.1]**.

Fig. 3.1 Auction guiding charts

STEP 1: I will give you the money. GIVE **[MXN]** $10 TOY MONEY.

STEP 2: You will do an offer for the product.

How much would you pay for the soap? **[Participant said his/her offer]**

STEP 3: You will draw a random price from the bag.

Draw the price and tell me how much it came out.

RESULT: EXPLAIN THE RESULTS WITH THE GUIDING CHART.

*IF **[HE/SHE]** WON THE AUCTION, ASK THE PARTICIPANT TO PAY THE RANDOM PRICE DRWAN FOR THE SOAP **[Participant paid with the toy money]**.

*IF **[HE/SHE]** LOST, THE PARTICIPANT DOES NOT PAY FOR THE SOAP.

Real auction

Now, let's continue with the real auction with the bread.

ENUMERATOR: APPLY THE PROCEDURE STEP BY STEP AS IT IS SHWON IN THE GUIDING CHART **[see Fig. 3.1]**.

STEP 1: I will give you money. GIVE **[MXN]** $60.

STEP 2: You will do an offer for the product.

We will auction only one of the two breads; you can see them on the table. POINT TO THE TABLE WITH THE BREADS.

If we auction a package of the green bread, how much would you pay? **[Participant said his/her offer]**

If we auction a package of the red bread, how much would you pay? **[Participant said his/her offer]**

ENUMERATOR: USE THE FIRST BREAD TASTED **[Remember it was randomly chosen]** TO DO THE AUCTION AND INFORM THE INTERVIEWEE ABOUT THE DECISION.

STEP 3: You will draw a random price from the bag. Draw a price and tell me the price drawn.

RESULT: EXPLAIN THE RESULT THAT APPLIES WITH THE GUIDING CHART.

Did the participant win the auction?

*IF **[HE/SHE]** WON THE AUCTION, ASK THE PARTICIPANT TO PAY FOR THE BREAD AT THE RANDOM PRICE DRAWN.

*IF **[HE/SHE]** LOST, THE PARTICIPANT DOES NOT BUY THE BREAD AND KEEPS THE [MXN] $60.

[END OF AUCTION]

CHAPTER 4

Influence of Poverty Concerns on Demand for Healthier Foods

A field experiment in Mexico City

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ABSTRACT

Living in poverty can present cognitive biases that exacerbate constraints to achieving healthier diets. This study evaluated the influence of monetary and health concerns on the willingness to pay (WTP) for healthier foods in a low-income section of Mexico City. We employed priming techniques from the scarcity literature, which are applied for the first time to healthy food purchasing behaviours in low-income settings. Our predictions are based on a dual system framework, with choices resulting from the interaction of deliberative and affective aspects. The WTP was elicited through a BDM mechanism with 423 participants. Results showed that induced poverty concerns reduced the valuations of one of the study's healthy food varieties by 0.17 standard deviations. The latter effect caused a negative shift in the estimated demand exclusively among the lower-income groups in the sample. The WTP for a healthy bread product but one with relatively high sugar and fat content was less affected by induced poverty concerns. Potential mechanisms were assessed through regression analysis and structural equation modelling. The relationship between poverty concerns and WTP was mediated by increased levels of stress. While we could not rule out impact on cognitive load, it was not deemed a mediator in this study. Policies geared to improve economic and psychological well-being among low-income consumers may aid to increase their demand for healthy foods.

4.1 INTRODUCTION

Currently, low- and middle-income countries have the highest burden of the obesity pandemic (Ford et al., 2017). In Latin America, obesity and unhealthy dietary behaviours have tended to have higher prevalence in urban areas and in higher-socioeconomic status groups. Yet, such habits are expanding in rural areas and among those in lower-socioeconomic status groups (Rivera-Dommarco et al., 2018). Transcending such trends is challenging for consumers because food choices are constrained by multiple factors like availability, affordability, marketing strategies, lack of understandable information about food products' nutritional profile, the food selection environment and non-nutrition attributes associated with preferences for unhealthy foods, such as taste and convenience (Mancino et al., 2018). Additionally, biases and heuristics in decision-making induce consumers to deviate from deliberative, conscious decisions and intensify some of the factors just described (van Kleef & van Trijp, 2018; Wilson et al., 2016). Hence food choices are likely driven by affective motivations, especially in poverty contexts (Beenackers et al., 2018; Kremer et al., 2019; Ruhm, 2012). Such behaviours are linked to "self-control issues" in the dietary behaviours literature, aspects that have also been used in economics to explain observed behaviours in poverty settings (Bernheim et al., 2015; Schilbach et al., 2016). Poverty entails particular psychological consequences that may render individuals more prone to make decisions based on convenience, taste, or the desire to feel full, as well as to neglect nutrition/health information and to choose foods with less nutritional value (Haushofer & Fehr, 2014; Just & Gabrielyan, 2018; Zhao & Tomm, 2017). Furthermore, chronic stress associated with poverty and prolonged financial problems is one of the emerging risk factors contributing to obesity, given its influence on appetite levels and related coping behaviours (Ford et al., 2017; Siahpush et al., 2014). Therefore, the demand for healthy foods in low-income settings is not only hindered by restricted budgets and other traditional factors, but also by persistent psychological constraints.

The literature on *scarcity* has expanded over the last decade and deepened our understanding on how the psychology of poverty impedes economic decision-making and behaviours (Bruijn, 2021). For instance, poverty may reduce attention to other important aspects of life by inducing a focus on the most pressing needs (Mani et al., 2013). Poverty may also increase time discounting and risk aversion through its adverse effects on cognitive functions (Bartoš et al., 2021; Ong et al., 2019). Cognitive load and stress are among the main potential mechanisms in the related literature. For example, financial worries induced in lab experiments increased cognitive load among shoppers in the United States and farmers in Brazil (Lichand & Mani, 2020; Mani et al., 2013). These findings were confirmed in the field by the same authors, who also observed that such adverse effects were more prevalent in the poor as compared to the better off. Using a similar lab manipulation, Dalton et al. (2019) showed that exposing Vietnamese owners

of small retail businesses to financial worries increased their level of perceived stress, but did not alter cognitive load. Prior research also suggested that stress caused by poverty changed people's revealed preferences (e.g., risk and time preferences), which may have lowered their willingness to adopt new technologies and invest in long term outcomes regarding education and health (Haushofer & Fehr, 2014). Other studies have shown mixed results with regards to stress and its links to executive control functions, and economic behaviours like temporal discounting (Kremer et al., 2019; Tsai et al., 2018). There is scarce research linking issues in the poverty psychology with food purchasing behaviours. There are a few studies that have analysed these aspects through willingness to pay methods, but they did not have a particular focus on consumer preferences for healthy foods, while only one of them manipulated financial concerns and had a predominantly low-income sample (Huijsmans et al., 2019; Schofield & Venkataramani, 2021).

We address this gap in the literature by assessing the influence of poverty related concerns on the potential demand for healthy foods in three lower-income municipalities of Mexico City. Specifically, we elicit the willingness pay (WTP) of primary household shoppers for healthy packaged bread. Mexico City, as well as other to large cities in Latin America, is experiencing a pronounced shift towards more convenient products, for instance from maize tortilla to wheat bread (Dominguez-Viera et al., 2022; Popkin & Reardon, 2018). Recent research has shown that the availability of healthy variants of the latter foods in Mexico City is even more limited in low- than in high-income neighbourhoods (Marrón-Ponce et al., 2020b). The large availability of unhealthy foods in retail outlets may actually be the consequence of the predominantly affective nature of consumers' dietary behaviours, which is usually reinforced by stressors or persistent cognitive efforts (Ruhm, 2012). Hence the relevance to shed light on lower-income consumers' acceptance for healthy products, and if increased poverty concerns reduce their WTP for these varieties. The sources of worry in low- income areas are diverse, including financial hardship, neighbourhood level stressors, such as crime and noise, and limited access to health care (Shafir, 2017). In our experiment, we chose financial and health concerns, as the former is an obvious problem, and the latter was predetermined as a major source of concern during focus groups in the research area. Additionally, we try to understand the uptake of nutrition and health information when low-income individuals face such challenging situations. To test this process, we induced the concerns after providing participants with information about the nutritional and health profile of the healthy products. The effective use of information requires cognitive efforts, processes that are compromised for those living in poverty as explained above. Thus, we expect that the effectiveness of information is reduced with increased poverty concerns. Further assumptions are provided in detail in the following section.

4.2 THEORETICAL PREDICTIONS AND HYPOTHESES

Individuals' cognitive operations can be modelled using a dual system framework. These models explain human behaviour as the outcome of brain interactions between two systems: 1) the affective system (System 1), that encompasses emotions and other motivational states and generally focusses on the here and now; and the deliberative system (System 2), that assesses options in a broad and goal-oriented perspective and is more concerned with long term outcomes (Fudenberg & Levine, 2006; Loewenstein et al., 2015). System 1 processes are fast, automatic, effortless, emotionally charged and governed by habit, so that this type of thinking is prone to biases and errors; whereas the operations of System 2 are slow, effortful, deliberate and costly, and as a result they typically yield more unbiased and accurate results (Kahneman, 2003; Schilbach et al., 2016).

When making decisions about food, both these systems may play a role (Ruhm, 2012). Since System 1 is always involved in any decision, as it is effortless and automatic and always 'on', the extent to which health considerations influence the decision depends on the extent to which System 2 is activated. It is likely that in most routine consumer decisions, where System 1 dominates the decision-making process, consumers will focus on aspects like familiarity, availability, immediate gratification (e.g., taste), cues about affordability and relative price differences, rather than long term health concerns and absolute price differences (Azar, 2011). Therefore, since healthier food options are usually more expensive, less familiar, less palatable and less available than the regular options, consumers who do not consider the long-term effects of their decisions will value healthy food below the market price. In other words, it requires an effortful involvement of the System 2 related long-term health concerns for the consumer to appreciate that the higher price for healthier food is warranted. Furthermore, the demand for healthy foods in lower-income contexts tends to be bounded by the absence of understandable nutrition information (Mancino et al., 2018). Thus, in general we expect the following:

H1. In the absence of the nutrition information, WTP for healthy food is below its market price.

It has been shown that willpower is required to control System 1 motivations and allow System 2 to influence decision-making (Shiv & Fedorikhin, 1999). Loewenstein et al. (2015) developed a tractable dual system framework where the latter processes are modelled. Following their approach, we can express WTP as follows:

$$\mathrm{WTP}_i = u(x, D)\left\{\frac{1+h[W(\tau),\sigma]a_x}{1+h[W(\tau),\sigma]a_m}\right\}$$

where WTP is the willingness to pay, $u(x, D)$ is the value assigned to a food item x by System 2, which leaves a disposable income *D* if purchased; $h(W(\tau), \sigma)$ is the cost to System 2 of exerting willpower to control System 1 motivations (i.e., ability to exercise self-control (Ruhm, 2012)). This cost is increasing in the level of competing cognitive demands σ (e.g., cognitive load) and decreasing in terms of willpower strength $W(\tau)$. As an addition to Lowenstein et al.'s model, we assume that willpower strength is a function of the stress level T (Ruhm, 2012). This is consistent with studies that link chronic financial stress with smoking relapse and unhealthy eating behaviours (Beenackers et al., 2018; van Rongen et al., 2019). The relationship between stress and motivations is generally considered to be an inverted U shape, where outcomes improve from low to medium stress levels, but decrease if stress levels continue to rise after certain threshold level (Cahlíková et al., 2020; Egeth & Kahneman, 1975). As our participants live in a relatively stressful environment with high levels of poverty and insecurity, we expect the effect of additional stress to be negative. Moreover, a_x and a_m are the positive affective intensities for the food item x and money, respectively. If a_x increases, WTP increases; whereas if $a_m$increases, WTP decreases. As feelings of money scarcity create a greater focus on cues associated with money, we posit that for low-income individuals $(a_m/a_x) > 1$ (Zhao & Tomm, 2017).

We assume that poverty concerns increase σ and τ (Haushofer & Fehr, 2014; Mani et al., 2013; Schilbach et al., 2016). Consequently, exerting willpower becomes more costly when poverty concerns increase, making it less likely that people engage their System 2 processes. Given that $(a_m/a_x) > 1$, this results in a negative deviation from the deliberative valuation of x, which translates into a lower WTP. As they persistently experience these situations, such concerns are plausibly more disturbing for the poor than for the rich (Mani et al., 2013). Thus, we posit that the above effects will be exacerbated for the lower-income categories. From this, the following mediation hypothesis arises naturally:

H2. Poverty related concerns increase cognitive load and stress, which then leads to a lower WTP for healthy food. The latter effect is higher among lower-income groups.

To effectively use information individuals require substantial cognitive efforts to consider future implications and trade-offs regarding nutrition, health and costs (Hunter et al., 2018). Hence nutrition and health information are more likely to affect decisions when System 2 is engaged (Just & Gabrielyan, 2018). In fact, when new knowledge signals positive benefits of healthy foods, System 2's valuation (x, D) increases. However, when σ and τ increase, System 1 becomes more dominant, which makes individuals more prone to unhealthier food choices and to counteract the positive effect of information (Carroll et al., 2018). Altogether, this leads to the following interaction hypothesis:

H3. Nutrition information leads to increased WTP for healthy food, but the effect is smaller when poverty related concerns are present.

4.3 MATERIALS AND METHODS

Field work in Mexico City was carried out between September-October 2019 in six locations between 9 am and 4 pm during twenty weekdays. Subjects were fully informed about the procedures and signed consent forms. A pre-analysis plan that included the above hypotheses was registered before data collection (see http://egap.org/registration/6042). The research design received ethical approval from Wageningen University's Social Sciences Ethics Committee, and CIMMYT's Institutional Research Ethics Committee.

4.3.1 Participants

We used venue-based sampling and purposely selected three densely populated municipalities in peri urban Mexico City (Chimalhuacan, Chicoloapan and Texcoco). These municipalities comprised high or very high levels of poverty according to the Index of Urban Marginalization elaborated by the *National Population Council* (CONAPO, by its initials in Spanish). This index includes ten indicators covering four dimensions: education, health, housing conditions, and asset ownership. Within these municipalities, we purposely selected six sites where we were likely to encounter people belonging to our target group of primary shoppers. All sites were in areas with high levels of poverty, but to increase the likelihood of encountering both poor and less poor people, we included sites surrounded by areas with medium level poverty. The selected sites for data collection were a central square, a shopping mall, and locations in streets close to schools.

We targeted adult primary shoppers with no allergies or personal reasons preventing them from eating bread and interviewed them on the spot upon accepting to participate. Women comprised the majority of respondents (71%) (see Table 1), which reflects that they are typically the primary grocery shoppers (Dominguez-Vieraw et al., 2022). Most participants had consumed packaged bread in the previous week (63%). The average participant reported a moderately high stress level about being able to afford grocery expenses in the past month (M=3.4 and SD=1.13 on a 1-5 scale). Many respondents (55%) reported to feel highly or extremely stressed about the situation just described. As seen in Table 1, that was in line with most of the sample (88%) living in a household with a low-income (maximum monthly income of MXN 11,000 (USD 562)). People with low-income experienced more stress: The share of participants that reported to feel highly or extremely stressed over the past month ranged from 60% for the bottom income category to 20% for those in the top income category in the sample (out of 6 categories).

Table 1
Summary statistics.

Indicator	Mean	Std. Dev.	Min	Max
	(1)	(2)	(3)	(4)
Demographics				
Female	0.71	0.45	0	1
Age (years)	42.60	15.01	18	84
In partnership[1]	0.64	0.48	0	1
Children dependency ratio[2]	0.22	0.21	0	1
Household size	4.48	2.14	1	17
No formal education	0.03	0.18	0	1
Primary education	0.54	0.50	0	1
Secondary education	0.30	0.46	0	1
Tertiary education	0.13	0.34	0	1
In a remunerated activity	0.67	0.47	0	1
Weekly grocery expenses (MXN)	713.31	404.73	30	3000
Monthly household income (yes=1)				
Very low (MXN 0 - 2,500)	0.22	0.41	0	1
Low (MXN 2,501 - 5,000)	0.37	0.48	0	1
Middle-low (MXN 5,001 - 11,000)	0.30	0.46	0	1
Middle-high (MXN 11,001 - 17,000)	0.08	0.28	0	1
High (MXN 17,001 - 29,000)	0.02	0.14	0	1
Very high (MXN 29,001 - More)	0.01	0.11	0	1
Food consumption previous week (yes=1)				
Tortilla	0.97	0.18	0	1
Baguette	0.86	0.35	0	1
Packaged bread	0.63	0.48	0	1
Bread preferences (yes=1)				
Purchases packaged bread weekly	0.52	0.50	0	1
Restricts bread for HH member's health	0.22	0.42	0	1
Willingness to pay (MXN)				
Green bread	30.68	9.57	0	60
Red bread	36.02	9.50	11	60
Psychological measures (yes=1)[3]				
Not in a hurry	0.39	0.49	0	1
Not tired	0.54	0.50	0	1
Highly stressed past month[4]	0.55	0.50	0	1

Notes: [1]Incudes married and living together. [2]Children below 12 years of age divided by household size. [3]Median splits of scales from 1 to 5. [4]Highly or extremely worried about affording grocery expenses in the past month.

4.3.2 Experimental treatments

Each subject was randomly allocated to one of four potential treatment groups, based on a 2x2x2 factorial design with: a) two between subjects treatments, namely nutrition information (Yes/No) and poverty concern (High/Low); b) one within subjects treatment, namely two different types of healthy bread. The between subject treatments are detailed below:

i. *Nutrition and health information.* Before the elicitation of WTP, an enumerator explained that both products were high in fibre, low in fat, high in whole grains content and that consuming a diet rich in whole grains reduced the risk of constipation and colon cancer (Appendix 2). Afterwards, the enumerator asked two questions to assess knowledge acquisition and level of attention.

ii. *Poverty concern.* An enumerator presented a hypothetical scenario to bring pre-existent worries top of mind. We followed standard priming techniques used previously elsewhere (Bartoš et al., 2021; Dalton et al., 2019). Participants were asked to consider a course of unfortunate events intended to create different levels of stress and cognitive load. Three focus groups were organized before data collection and helped shape the scenario to the local context. It comprised two associated sources of hardship, both with high and low versions: an economic shock resulting from a health problem of a household member. This was the exact wording used:

High (**Low**) condition: Imagine that an unexpected expenditure of MXN 20,000 (USD 1,020.4) (**MXN 50 (USD 2.6)**) arises for a major (**minor**) medical treatment for one of your family members. You do not have health insurance and must go to a private health centre. Imagine how would you respond to this situation. Would you have to borrow money or pawn your belongings to cover this expense? Would you have to adjust your weekly budget for food? How stressed would you feel in this situation?

The questions about borrowing and pawning were part of the priming process and served to measure the difficulty of the scenario. To avoid a lengthy interview, we asked closed questions instead of the conventionally used open questions. The final question was our measure of stress caused by the scenario. It was set in a 1 to 5 scale, from no stress to extremely stressed.

4.3.3 Procedure and materials

To estimate the effects of our treatments on the WTP for healthy food, we used two bread products, which throughout the rest of the text we refer to as *green* and *red* based on the packaging colours. We focused on bread because of its increasing popularity as substitute for traditional Mexican foods like tortilla among low- and middle-income consumers in

urban areas like Mexico City (Dominguez-Viera et al., 2022). The products were selected from a set of seventeen packaged breads available in Mexico City, which were classified as healthy by Marrón-Ponce et al. (2020b) following the Pan American Health Organization's Nutrient Profile Model (PAHO, 2016). The model calculates nutrition scores according to calories, sugar, saturated fat, sodium, protein and fibre content (Appendix 1). After focus group discussions, we selected the two final products, which: a) had the traditional sandwich like slice; b) had a colour that was appealing to consumers in the area (not black) and signalling healthiness (not white); c) were not readily available in the research zones; and d) were not of the same brand. According to data collected by Marrón-Ponce et al. (2020b) in selected retail outlets (e.g., supermarkets, independently owned grocery stores, corner stores and convenience stores) of Mexico City, their mean prices were MXN 49 (USD 2.25) and MXN 44 (USD 2.51) for the red and green products, respectively.

We used the Becker–DeGroot–Marschak (BDM) mechanism to elicit WTP for the products. Fig. 1 depicts the basic elements of the experiment (see materials and full protocol in appendix 3). We started with the provision of information for those subjects selected into the treatments with information. Next, participants engaged in sensory evaluations, where they rated both products on a scale of 1-7 regarding smell, taste, texture, appearance, colour and size. Subsequently, a practice auction round was implemented using a bar of soap and fake money. In a fourth step, we induced the poverty concerns. Afterwards, participants were endowed with MXN 60 (USD 3.06), an amount that was enough to buy a package of either of the products at market prices, and they placed their bids for both products. Finally, one of the two varieties was randomly selected to be used in the auction, and a random price was drawn from a bag that contained five numbers set around the market prices of packaged bread. If the bid was higher or equal to the random price, a participant won the auction, paid the randomly generated price, kept the change and received the product. Otherwise, he/she lost the auction and kept the endowment in full.

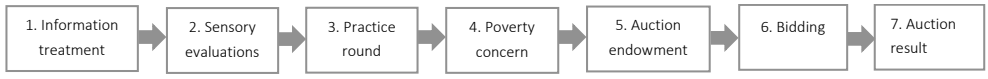


Fig. 1. Elements in the experimental procedure.

After the auction, we used two raven matrices to assess cognitive skills (see materials in appendix 4).

4.3.4 Empirical strategy

The primary outcome of the study is the estimated WTP for each healthy bread variety. Secondary outcomes used to explain the mechanism behind our results are stress level and

cognitive skills. We defined stress level as a dummy, which is 1 if the individual indicated feeling very or extremely stressed in the poverty concern treatment, 0 otherwise. Cognitive skills were measured as the number of correct answers (0-2) to the raven matrices. Finally, we added two variables to further explore the potential stress caused by the poverty concern: dummy variables for whether respondents would have to engage in borrowing *or pawning* or to a*djusting grocery expenses*, respectively, in response to the concerns raised.

The general specification to estimate the main results is as follows:

$$Y_{ij} = \alpha_j + \beta_1 I_{ij} + \beta_2 P_{ij} + \beta_3 I_{ij} P_{ij} + \beta_4 W_{ij} P_{ij} + \gamma W_{ij} + \delta X_{ij} + \varepsilon_{ij}$$

where *i* indexes individual participants and *j* the interview site; *Y* represents our various outcomes of interest; *P* is a dummy for poverty concern -equal to 1 if the subject was confronted with the high condition, 0 if presented with the low condition; *I* is a dummy for the information treatment, which is 1 if treated with the nutrition and health information, 0 otherwise; *W* is a dummy for being in the *lower-income* categories (maximum household monthly income of MXN 5,000 (USD 255)), which were determined by a median split of the 6 income categories in the data (see Table 1); X are control variables, including sociodemographic variables, dummies to proxy hunger and the psychological condition of the participants, and bread preferences. α_j is a set of location specific intercepts. β, γ and δ are parameters, with β our parameters of interest -the effects of the treatments.

Sociodemographic controls are *age* in years, *household size*, *dependency ratio*, calculated dividing the number of children below 12 years of age by the household size; and dummies for being *female*, *in a partnership*, *in a remunerated activity*, and having *secondary education and above*. The hunger dummy was measured as equal to 1 if the last meal happened recently (<4 hrs), 0 otherwise. The psychological dummies are *not in a hurry*, *not tired* and *high stress level past month*. Bread preferences cover a *sensory index*, constructed as the first principal component of the seven factors rated in the sensory evaluations; and a dummy indicating *bread restrictions*, which is 1 if purchases of bread are restricted due to a household member's health condition, 0 otherwise.

Randomization checks provided only slight unbalances between treatment groups for these controls (see Table 2). Moreover, joint tests of orthogonality (i.e., binary probit with the treatment variable on the left-hand side and controls on the right-hand side) suggested that the groups in the poverty concern (Prob>χ^2=0.117) and information (Prob>χ^2=0.341) treatments are comparable to the control group. Likewise, we checked if enumerator's characteristics caused sample bias. We focused on enumerators' gender, as the team was mainly heterogenous in this aspect (3 males and 3 females). While there

were only a few differences in the characteristics of participants interviewed by male and female enumerators (Appendix 1), a test of orthogonality showed that these were jointly significant (Prob>χ^2=0.047). Hence, we will add enumerator fixed effects in our regressions as a robustness check.

All regression analyses were performed through OLS. Note that the estimation method for the dichotomous dependent variables is a linear probability model. An alternative would be using logit or probit estimation. However, the latter methods have issues with estimating the marginal effects for interaction terms, which are important in our estimations (Belot et al., 2016). Estimated standard errors are robust. We control for multiple hypothesis testing using the false discovery rate (FDR) of Anderson and the Romano-Wolf multiple hypothesis correction to control the familywise error rate (FWER) (Anderson & Mellor, 2008; Clarke et al., 2019). Finally, we performed an influential points analysis (*lvr2plot* in Stata), resulting in the deletion of 25 observations from the sample which had cook's distance values that were higher than $4/(N-k-1)$. The final sample size was 423 participants.

We deviated from the pre-analysis plan (PAP) in four aspects. First, we changed the income variable from using the lowest income category to a group determined by a median split. We proceeded in that way because this categorization is easier to interpret and is often employed in scarcity papers (Mani et al., 2013; Shah et al., 2015). This change did not alter our findings. Second, we indicated in the PAP that we would cluster standard errors at the location level. We used robust standard errors instead, as it is standard practice in similar experimental designs with randomization at the individual level (Bartoš et al., 2021). This gives almost identical results. Third, we did not anticipate the influential points analysis, which we implemented to avoid outliers affecting the accuracy of our regressions. Deletion of the influential observations did not affect our manipulation checks but strengthened our main results. Lastly, the PAP did not mention the Romano-Wolf method for correcting for multiple hypothesis testing. We added this method because it is more conservative than the FDR method, which is more suitable for testing a large number of hypotheses (Clarke et al., 2019).

Table 2
Randomization checks.

Variable	Poverty concern		*p*-value†	Information		*p*-value†
	Hard	Easy		Yes	No	
Female (dummy)	0.72	0.71	0.781	0.72	0.70	0.582
Age (years)	42.94	42.25	0.640	42.30	42.90	0.678
In partnership (dummy)[1]	0.66	0.62	0.404	0.67	0.62	0.226
Children dependency ratio[2]	0.24	0.20	0.087	0.22	0.22	0.880
Household size	4.36	4.61	0.226	4.35	4.61	0.224
Above secondary education (dummy)	0.43	0.43	0.990	0.48	0.38	0.058
In a remunerated activity (dummy)	0.69	0.65	0.354	0.69	0.66	0.467
HH with lower-income (dummy)	0.56	0.60	0.415	0.59	0.58	0.786
Restricts bread for a household member's health condition (dummy)	0.24	0.20	0.349	0.25	0.20	0.212
Had last meal recently (dummy)	0.54	0.47	0.133	0.54	0.47	0.189
Not in a hurry (dummy)	0.33	0.46	0.004	0.37	0.42	0.329
Not tired (dummy)	0.51	0.58	0.146	0.54	0.55	0.817
Highly stressed past month (dummy)[3]	0.51	0.58	0.174	0.54	0.55	0.894
Sensory index green bread	-0.06	0.06	0.234	0.04	-0.04	0.388
Sensory index red bread	-0.00	0.00	0.989	-0.07	0.07	0.126
N	216	207		210	213	

Notes: [1]Incudes married and living together. [2]Children below 12 years of age divided by household size. [3]Highly or extremely worried about affording grocery expenses in the past month. †If dummy variable, *p*-value is based on Pearson $\chi 2$ test for the independence between variables, otherwise, it is based on a t-test on equality of means between groups. * p<0.1, ** p<0.05, *** p<0.01.

4.4 RESULTS

4.4.1 Willingness to pay in the absence of nutrition information

Without providing nutrition information, average bids for the red and green varieties were MXN 35.8 (95% CI 34.5-37.1) and MXN 30.9 (95% CI 29.5-32.2), respectively. The higher valuation for the former variety aligned with the sensory evaluations, where the red product had significantly higher scores than the green product across all attributes (Appendix 1). Regarding the ingredients that usually improve sensory characteristics, the former had a higher saturated fat and sugar content than the latter (Appendix 1). The valuations of both products were significantly lower than their market prices (MXN 44-49). Thus, we found strong support for hypothesis 1, leading to the following result:

Result 1: In the absence of the nutrition information, WTP for both healthy food items are below their market prices.

4.4.2 Manipulation checks

The average score in terms of stress for participants in the high poverty concern was 4.0 (*SD*=1.02) on a scale of 1 to 5, compared to 2.9 (*SD*=1.25) for the low poverty concern. Furthermore, the reported likelihood of borrowing/pawning and adjusting grocery expenses was 26.7 and 12.7 percentage points higher under the high condition (see Table 3). While individuals treated with the high condition had a higher level of stress than those in the low condition, their cognitive capacity was not affected (see Table 3). Whether the respondent won or lost the auction also did not affect cognitive load.

We found a negative relationship between stress and income level. The share of participants who reported to feel highly stressed after the high scenario ranged from 85% to 25% for those in the bottom and top income categories, respectively, figures higher than the share of participants experiencing high or extreme stress about affording their groceries in the previous month. Yet, there was no additional effect of the high condition for those in the lower-income categories (see interaction terms in Table 3, columns 3, 6, 9, 12). The FDR and FWER corrections did not alter the statistical significance assessments. This leads to the following statement underling the mechanism of the study (H2):

Result 2a: Poverty related concerns increase stress but do not affect cognitive load.

Table 3

Effect of poverty concerns on reported stress level, measured cognitive skills and reported financial decisions.

Dependent variable	Highly stressed (dummy)			Cognitive skills (0-2)			Borrowing or pawning (dummy)			Adjusting grocery expenses (dummy)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
High poverty concern	0.481***	0.449***	0.473***	0.024	0.071	0.001	0.267***	0.253***	0.308***	0.127***	0.065	0.135**
	(0.041)	(0.059)	(0.065)	(0.054)	(0.079)	(0.069)	(0.040)	(0.055)	(0.065)	(0.038)	(0.054)	(0.067)
p-value	*0.000*	*0.000*	*0.000*	*0.326*	*0.185*	*0.495*	*0.000*	*0.000*	*0.000*	*0.001*	*0.116*	*0.022*
FDR q-value	*0.001*	*0.001*	*0.001*	*0.254*	*0.276*	*0.493*	*0.001*	*0.001*	*0.001*	*0.003*	*0.228*	*0.080*
FWER p-value	*0.000*	*0.000*	*0.000*	*0.323*	*0.208*	*0.461*	*0.000*	*0.000*	*0.000*	*0.001*	*0.208*	*0.044*
Information	0.016	-0.018	0.016	0.097**	0.145**	0.097**	-0.006	-0.021	-0.008	0.015	-0.049	0.014
	(0.042)	(0.062)	(0.042)	(0.054)	(0.078)	(0.054)	(0.038)	(0.066)	(0.039)	(0.038)	(0.059)	(0.038)
p-value	*0.354*	*0.388*	*0.351*	*0.037*	*0.031*	*0.036*	*0.437*	*0.375*	*0.421*	*0.348*	*0.202*	*0.352*
FDR q-value	*0.254*	*0.386*	*0.459*	*0.049*	*0.116*	*0.097*	*0.280*	*0.386*	*0.459*	*0.254*	*0.276*	*0.459*
FWER p-value	*0.659*	*0.898*	*0.659*	*0.128*	*0.113*	*0.125*	*0.659*	*0.898*	*0.659*	*0.659*	*0.898*	*0.659*
High poverty concern*Information		0.065			-0.095			0.029			0.125*	
		(0.083)			(0.105)			(0.077)			(0.076)	
p-value		*0.216*			*0.816*			*0.351*			*0.050*	
FDR q-value		*0.276*			*0.480*			*0.386*			*0.142*	
FWER p-value		*0.495*			*0.821*			*0.578*			*0.178*	
High poverty concern*Lower-income			0.015			0.041			-0.070			-0.015
			(0.085)			(0.107)			(0.082)			(0.081)
p-value			*0.432*			*0.352*			*0.197*			*0.427*
FDR q-value			*0.459*			*0.459*			*0.459*			*0.459*
FWER p-value			*0.787*			*0.787*			*0.792*			*0.787*
Lower-income	0.053	0.055	0.045	-0.093*	-0.095*	-0.114*	0.083**	0.083**	0.119**	0.078**	0.081**	0.086*
	(0.044)	(0.044)	(0.064)	(0.060)	(0.061)	(0.086)	(0.042)	(0.042)	(0.071)	(0.042)	(0.042)	(0.065)

Dependent variable	Highly stressed (dummy)			Cognitive skills (0-2)			Borrowing or pawning (dummy)			Adjusting grocery expenses (dummy)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	-0.064	-0.052	-0.060	1.900***	1.884***	1.911***	0.471***	0.477***	0.452***	0.449***	0.470***	0.445***
	(0.129)	(0.131)	(0.131)	(0.175)	(0.176)	(0.178)	(0.127)	(0.127)	(0.132)	(0.128)	(0.125)	(0.131)
R^2	0.337	0.338	0.337	0.119	0.121	0.119	0.182	0.182	0.183	0.154	0.159	0.154
Mean (Low)	0.32			1.75			0.65			0.75		

Notes: OLS estimations and observations equal to 423 in all columns (422 in 4,5,6). Robust standard errors in parentheses. All regressions include controls for demographics, restricts bread, sensory indices of the red and green varieties, psychological measures and location fixed effects. p-value corresponds to one-sided OLS p-values. * p<0.1, ** p<0.05, *** p<0.01, based on the latter values. FDR q-values calculated according to Anderson & Mellor (2008). FWER corrected p-values based on Clarke et al. (2019), with 3000 replications. FDR and FWER calculated pooling the specifications in the following groups of columns: a) 1,4,7, 11; b) 2, 5, 8, 11; c) 3, 6, 9, 12.

4.4.3 Willingness to pay when poverty concerns are induced

In Tables 4a and 4b, we present the main regression analysis for WTP for the two food products. For the less palatable green variety, the WTP was significantly lower under the high than under the low poverty concern. On average, a participant induced to think about high poverty concerns offered MXN 1.61 less (USD 0.08), equivalent to roughly 0.17 SD. This result was robust to FWER corrections (see Table 4a), the inclusion of day of the week and enumerator fixed effects (Appendix 1). The effect pointed in the same direction for the better-tasting red product, but the coefficient was statistically insignificant.

Result 2b: Poverty related concerns decrease WTP only for one of the healthy food items.

To test hypothesis 2 in full, we performed a mediation analysis through structural equation modelling for the green product (see Fig. 2). The direct effects in the stress path were both significant (top of the figure), while the two direct effects in the cognitive load path were insignificant (bottom of the figure). The indirect effect of the high condition on the WTP for the green product via stress was significant $(\beta = -0.98, \rho = 0.05)$, whereas the indirect effect through cognitive load was insignificant $(\beta = 0.014, \rho = 0.70)$. The direct effect of the high condition on the green product's WTP was not significant after controlling for the indirect effects $(\beta = 0.60, \rho = 0.51)$. This suggested that stress fully mediated the effect of the high condition on the valuation of the green variety. We did an alternative analysis where the mediation happened via stress and cognitive load operating in series, but found that the effect of stress on cognitive load was insignificant. Therefore, we found partial evidence in favour of the mediation hypothesis:

Result 2c: Poverty related concerns decrease WTP for the healthy foods via increased stress.

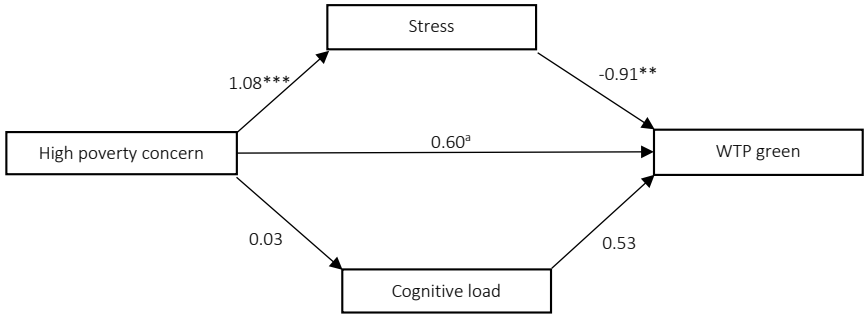
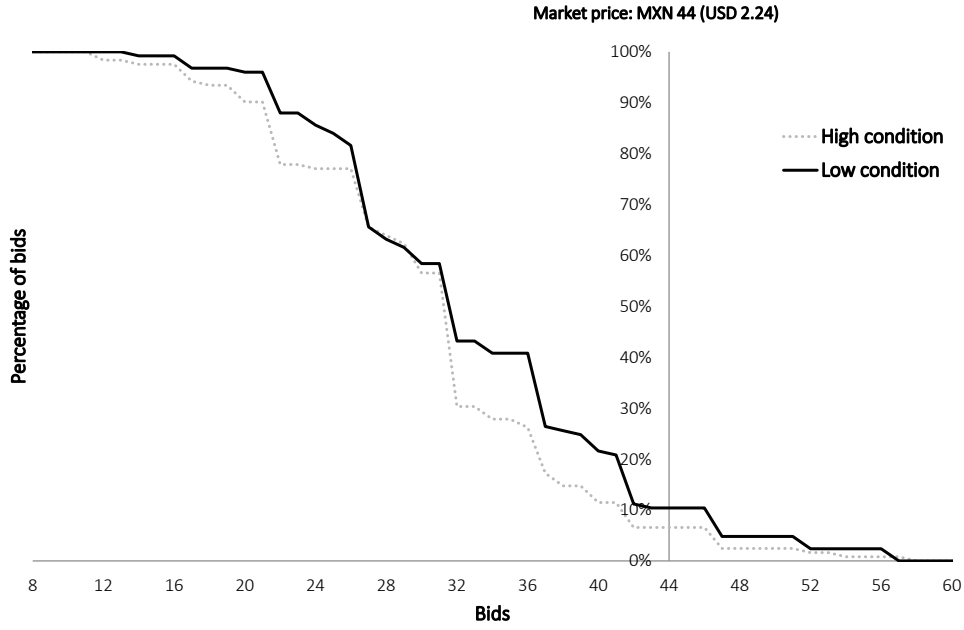


Fig. 2. Simple mediation analysis with high poverty condition as independent variable, stress (categorical variable) and cognitive load as mediators and WTP for the green variety as dependent variable.
Notes: Values shown are unstandardized regression coefficients. Estimations performed using robust standard errors and including these covariates: sociodemographics, restricts bread, sensory indices, psychological measures and location fixed effects. [a]Direct effect after controlling for the indirect effects. * p<0.1, ** p<0.05, *** p<0.01.

As depicted in Fig. 3, for the green variety there was a backward shift in the estimated demands among the lower-income participants treated with the high condition, especially around market prices. For higher-income participants the backward shift is only perceptible in the range of lower bids, then the demands crossover around offers equivalent to market prices. A stochastic dominance test showed that only for the lower-income categories the distribution of bids between the high and low conditions significantly differed $(\text{Somers' D test: } \mathrm{D} = -0.124, \rho = 0.04, one - tailed\ test)$. However, the interaction treatment effects with the lower-income categories for both products were negative, but statistically insignificant in our main regression analysis (see column 6 in Tables 4a and 4b). In the light of these findings, we found suggestive evidence regarding the interaction component of hypothesis 2:

Result 2d: The effect of poverty related concerns on WTP for healthy foods does not differ between the lower- and higher-income groups. The negative shift in the distribution of bids due to this effect is mainly driven by the former group.

Panel I: Participants in lower-income categories



Panel II: Participants in higher-income categories

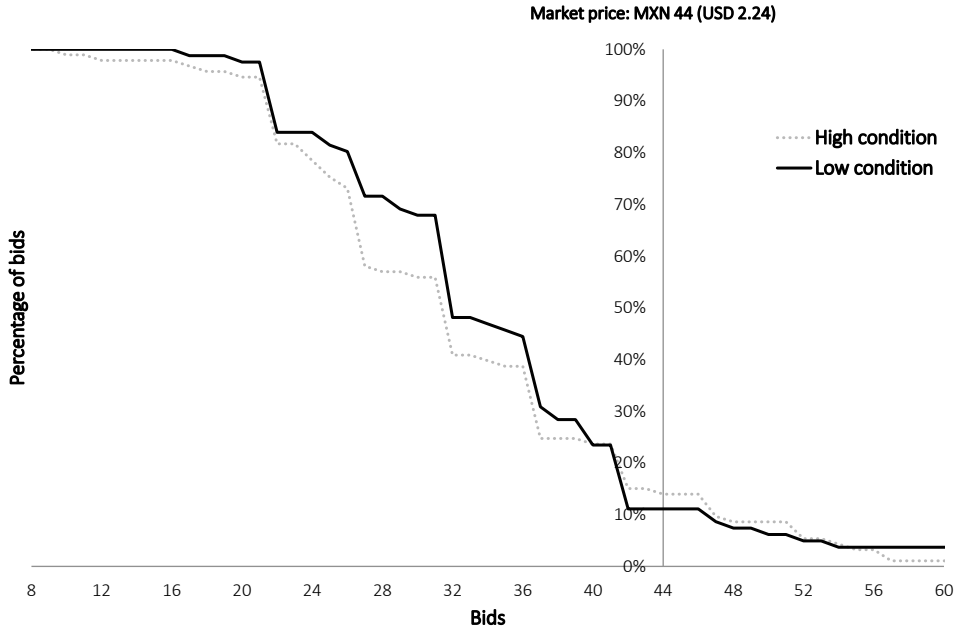


Fig. 3. Green bread. Cumulative percentage of bids by income level and poverty concern condition.
Notes: The lines plot the share of bids for the green bread that were greater than or equal to the corresponding bid in the horizontal axis. The vertical axis crosses the horizontal axis on the market price of the green bread.

4.4.4 Effectiveness of nutrition information when poverty concerns are induced

Enumerators presented respondents information regarding the nutritional profile and health benefits of both products. As depicted in Tables 4a and 4b, this information did not have a significant effect on WTP for either of the two products. It naturally follows that the interaction effect with the high poverty concern was statistically insignificant. These results were not driven by inattention to the information: Around 80% of participants recalled one or more attributes for both the nutrition and health components of the information. These figures did not differ by poverty concern condition and/or income. Thus, our findings did not support hypothesis 3.

Result 3: Nutrition and health information do not affect WTP for healthy foods. This effect remains unchanged when poverty related concerns are present.

Table 4a

Regression analysis on willingness to pay for the green bread.

Dependent variable	Willingness to pay ($MXN)					
	(1)	(2)	(3)	(4)	(5)	(6)
High poverty concern	-1.709**	-2.832**	-1.454	-1.612**	-2.403**	-1.561
	(0.864)	(1.275)	(1.472)	(0.834)	(1.258)	(1.400)
p-value	*0.024*	*0.014*	*0.162*	*0.027*	*0.030*	*0.126*
FDR q-value	*0.107*	*0.092*	*0.866*	*0.122*	*0.220*	*0.872*
FWER p-value	*0.048*	*0.026*	*0.260*	*0.056*	*0.059*	*0.203*
Information	-0.081	-1.243	-0.079	-0.669	-1.487	-0.671
	(0.886)	(1.252)	(0.885)	(0.826)	(1.193)	(0.829)
p-value	*0.464*	*0.161*	*0.464*	*0.186*	*0.101*	*0.187*
FDR q-value	*0.356*	*0.252*	*0.866*	*0.229*	*0.297*	*0.872*
FWER p-value	*0.548*	*0.238*	*0.543*	*0.275*	*0.162*	*0.275*
High poverty concern*Information		2.270			1.595	
		(1.771)			(1.708)	
p-value		*0.100*			*0.183*	
FDR q-value		*0.252*			*0.297*	
FWER p-value		*0.150*			*0.273*	
High poverty concern*Lower-income			-0.527			-0.089
			(1.828)			(1.779)
p-value			*0.387*			*0.495*
FDR q-value			*0.866*			*0.872*
FWER p-value			*0.416*			*0.502*
Lower-income			-0.979	-0.849	-0.813	-0.803
			(1.271)	(0.976)	(0.978)	(1.340)
Constant	30.364***	30.857***	31.068***	30.219***	30.481***	30.193***
	(1.482)	(1.508)	(1.747)	(3.037)	(3.042)	(3.107)
Controls†	no	no	no	yes	yes	yes
R^2	0.099	0.102	0.103	0.200	0.202	0.200

Notes: OLS estimations and observations equal to 421 in all columns. Robust standard errors in parentheses. Estimations do not include two participants that offered bids equal to 0 in the auction. †Demographics, restricts bread, sensory index (FWER p-value estimations include indices for both products), psychological measures. Location fixed effects included in all columns. p-value corresponds to one-sided OLS p-values. * p<0.1, ** p<0.05, *** p<0.01, based on the latter values. FDR q-values calculated according to Anderson & Mellor (2008). FWER corrected p-values based on Clarke et al. (2019), with 3000 replications. In the FDR and FWER corrections, the WTP for each variety were pooled as two outcomes.

Table 4b

Regression analysis on willingness to pay for the red bread.

Dependent variable	Willingness to pay ($MXN)					
	(1)	(2)	(3)	(4)	(5)	(6)
High poverty concern	-1.080	-1.479	-0.686	-1.037	-1.031	-0.878
	(0.893)	(1.260)	(1.427)	(0.859)	(1.195)	-1.346
p-value	*0.131*	*0.127*	*0.361*	*0.117*	*0.167*	*0.293*
FDR q-value	*0.245*	*0.252*	*0.866*	*0.213*	*0.297*	*0.872*
FWER p-value	*0.142*	*0.138*	*0.381*	*0.140*	*0.184*	*0.314*
Information	0.667	0.253	0.652	0.250	0.257	0.244
	(0.900)	(1.257)	(0.899)	(0.847)	(1.231)	-0.847
p-value	*0.207*	*0.411*	*0.211*	*0.323*	*0.417*	*0.328*
FDR q-value	*0.262*	*0.319*	*0.866*	*0.306*	*0.379*	*0.872*
FWER p-value	*0.294*	*0.542*	*0.298*	*0.438*	*0.542*	*0.440*
High poverty concern*Information		0.807			-0.013	
		(1.812)			(1.692)	
p-value		*0.313*			*0.441*	
FDR q-value		*0.319*			*0.379*	
FWER p-value		*0.320*			*0.454*	
High poverty concern*Lower-income			-0.704			-0.275
			(1.832)			(1.763)
p-value			*0.318*			*0.388*
FDR q-value			*0.866*			*0.872*
FWER p-value			*0.416*			*0.502*
Lower-income			-0.040	-0.322	-0.323	-0.18
			(1.260)	(0.943)	(0.944)	(1.322)
Constant	35.803***	35.978***	35.880***	37.621***	37.619***	37.545***
	(1.396)	(1.414)	(1.613)	(2.677)	(2.677)	(2.710)
Controls†	no	no	no	yes	yes	yes
R^2	0.079	0.079	0.079	0.227	0.227	0.227

Notes: OLS estimations and observations equal to 423 in all columns. Robust standard errors in parentheses. Estimations of p-values, FDR q-values, FWER p-values do not include two participants that offered bids equal to 0 in the auction. †Demographics, restricts bread, sensory index (FWER p-value estimations include indices for both products), psychological measures. Location fixed effects included in all columns. p-value corresponds to one-sided OLS p-values. * p<0.1, ** p<0.05, *** p<0.01, based on the latter values. FDR q-values calculated according to Anderson & Mellor (2008). FWER corrected p-values based on Clarke et al. (2019), with 3000 replications. In the FDR and FWER corrections, the WTP for each variety were pooled as two outcomes.

4.5 DISCUSSION

4.5.1 Principal findings

When entering a grocery store, lower-income shoppers may face greater internal challenges than their richer counterparts, aspects that go beyond traditional barriers for healthier food choices (e.g., affordability, knowledge, food selection environment). With this idea in mind, we went to low-income areas in Mexico City to test the influence of poverty related monetary and health concerns on the WTP for healthy foods. In general, our findings depict a story where the average participant had a WTP below the market prices for the two food items used in the study (called green and red bread). From a two systems perspective, the low valuations may be explained by aspects that drive System 1 decisions such as less familiarity and less availability of these products in low-income areas of Mexico City (Marrón-Ponce et al., 2020b). Whereas System 2's optimal valuation of healthy foods is likely higher than System 1's valuation, a relatively low WTP is also explained by deliberative factors such as absolute price differences with the most popular, cheaper options and budget constraint considerations. Additionally, our causal estimates showed that making individuals think about a major expenditure to cover health care costs decreased their valuations only for the green variety. The WTP for the product with more appreciated taste (i.e., the red bread was sweeter and fattier) was unaffected by the priming procedure. This possibly occurred because taste plays a major role in food choices when System 1 is more dominant, which we expected to happen when poverty concerns are present. This may be interpreted in our model as an increse in the affective intensity for this product, which in turn counteracted the negative impact of poverty concerns on its WTP. On the other hand, the effect size of poverty concerns on the valuation of the green product did not differ between the lower- and higher-income groups. We only demonstrated that this effect caused a negative shift in the estimated demand exclusively among the lower-income group. Perhaps we did not find differences in effect sizes because our sample did not resemble the population's income distribution, as most participants belonged to lower-income segments (Mani et al., 2013). Furthermore, the social distance between our participants may not be very substantial, they lived in the same general area. Therefore, our findings are mainly driven by participants from a low-income context and cannot be generalized to higher-income groups.

Rational approaches to influence dietary behaviours assume that individuals use all available information to make deliberative and conscious food decisions (Wilson et al., 2016). However, we could not back this argument as information was not effective in increasing the products' valuations. In this sense, we could not prove that the effect of information was reduced by the induced concerns. Future research may explore if inducing health preoccupations creates a more health-conscious mindset that is more

responsive to health information. This aspect is probably more prevalent among women, who comprised the majority of our sample and are often in charge of feeding their family. Health issues usually have strong emotional components (Loewenstein et al., 2015). Anecdotal comments by participants suggest that the health aspect in the scenario was more worrying than the financial source of hardship. This may have resulted in an increased affective intensity and subsequently a higher WTP for healthy foods. We did not ask participants about their current level of concern about health issues, a measure that could have aided to assess the effects of the induced concerns following the Yerkes-Dodson law. It is also likely that high levels of poverty concern may have induced attentional neglect of the information provided, although this outcome is not always replicated (Shah et al., 2019; Zhao & Tomm, 2017). Our survey did not back that proposition either, as most participants recalled aspects of the information provided. Knowledge does not fully guarantee that respondents took the information into account to make their decision, hence this evidence is only suggestive (Gabaix, 2019).

4.5.2 Mechanisms

We highlighted that the negative effect of poverty concerns on WTP was mediated by increased stress, but not by higher cognitive load. This aligns with past studies that used similar priming techniques (Dalton et al., 2019). Living in poverty and moderate levels of stress can also lead to normative rationality or positive outcomes (Bruijn, 2021). However, considering that baseline stress was above medium level for our sample and rose to high levels after the priming, the Yerkes-Dodson law would predict a negative impact on our outcomes of interest (Egeth & Kahneman, 1975). Our results are also in line with the evidence that links chronic financial scarcity or stress with unhealthy eating behaviours, where lower self-control is a potential mediator (Beenackers et al., 2018; Siahpush et al., 2014). The poverty and self-control association is usually linked to time preferences inconsistencies (Bartoš et al., 2021; Bernheim et al., 2015). While we can assume such relationships from dual system models as illustrated in Loewenstein et al. (2015), we did not elicit time preferences to confirm that. Other mechanisms may have also played a role. For instance, based on our model WTP could also be reduced by a higher affective intensity for money. Scarcity feelings create a greater focus on what is scarce (Zhao & Tomm, 2017), which was confirmed by participants likely borrowing, pawning or adjusting grocery expenses to address the hypothetical monetary scenario. Biological confounders such as differential nutrition or sleep are ruled out, as the stress and cognitive load measurements took place immediately and around 5 minutes after the priming, respectively (Lichand & Mani, 2020), while we also controlled for factors like level of tiredness and hunger.

4.5.3 Strengths and limitations

To our knowledge, this is the first application within the poverty psychology literature that employs a scarcity-priming technique to assess its effects on food purchasing behaviours in low-income settings. We also contribute to the mixed evidence on the role of stress on decision-making and to the menu of mediators in this literature that so far has largely focused on cognitive load (Bruijn, 2021). Considering other strengths, the study covered three different municipalities in the largest metropolitan area among low- and middle-income countries, while the products analysed are part of the most prominent processed food category in the Mexican retail sector. However, the study also has a few notable limitations as described below.

Regarding the generalization of our findings, as we did not randomly select our sample the results are not externally valid to the municipalities selected nor to Mexico City. We have no reason to believe that poor people in other places would behave differently, but this can only be tested by replicating the experiment in different locations. The main threat to internal validity is participants sharing details of the experiment with future respondents. We think this risk was limited, as we stayed no more than two days in most of the locations and the research took place in very busy locations with environmental noises. We also asked participants not to share details of the interview. Additionally, our data did not capture self-regulatory skills, aspect that could counteract the negative effects of the poverty concern treatment. Whereas perceived stress scales yield results in the same direction as cortisol measurement, we did not measure such alternative tests, which could provide further evidence to support our conclusions (Haushofer & Shapiro, 2016). It is plausible that the priming procedure affected cognitive load, as other scarcity research has stated (Lichand & Mani, 2020; Schofield & Venkataramani, 2021; Shah et al., 2015). Relative to past studies, the lack of a significant result could be due to an insufficient number of raven matrices to enable capturing enough variability. Finally, our results are limited to two healthy products within a single food category. We purposely discarded using unhealthy breads as we had a specific focus on healthy foods. Yet, the inclusion of such breads could have served as a benchmark. Based on our findings, we expect that the valuation of unhealthy products would be unaffected by poverty concerns, as such products tend to be very palatable. Huijsmans et al. (2019) used a wide set of food products and showed that a scarcity mindset only affects the valuation of products with relatively low market prices. Therefore, the influence of poverty concerns is likely to affect certain types of products.

4.6 CONCLUSIONS

Barriers for lower-income consumers to healthy dietary behaviours are not only economical but also psychological. Poverty concerns increase stress, which inhibits the ability to exert willpower. This mechanism leads to a decreased valuation of some particularly less tasty healthy products. The downward shift in the potential demand is concentrated in the poorest consumer segments. Further research with other food products with different levels of healthiness and categories, as well as a wide range of market prices is recommended, as our main results are limited to a single variety within one category. Our findings did not shed light on the potential nutrition and health information neglect in the presence of poverty concerns. This aspect is relevant as most food policies rely on educating consumers to make healthier food selections.

This work highlights the importance of developing integrative approaches to promote healthier diets in low-income areas. For instance, the results can be interpreted as a call for the expansion of cash transfers to increase purchasing power and relieve some of the poverty-related stress (Haushofer et al., 2021; Haushofer & Fehr, 2014). Whereas the expansion of cash transfers has been generally proposed in the scarcity literature to improve non-food behaviours, in the light of our results we posit that these policies may also aid in the context of food choices. At the same time, improvements in the food environment are needed to reduce the likelihood of affective-based food purchasing behaviours (Ruhm, 2012). As pointed out in our study, the easy availability of healthy products of good taste may aid to facilitate healthier selections. Another possibility is to strengthen willpower through psychologically grounded interventions that are effective even in persistent states of poverty (Banker et al., 2020; Duckworth et al., 2018). Such tools are likely relevant to counteract the negative effects of monetary and health challenges on the demand of lower-income consumers for healthy foods.

APPENDICES

Appendix 1. Additional tables

Table 1.1
Nutrition profile of the study's packaged breads and the conventional alternative.

Packaged bread	Protein	Fibre	Kcal	Sat. fat (per 100 gr.)	Carbs	Sugar	Sodium	Nutrition score*
Green	8.8	9.6	252.0	0.4	56.4	4.4	404.0	3
Red	11.8	4.7	287.1	0.9	49.4	7.1	376.5	2
Conventional (white)	6.8	0.0	246.6	0.3	50.7	6.8	439.2	-4

Notes: * Values shown with opposite sign with respect to standard methodology to reflect that a higher score means that the product is healthier. It is the weighted sum of the nutrition indicators shown in the table, where protein and fibre are favourable components that increase the score; while total fat, saturated fat, carbohydrates, sugar and sodium are unfavourable components that reduce the score. Source: own estimations based on data from Joaquín Marrón-Ponce et al. (2020b).

Table 1.2
Comparison of participants' characteristics across enumerators' gender.

Variable	Enumerators' gender		*p*-value[†]
	Male	Female	
Female (dummy)	0.72	0.70	0.588
Age (years)	43.73	41.69	0.164
In partnership (dummy)[1]	0.64	0.65	0.914
Children dependency ratio[2]	0.21	0.23	0.356
Household size	4.52	4.45	0.739
Above secondary education (dummy)	0.37	0.48	0.015
In a remunerated activity (dummy)	0.71	0.64	0.110
HH with lower-income (dummy)	0.56	0.60	0.387
Restricts bread for a household member's health condition (dummy)	0.21	0.24	0.480
Had last meal recently (dummy)	0.54	0.47	0.149
Not in a hurry (dummy)	0.42	0.38	0.381
Not tired (dummy)	0.58	0.52	0.221
Highly stressed past month (dummy)[3]	0.53	0.56	0.528
Sensory index green bread	-0.04	0.03	0.472
Sensory index red bread	-0.10	0.08	0.071
N	189	234	

Notes: Means reported in columns 1 and 2. [1]Incudes married and living together. [2]Children below 12 years of age divided by household size. [3]HIighly or extremely worried about affording grocery expenses in the past month. [†]If dummy variable, *p*-value is based on Pearson $\chi 2$ test for the independence between variables, otherwise, it is based on a t-test on equality of means between groups. * p<0.1, ** p<0.05, *** p<0.01.

Table 1.3
Sensory attributes' descriptive statistics by bread type.

Attribute	Bread type				Means diff.†
	Red		Green		
	Mean	Std. Dev.	Mean	Std. Dev.	
Smell	5.72	1.19	5.00	1.24	0.72***
Taste	6.02	1.06	4.87	1.34	1.16***
Texture	5.94	1.13	4.72	1.53	1.22***
Appearance	6.02	1.10	5.14	1.43	0.88***
Colour	5.99	1.01	5.31	1.30	0.68***
Size	6.24	1.02	5.53	1.40	0.71***
Thickness	6.14	1.10	5.39	1.45	0.75***

Note: † Paired t-test on equality of means. * p<0.1, ** p<0.05, *** p<0.01.

Table 1.4
Robustness checks: Adding enumerator and day of the week fixed effects.

PANEL I: Green bread			
Dependent variable	Willingness to pay (MXN)		
	(1)	(2)	(3)
High poverty concern	-1.612**	-1.814**	-1.755**
	(0.834)	(0.835)	(0.846)
Information	-0.669	-0.750	-0.715
	(0.826)	(0.830)	(0.835)
Constant	30.219***	30.982***	28.027***
	(3.037)	(3.185)	(3.994)
Fixed effects			
Enumerator	no	yes	yes
Day of week	no	no	yes
Controls[†]	yes	yes	yes
N	421	421	421
R^2	0.200	0.221	0.237
PANEL II: Red bread			
Dependent variable	Willingness to pay (MXN)		
	(1)	(2)	(3)
High poverty concern	-1.037	-1.018	-0.961
	(0.859)	(0.855)	(0.856)
Information	0.250	0.245	0.257
	(0.847)	(0.848)	(0.854)
Constant	37.621***	37.085***	35.289***
	(2.677)	(2.840)	(3.732)
Fixed effects			
Enumerator	no	yes	yes
Day of week	no	no	yes
Controls[†]	yes	yes	yes
N	423	423	423
R^2	0.227	0.240	0.250

Notes: OLS estimations in all columns. Robust standard errors in parentheses. Estimations in PANEL I do not include 2 participants that offered bids equal to 0 in the auction. * p<0.1, ** p<0.05, *** p<0.01, based on one-sided p-values. [†]Lower-income, sociodemographics, restricts bread, sensory index, psychological measures and location fixed effects.

Appendix 2. Sensory evaluations protocol

At the beginning of the survey we asked participants if they had allergies or any other reason that could prevent them from tasting bread. The exact wording (translated from Spanish) and visual material are shown below. Upper-case words were instructions for the enumerators and were not read out loud. Bolded words in square brackets are additional details for the reader.

Instructions

Now we will do a tasting to evaluate your perception about smell, taste, texture in the mouth, appearance, colour, size and thickness of two different types of bread.

[TREATED GROUP ONLY:] The breads that you will taste have a high nutritional value and the following characteristics **[See Fig. 2.1]**.

ENUMERATOR: SHOW THE NUTRITIONAL CHART TO THE PARTICIPANT.

Fig. 2.1. Nutrition and health Information.

Randomly draw the first bread to taste from this bag **[participant drew the bread's name and showed it to the enumerator].**

ENUMERATOR: THE BREAD DRWAN, WILL BE THE SAME TO BE AUCTIONED LATER.

ENUMERATOR: OFFER WATER **[in aplastic cup]**.

[A slice of bread in a sealed plastic bag was offered to each participant]

In a scale from 1 to 7, where 1 is I dislike it very much and 7 is I love it. Please evaluate this bread according to the following characteristics **[participant selected a score from the scale shown in Fig. 2.2 for each attribute]:**

1. Smell
2. Taste
3. Texture in the mouth
4. Appearance
5. Colour
6. Slice size
7. Thickness

Fig. 2.2. Sensory evaluation's visual scale.

[Participant repeated the procedure with the second bread]

Appendix 3. Auction and poverty concern protocol

The exact wording (translated from Spanish) and visual materials of the auction are shown below. Upper-case words were instructions for the enumerators and were not read out loud. Bolded words in square brackets are additional details for the reader.

Instructions

Practice round

Now, you will participate in a bread auction. First, we will do a practice with a soap.

ENUMERATOR: APPLY THE PROCEDURE STEP BY STEP AS IT IS SHOWN IN THE GUIDING CHART **[see Fig. 3.1]**.

STEP 1: I will give you the money. GIVE **[MXN]** $10 TOY MONEY.

STEP 2: You will do an offer for the product.

How much would you pay for the soap? **[Participant said his/her offer]**

STEP 3: You will draw a random price from the bag.

Draw the price and tell me how much it came out.

RESULT: EXPLAIN THE RESULTS WITH THE GUIDING CHART.

*IF **[HE/SHE]** WON THE AUCTION, ASK THE PARTICIPANT TO PAY THE RANDOM PRICE DRWAN FOR THE SOAP **[Participant paid with the toy money]**.

*IF **[HE/SHE]** LOST, THE PARTICIPANT DOES NOT PAY FOR THE SOAP.

Fig. 3.1. Auction guiding charts.

Poverty concern scenario

Before continuing, I will ask you some questions about your family's spending decisions.

In general, how much do you spend per week on the family groceries?

Now I will present you a scenario:

[words in parenthesis were used in the low condition]

High (Low) condition: Imagine that an unexpected expenditure of MXN 20,000 (MXN 50) arises for a major (minor) medical treatment for one of your family members. You do not have health insurance and have to go to a private health centre. Imagine how would you respond to this situation.

Would you have to borrow money or pawn your belongings to cover this expense? **[Yes/ No]**

Would you have to adjust your weekly budget for food? **[Yes/No]**

How stressed would you feel in this situation? **[1. Nothing-; 2. Little-; 3; Moderately-; 4. Very-; 5. Extremely-]**

Real auction

Now, let's continue with the real auction with the bread.

ENUMERATOR: APPLY THE PROCEDURE STEP BY STEP AS IT IS SHWON IN THE GUIDING CHART **[see Fig. 3.1]**.

STEP 1: I will give you money. GIVE **[MXN]** $60.

STEP 2: You will do an offer for the product.

We will auction only one of the two breads; you can see them on the table. POINT TO THE TABLE WITH THE BREADS.

If we auction a package of the green bread, how much would you pay? **[Participant said his/her offer]**

If we auction a package of the red bread, how much would you pay? **[Participant said his/her offer]**

ENUMERATOR: USE THE FIRST BREAD TASTED **[Remember it was randomly chosen]** TO DO THE AUCTION AND INFORM THE INTERVIEWEE ABOUT THE DECISION.

STEP 3: You will draw a random price from the bag. Draw a price and tell me the price drawn.

RESULT: EXPLAIN THE RESULT THAT APPLIES WITH THE GUIDING CHART.

Did the participant win the auction?

*IF **[HE/SHE]** WON THE AUCTION, ASK THE PARTICIPANT TO PAY FOR THE BREAD AT THE RANDOM PRICE DRAWN.

*IF **[HE/SHE]** LOST, THE PARTICIPANT DOES NOT BUY THE BREAD AND KEEPS THE [MXN] $60.

[END OF AUCTION]

Appendix 4. Raven matrices

Here, we first explained the matrices with an example, saying that there is a missing image in the pattern that was among the six options shown below the pattern. Once we made sure that the participant understood the process, we continued with the two matrices in Fig. 4.1. The participant only had to point to the image that they thought fitted in the pattern.

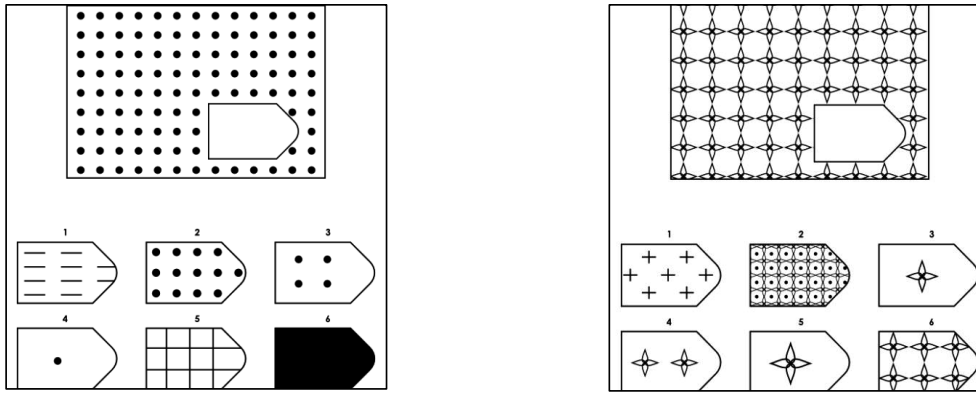


Fig. 4.1. Raven matrices.

After the raven matrices part, each enumerator showed his/her gratitude to the participant and highlighted the importance of his/her previous answers to counteract the expected increases in stress and cognitive load.

CHAPTER 5

5

Relaxed Minds for Healthier Food Choice at School

A field experiment in southern Mexico

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ABSTRACT

There is a large body of behavioural economics literature on interventions to improve diets in school settings. Yet, there is limited evidence in the field attempting to strengthen children's ability to exercise self-control to reach such goal. Such aspects are crucial in the context of the COVID-19 pandemic, which has exacerbated psychological distress and unhealthier food choices among children. We conducted a field experiment in southern Mexico to assess the impact of stress reduction strategies on the food choices of over 1,400 children in grades 4-6. Half of the school-classes in the sample were randomly assigned to a stress reduction strategy namely meditation, which comprised 6 audios with basic relaxation techniques and intuitive messages to guide food choices. Additionally, all participants received information signalling that an amaranth snack was nutritious (i.e., the healthy snack), which was paired with a chocolate bar (i.e., the unhealthy snack) as part of a snack choice experiment. Our findings revealed that the meditation program effectively reduced stress among treated children. The effect was larger among students attending schools in lower-income areas. In general, we found that the share of students choosing the healthy snack did not differ between the treated and the control groups. Yet, we highlighted that meditation increased healthy snack choices by 4%-points among children that chose their snack for non-health or nutrition-related reasons. Upon collecting their snack, students had the chance to exchange their original choice for the other snack. Whereas students that meditated were more likely to exchange their original "unhealthy snack" towards the healthy snack than students in the control group, there was no significant difference between both groups for exchanges towards the unhealthy snack. Our study sheds some light on the relevance of addressing psychological well-being to complement other strategies to improve food choice at school, particularly in post-pandemic times.

5.1 INTRODUCTION

The global efforts to promote healthy food choices and improve diets often rely on educating the public (Willett et al., 2019). However, it is increasingly recognized that information does not necessarily motivate individuals to change their diets (List & Samek, 2015; Samek, 2019; van Kleef & van Trijp, 2018). The effectiveness of information provision is bounded by biases and heuristics that make individuals more prone to unhealthy food choices, particularly in stressful situations. Stress has been shown to be associated with higher craving for and consumption of high-fat and high-sugar foods, especially when consumed as between-meals snacks (O'Connor et al., 2008). The recent evidence suggests that the impact of stress on unhealthy eating may be observed in children as young as eight-nine years old (Hill et al., 2018).

The past two years have been particularly stressful for many people, as the COVID-19 pandemic was found to be associated with stress-related mental illnesses, such as anxiety and depression (Kar et al., 2021). Not just the fear of illness but also the socioeconomic consequences of the pandemic: lack of financial resources, unemployment, and fear of a new recession could have increased stress (Landa-Blanco et al., 2021). These effects are likely to be especially high in low-income settings, where poverty-related stress already affects healthy behaviours (Bruijn, 2021; Just & Gabrielyan, 2018). In the present study context, Mexico, up to 50 percent of the population might suffer from COVID19-related psychological distress (Landa-Blanco et al., 2021). More prolonged schools closure than in other regions, home isolation, limited access to a computer and/or internet for online education, as well as lack of parental support affected children as much as adults (Landa-Blanco et al., 2021). Moreover, the emerging research on the effects of COVID-19 pandemic on children's weight status suggests acceleration of weight gains especially among school-age children (Vogel et al., 2022).

During the last decades, Mexico, like other low- and middle-income countries, has experienced a steep increase in the consumption of ultra-processed foods and drinks (e.g. sweetened beverages, snacks, sweets and desserts), limited intake of whole foods (e.g. fruits, vegetables, high-fibre cereals), and significant reduction in physical activity (Rivera-Dommarco, 2012). These lifestyle changes together with increasingly obesogenic environment contributed to rising prevalence of overweight/obesity and other diet-related noncommunicable diseases (Giuntella et al., 2020; Popkin & Ng, 2021; Rivera-Dommarco et al., 2018). At the same time, the policy focus on tackling the obesity epidemic might shadow other forms of malnutrition, such as micronutrient deficiencies, which have been found to be associated with regular consumption of unhealthy diets and may have negative consequences for the health and learning capacity of school-age children (Flores et al., 2010; Gaona-Pineda et al., 2018; Rivera-Dommarco et al., 2018).

The advantages of promoting healthier diets in school settings are widely recognized, as eating behaviours are formed in childhood and school grounds allow easy, continuous, intensive contact with children (Dudley et al., 2015). There is a large body of literature assessing the impact of school interventions on children's dietary decisions (DeCosta et al., 2017; Madden et al., 2017). In the field of behavioural economics, most of the related studies focused on externally-deployed tools, such as information provision, nudges, changes in food environment or temporary incentives (Belot et al., 2016; DeCosta et al., 2017; List & Samek, 2015; Loewenstein et al., 2016). On the other hand, cognitive self-deployed strategies other than goal-setting (e.g., self-monitoring, psychological distancing, meditation, cognitive therapy) have not been yet utilized in the behavioural economics research to address healthier eating at schools (Duckworth et al., 2018; Reijula & Hertwig, 2022; Samek, 2019). Such strategies are more commonly used in interventions addressing childhood obesity, but the pool of research is still limited (Salam et al., 2020). In the specific case of meditation, such school interventions usually suffer from relatively small sample sizes (de Lara Perez & Delgado-Rios, 2022). Altogether, there is scarce related research in the bodies of literature addressed above regarding interventions conducted in low- and middle-income countries (Brown et al., 2019; Keats et al., 2021; Salam et al., 2020).[5]

In the present study, we propose a self-deployed strategy namely meditation to improve food choices among school-age children in southern Mexico. This region has the highest rates of poverty and overweight/obesity among children below 5 years of age, and both the highest prevalence of diabetes and lowest dietary diversity in the group of adults (CONEVAL, 2019; Levy et al., 2016; Shamah et al., 2018). Meditation has been shown to reduce stress, ameliorate outcomes associated with increased self-control and reduced impulsive eating, and, in turn, increase consumption of healthy foods (Duckworth et al., 2018; Fredrickson et al., 2021; Sala et al., 2020). These benefits are especially relevant now that COVID-19 has aggravated stress levels. While schools have recently opened again, children face the consequences of the damage to academic performance caused by the long period of social isolation and of the socioeconomic stress many of their parents still experience. Focus group discussions with parents and comments by schools' staff in the research area shed light on the emotional impact of the pandemic on school-age children from different income-levels, which likely affected their diets (UNICEF, 2021a, 2021b). Therefore, at the end of the meditation intervention, we assessed the impact of this strategy on children's food choices via reductions in their stress level. We measured the behavioural outcome through a snack choice experiment, where participants selected either a healthy grains bar or an unhealthy ultra-processed snack. Furthermore, we tested

5 For example, most lifestyle modification studies in the review by Salam et al. (81%, n = 531) were conducted in high-income countries. Within the same review, we identified only 3 studies focusing on cognitive self-deployed strategies that were conducted at schools in low- and middle-income countries.

if meditation reduced dynamically inconsistent choices by allowing children to change their original choice while collecting their snack.

The paper has the following structure. In the next section, we present the main hypotheses of this study. Then, we present details about the sample, experimental materials and design, as well as the estimation strategy. In the fourth section, we report the results of the study. In the final section, we discuss the results and conclude.

5.2 HYPOTHESES

Individuals' decision-making processes can be modelled using a dual system framework (Kahneman, 2003). These models explain human behaviour as the outcome of brain interactions between two systems: 1) the affective system (System 1), that encompasses emotions and other motivational states and generally focusses on the here and now; and the deliberative system (System 2), that assesses options in a broad and goal-oriented perspective and is more concerned with long term outcomes (Fudenberg & Levine, 2006; Loewenstein et al., 2015). System 1 processes are fast, automatic, effortless, emotionally charged and governed by habit, so that this type of thinking is prone to biases and errors; whereas the operations of System 2 are slow, effortful, deliberate and costly, and as a result they typically yield more unbiased and accurate results (Kahneman, 2003; Schilbach et al., 2016).

Loewenstein et al. (2015) introduced a tractable version of two-system models where the ability of System 2 to influence System 1 is moderated by the cost of exerting willpower and the intensity of affective motivations. If the latter two factors decrease, it is more likely that an individual will make choices aligned with System 2's preferences. The cost of exerting willpower is equivalent to the ability of exercising self-control and is decreasing in terms of increased willpower strength and reduced cognitive demands (Loewenstein et al., 2015; Ruhm, 2012). Furthermore, willpower strength can be assumed to be negatively affected by higher levels of stress, which is consistent with research linking financial stress with unhealthy eating behaviours (Beenackers et al., 2018; Maier et al., 2015; van Rongen et al., 2019). It has been shown that meditation practices reduce stress, thus strengthening System 2 relative to System 1 (Alem et al., 2021; Sala et al., 2020). In particular, school-based meditation interventions have been shown to be a valuable means of reducing stress among children (Campion & Rocco, 2009; Sapthiang et al., 2019). Then, the following mediation hypothesis arises:

Hypothesis 1. Meditation practices reduce stress among children.

As a result of the reduced stress, we expect that children will take more effortful and deliberate decisions, in this case, healthier food selections (Fredrickson et al., 2021; Sala et al., 2020). There is specific evidence that links children's eating behaviours with emotions, which supports the notion that reduced stress will lead to fewer unhealthy food choices (Messerli-Bürgy et al., 2018; Powell et al., 2017). 2). Meditation practices improve certain self-control outcomes (e.g., eating fewer sweets, less impulsive eating) due to the enhancement of System 2 processes, such as attention outcomes (e.g., sustained attention, working memory) and emotion regulation skills (e.g., openness and acceptance towards life experiences); and to the attenuation of System-1 aspects, such as negative affect outcomes (e.g., depression, anxiety) and impulsive behaviours (e.g., craving) (Creswell, 2017; Duckworth et al., 2018; Jensen et al., 2012; Mason et al., 2016). Therefore, children treated with meditation will be more likely to choose the healthy snack in the food choice experiment. Considering the above scenario, our primary prediction is as follows:

Hypothesis 2: Meditation practices improve children's food choices.

We predict an additional effect related to dynamically inconsistent choices. Such behaviours arise when decision-maker's preferences (i.e., revealed preferences) change over time, in such a way that a preference can become inconsistent at another point in time (Sadoff et al., 2020). As shown by Sadoff and co-authors, the direction of dynamically inconsistent food choices among adults is systematically towards less healthy foods. In other words, if adults have the chance to change an advance choice made in the past between healthy an unhealthy foods, they are more likely to switch from healthy to unhealthy options than the other way around. In general, children discount the future more than adults and especially younger and lower-income children are more impatient than others, hence their propensity to make fewer healthy dietary choices (Belot et al., 2016; Just & Price, 2013; Loewenstein et al., 2015). Under Loewenstein's model, a reduction in the cost of exerting willpower would lead to less dynamic inconsistencies. As meditation is expected to reduce such cost (see above), we posit the following hypothesis:

Hypothesis 3: Children practicing mediation make fewer dynamically inconsistent choices in the direction of unhealthy foods.

5.3 MATERIALS AND METHODS

Data collection was carried out in Oaxaca, Mexico between March and June 2022 at 27 primary schools (see Fig. 1). At the start of the intervention, primary schools in the area had the option to open voluntarily but most of them were still closed and some COVID-19 regulations such as mandatory use of face masks were still in place at the schools that

were already open. Mothers or tutors signed informed consent forms on behalf of their children. A pre-analysis plan was registered before data collection (see https://osf.io/f7yan). The research design received ethical approval from Wageningen University's Social Sciences Ethics Committee. The study was also approved by the State of Oaxaca's Secretariat of Education.

5.3.1 Sample

In Oaxaca, 64% of the population lives in condition of poverty (CONEVAL, 2019). Yet, we selected both public (10) and private (17) schools, which enabled a mix of households with different income levels. The majority of the students (67%) in the sample attended a school located in a higher-income area (see Table 1), mainly because most of the schools that opened after prolonged closures were located around the main urban centre. We focused on urban and peri-urban areas (see Fig. 1), where the consumption of unhealthy processed foods is more generalized than in rural areas (Popkin & Reardon, 2018). In the context of the pandemic, there was still a substantial share of schools with online or other sorts of remote schooling, so we focused on schools where students came fully in person (16) or in hybrid (11) formats. Furthermore, we concentrated on the grades 4-6 with children aged 9 to 12, the stage of life where the relationship between emotions and food choices becomes more salient (Blissett et al., 2010).

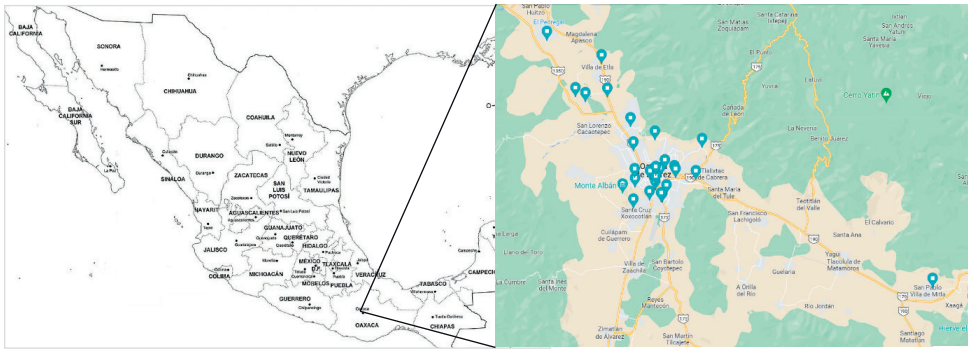

Fig. 1. Research area and schools included in the sample.
Notes: The state of Oaxaca is encircled in the left image. The image on the right shows the metropolitan area of Oaxaca (coloured in light brown), where the schools in the sample are represented by 27 blue spots.

The sample of participants with consent from their parents was 1,615 students, which was lower than our estimates in the power calculations (1,850) because the available schools had smaller class sizes than previously estimated. In the end, we collected data from 1,467 students because 9.2% of the original sample did not attend classes on the day of the survey or their group was excluded as the school made changes in the composition of their class after treatment assignment. We were not concerned about the attrition

issue, as the attrition rate was relatively small and some background indicators (i.e., mother/tutor's age and education) of those who had attrited were similar to the sample collected. After cleaning the data from observations with incomplete sociodemographic information and outliers, the final analytical sample was 1,433. The share of girls and boys was even in the sample (see Table 1). The percentages of students in each grade were similar, but slightly higher for 4th grade, which explains that average age was around that of a fourth grader (10.34). Whereas the majority of the students' mothers completed at most secondary education, we still had a substantial share of them having a tertiary level of education completed (44%). Most of the students had a female teacher (61%).

Two focus groups with mothers and teachers mostly from private schools were organized in the research area. In the context of the ongoing pandemic, the idea of the focus groups was to get a better understanding about school-age children's baseline levels of stress and to determine potential impacts on eating behaviours. The participants reported high levels of distress among children (e.g., angriness, frustration, sadness) due to lack of socialization with their peers, the uncertainty about the duration of the lockdowns, witnessing tensions among their parents and being afraid of COVID-19 contagion once they were back in school. In some cases, children received psychological support. Some disruptions were also observed in eating behaviours, such as a stronger preference towards foods high in saturated fats and processed foods. Teachers mentioned that some students gained weight during the period because of reduced physical activity. We expect that some of these indicators may be exacerbated in lower-income areas due to more extended school closures, lack of access to a computer to attend online schooling, lack of access to a psychologist and pre-existing economic pressures at home.

5.3.2 Products

For the healthy snack, we decided to focus on an amaranth bar, because it is a traditional Mexican food that is popular in Oaxaca and has a higher micronutrient content than other highly consumed cereals such as wheat, rice and maize. After searching in the market, consulting a local amaranth processor (see https://www.puentemexico.org/) and the piloting phase, we chose a traditional bar called *alegria* in Spanish (see Fig. 2). Given its amaranth and nuts/seeds content, this snack was high in fiber, protein, iron and calcium (Orona-Tamayo & Paredes-López, 2017; Rastogi & Shukla, 2013). Following the recent labelling regulations in Mexico, this type of snack usually wears the labels "excess of calories" and "excess of sugar" in big retailers. To upgrade the snacks used in our experiment, we asked the amaranth processor to provide us with a version reduced in sugar.

Table 1
Summary statistics.

Indicator	Mean (1)	Std. Dev. (2)	Min (3)	Max (4)
Students				
Girl	0.50	0.50	0	1
Age (years)	10.34	0.97	8	13
4th Grade	0.37	0.48	0	1
5th Grade	0.30	0.46	0	1
6th Grade	0.34	0.47	0	1
Mothers/tutors				
Age (years)	38.85	6.97	20	76
No formal education	0.02	0.13	0	1
Primary education	0.29	0.45	0	1
Secondary education	0.25	0.43	0	1
Tertiary education	0.44	0.50	0	1
Teacher				
Share of students with a female teacher	0.61	0.49	0	1
Schools				
Share of students in a school located in:				
Lower-income area[1]	0.33	0.47	0	1
Higher-income area[2]	0.67	0.47	0	1
Main urban centre[3]	0.36	0.48	0	1
Close proximity to the main urban centre[4]	0.17	0.38	0	1
Outskirts of main urban centre[5]	0.26	0.44	0	1
Area distant from main urban centre[6]	0.21	0.41	0	1
Share of students attending:				
Public school	0.56	0.50	0	1
School fully in person	0.75	0.43	0	1
Religious schools	0.16	0.36	0	1
Schools with meditation or yoga programs	0.12	0.33	0	1

Notes: [1]Locations with high or very high levels of poverty according to the Index of Urban Marginalization (IUM) elaborated by the National Population Council (CONAPO). [2]Locations with medium or low levels of poverty according to the IUM elaborated by the CONAPO. [3]Located less than 3 kms away from the centrum of Oaxaca City. [4]Located between 3 and 5 kms away from the centrum of Oaxaca City. [5]Located between 5 and 10 kms away from the centrum of Oaxaca City. [6]Located more than 10 kms away from the centrum of Oaxaca City.

Chocolate bars were identified as the most popular type of unhealthy snack in the area. To determine the specific product, we consulted parents and children and searched in the market for snacks roughly similar to the amaranth snack in terms of price (MXN 17 (USD 0.83)) and weight (40g). The pilot informed the final selection, which corresponded to the most popular chocolate out of three options. The selected option had three labels in its original packaging namely "excess of calories", "excess of sugars" and "excess of saturated fat". We assumed that the high content of the latter ingredients and its associated tastiness made this a temptation product that is hard to resist under System 1 processes related to immediate gratification and emotional eating. Given their popularity, children would be more prone to automatic and habitual choices.

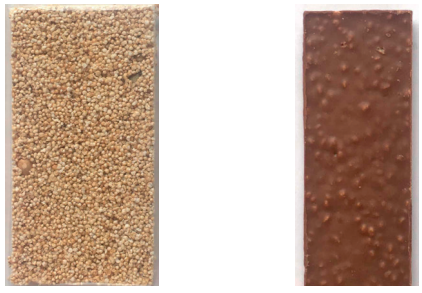

Fig. 2. Amaranth and chocolate snack.

5.3.3 Experimental design

Our study has a block-clustered randomized design (RCT), where clusters are the school classes from grades 4-6 (the three blocks). To avoid COVID-19 contagion, six schools divided each of their classes in two subgroups, so for our study each of these subgroups was considered as a class. All children that attended school in person and had permission from their parents were part of the sample. Half of the school classes in each grade of each school were randomly assigned to a *meditation program* comprised of 6 audios. During the duration of the program, the control group did not receive any sort of intervention such as placebo audios.

The audios of the program were provided by a company specialized on self-development and meditation programs (see https://atahualpairigoyen.com/). The intensity was set to 6 sessions, because we expected the positive effects of meditation to be more salient after some time and the children to need some time to familiarize themselves with this new practice. We asked teachers to play the meditation audios on a daily basis and the specific schedule of the sessions was agreed depending on the availability of the trained teachers[6] (i.e., the teacher in charge of the class). The schedule was not consistent across schools

6 Some teachers are in the classroom before recess, whereas some of them teach after recess.

as some of them had different types of hybrid formats in the context of the pandemic[7], thereby resulting in the meditation program lasting between 1 and 3 weeks. Specific instructions were provided to teachers to tell their students to keep their school materials in their backpacks to clear their space and to follow thoroughly the instructions provided in the audios (e.g., close their eyes) (full instructions in appendix 1). The teachers had the option to practice the meditation with their students voluntarily. Each meditation session lasted from 5 to 10 minutes, and its main objective was to guide children to reach a state of relaxation that may enable them to make better food choices. At the same time, we shaped the program towards achieving the specific goal (healthier food choices), a feature that was recently identified in the related literature (Haushofer et al., 2021). In particular, the meditation program included the following components: 1) instructions about sitting position 2) breathing and mental body scan exercises; 3) playful stories that guide children to an imaginary place where they can cultivate positive emotions; 4) guided stories that help children to identify which foods are natural and good for their bodies; 5) an invitation to experience those foods that are good for their bodies in their daily lives. Aspects 4) and 5) differ from the standard nutrition information, as they are linked to feelings or perceptions of food, whereas standard information is comprised by facts about nutrition and health. All the mediation audios covered aspects 1), 2) and 3), while only audios 2, 3, 4 and 6 covered aspects 4) and 5).

The research team was introduced to the students on the first meditation day (full script in appendix 2) but remained outside the classroom while the mediations were played. The application of the audios 1 to 5 was monitored by enumerators, generally the first two days on-site and afterwards remotely via instant messaging (i.e., WhatsApp), as teachers usually handled the application of the audios very easily. Yet, enumerators assisted the teachers to play the audios when needed, but always stayed outside while the audios were played. Immediately after the final mediation session, all treatment and control children participated in a food choice experiment. The experimental choice was recorded in a brief questionnaire (Appendix 3). The first question appeared alone in the first page of the survey, where children chose between two images of snacks. The rest of the questions were asked in the second page of the survey to reduce the likelihood of influencing the snack choice. These questions asked about food preferences and measured stress. The stress section consisted of a set of five questions from the stress in children (SIC) questionnaire (Michels et al., 2012; Osika et al., 2007). The stress questions involved: i) feeling of relaxation, ii) feeling of happiness and iii) whether the child enjoys going to school, which were measured as 1 for *no*, 2 for *sometimes* and 3 for *yes*; iv) frequency of stomach aches and v) frequency of eating when stressed (i.e., emotional eating), which was measured as 1 for *very frequently*, 2 for *sometimes* and 3 for *never*.

7 For example, some students attended school two days per week on different days by class. It was also common that some students were present in the first half of the morning and the rest in the second half of the morning.

The research team told children that they got the chosen snack as a thank you token for filling in the questionnaire. They could choose either an amaranth snack (i.e., the healthy snack) or a chocolate (i.e., the unhealthy snack). Children could see an example specimen of each snack (as shown in Fig. 2). Both specimens were shown by the research team in clear plastic packaging to avoid teacher, marketing or novelty effects. To signal that the amaranth product is healthy, we referred to it as a "nutritious amaranth bar" in the survey. All subjects received this signalling, so we did not have a pure control group. Similar to Samek (2019), we assumed that information alone would not have a large effect on behaviour. The effective use of information requires substantial System 2-related cognitive efforts to consider future implications and trade-offs regarding nutrition, health and costs (Just & Gabrielyan, 2018; Mancino et al., 2018). As meditation improves System 2's processes and our meditation audios were purposely geared towards healthier food choices, we expected that nutrition information is more likely to affect the food selections of those children practicing mediation.

Immediately after filling in the surveys, students were moved to a different place to collect their snack, one by one, to a spot out of sight from the rest of the class. Depending on the characteristics of the school building, the other students waited for their turn sitting on the classroom or in a line controlled by enumerators and teachers to avoid that children shared their survey's answers. Enumerators handed the surveys to the teachers, who called in the next child in turn based on the order of the surveys collected. While picking up their snack, enumerators gave the children the chance to exchange their original choice, so that we could assess the consistency of their food choices (exact wording in appendix 4). They did not know they could change their mind at the time of the original choice in the questionnaire. This approach was similar to Augenblick et al. (2015) and Sadoff et al. (2020), but we measured the above outcome over a shorter time span (minutes vs a week), as we assumed that children tend to be more impatient/impulsive than adults. It is possible that children switch from the unhealthy towards the healthy snack, but we expected that it would be more probable to see switches to the unhealthy option due to its tempting nature. This is in line with the findings in Sadoff et al. (2020).

Control groups encountered our research team for the first time during the survey and snack collection parts of the study, whereas treatment groups had seen some members of our team since the beginning of the meditation intervention. To have a more homogenous response from both groups during the survey and snack collection, the enumerators that handled those steps in the treatment groups were different from those monitoring the meditation intervention. The detailed procedure of the day of the food choice experiment is shown in Fig. 3 below.

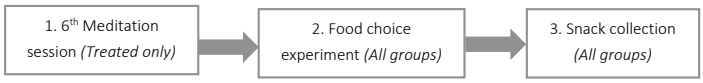

Fig. 3. Timing of procedures during the day of the food choice experiment.

5.3.4 Estimation strategy

We estimated the following model:

$$Y_{ij} = \beta_0 + \beta_1 Meditation_j + \delta X_{ij} + m_s + t_g + \varepsilon_{ij}$$

where *i* and *j* index participant children and the cluster (school class), respectively.

- Y_{ij}: Outcome variables. Our primary outcome equals 1 if a child chose the healthy snack, 0 otherwise.

    - The secondary outcomes were the following:

      1) stress, which is measured as the first component of a principal component analysis using the five stress questions mentioned above (Appendix 5).

      2) dynamically inconsistent food choice (i.e., willpower), dummy equal to 1 if the child exchanged his/her original snack choice from the healthy (unhealthy) snack to the unhealthy (healthy) snack at the moment of collection; 0 otherwise.

- $Meditation_j$: Treatment variable. Dummy equal to 1 if the child is exposed to mediation practices, 0 otherwise.

- X_{ij}: Covariates. sociodemographic controls (children's gender and age; maternal education and age; teacher's gender).

- m_s, t_g: Fixed effects for school and grade.

- ε_{ij}: Error term.

Our primary estimation method was an OLS or linear probability model. A probit model was used as a robustness check for the binary outcomes. Standard errors were clustered at the class level *j* (N=130). Although there were some imbalances in the characteristics (e.g., female teacher, location) between the control and treated groups (Table 2); a joint

test of orthogonality (i.e., binary probit with the treatment variable on the left-hand side and controls on the right-hand side) suggested that the meditation group was comparable to the control group (Prob>χ^2=0.822). Some controls declared in the pre-analysis plan were not used in the model (e.g., marginalization index, number of meditations practiced by teachers, student-teacher ratio, enumerator and day of the week) because of multicollinearity issues. To assess heterogenous effects without specific hypotheses, we included an exploratory analysis to distinguish gender (pre-registered), income (not pre-registered) and reasons for the snack choice (not pre-registered). For the latter analysis, we controlled for multiple hypothesis testing using the Romano-Wolf correction to control the familywise error rate (FWER) (Clarke et al., 2019).

Table 2
Randomization checks.

Variable	Meditation program		*p*-value[Y]
	Yes	No	
Girl (dummy)	0.50	0.50	0.950
Age	10.32	10.42	0.072
4th Grade (dummy)	0.38	0.35	0.401
5th Grade (dummy)	0.31	0.29	0.373
6th Grade (dummy)	0.32	0.36	0.086
Consumed an amaranth snack last week (dummy)	0.23	0.22	0.981
Consumed a chocolate snack last week (dummy)	0.28	0.25	0.296
Mother's age	39.06	38.60	0.210
Well-educated mother (dummy)[1]	0.45	0.44	0.689
Female teacher (dummy)	0.64	0.58	0.014
Attends school located in (dummies):			
Lower-income area[2]	0.34	0.32	0.388
Main urban centre[3]	0.33	0.39	0.013
Close proximity to the main urban centre[4]	0.16	0.18	0.340
Outskirts of main urban centre[5]	0.29	0.24	0.036
Area distant from main urban centre[6]	0.22	0.19	0.125
Attends (dummies):			
Public school	0.54	0.57	0.213
School fully in person	0.73	0.77	0.086
Religious school	0.16	0.15	0.676
School with meditation or yoga programs	0.13	0.10	0.078
N	768	665	

Notes: [1]Completed tertiary education. [2]Locations with high or very high levels of poverty according to the Index of Urban Marginalization elaborated by the National Population Council. [3]Located less than 3 kms away from the centrum of Oaxaca City. [4]Located between 3 and 5 kms away from the centrum of Oaxaca City. [5]Located between 5 and 10 kms away from the centrum of Oaxaca City. [6]Located more than 10 kms away from the centrum of Oaxaca City. [Y]If dummy variable, p-value is based on Pearson $\chi 2$ test for the independence between variables, otherwise, it is based on a t-test on equality of means between groups.

5.4 RESULTS

5.4.1 Sensory evaluation of the products

A week prior to the food choice experiment, the share of students that consumed any chocolate bar was somewhat larger than the corresponding share for amaranth bars ((Prob>*t*=0.014), it was 27% and 23%, respectively. After the treatment was administered, we asked the children about their visual perception of the products. The answers did not differ by treatment condition. The study's products had exactly the same weight, but a slight majority of subjects in the sample (53%) perceived the amaranth snack as more filling than the chocolate snack. Participants craved more for the chocolate snack than for the amaranth snack (Prob>*t*=0.000), as their average scores (scale 1-5) were 3.90 (*SD*=1.11) and 3.44 (*SD*=0.98), respectively.

5.4.2 Manipulation checks

Table 3 shows the effects of the meditation program on the different stress reduction aspects. We highlight that children treated with the meditation program reported a significantly higher score in terms of relaxation. Anecdotical comments by teachers confirmed that students looked very calm and focused after the meditation. On average, the scores of happiness and enjoys going to school were quite high (2.7-2.8 out of 3) and were not significantly different between treatment groups. Also, no differences were reported for reductions in emotional eating. Contrary to expectations, students in the control group reported higher scores for reductions in the frequency of stomach aches. All in all, students exposed to meditation reported a reduction in stress, as their stress reduction score was significantly higher than for those who did not meditate. This leads to the following statement underling the mechanism of the study (H1):

Result 1: Practice of meditation reduces stress among school-age children.

Table 3
Effect of meditation on reported indicators of stress reduction.

Dependent variable				*Reduction in frequency of:*		
	Relaxed	Happy	Enjoys going to school	Stomach-ache	Emotional eating	Stress reduction score[Y]
	(1)	(2)	(3)	(4)	(5)	(6)
Meditation	0.236***	0.015	-0.022	-0.140***	-0.023	0.414***
	(0.033)	(0.026)	(0.021)	(0.030)	(0.033)	(0.058)
Girl	0.010	-0.035	0.059***	-0.082***	-0.081*	0.018
	(0.029)	(0.026)	(0.022)	(0.029)	(0.045)	(0.052)
Age	-0.033	-0.028	0.015	-0.010	-0.052*	-0.058
	(0.028)	(0.025)	(0.022)	(0.027)	(0.028)	(0.049)
Well-educated mother	-0.037	-0.005	-0.063*	0.019	0.015	-0.065
	(0.035)	(0.032)	(0.034)	(0.037)	(0.043)	(0.061)
Mother's age	-0.001	-0.001	-0.001	-0.004*	0.004	-0.001
	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)	(0.003)
Female teacher	0.063*	0.088***	-0.006	0.046	0.055	0.112*
	(0.035)	(0.026)	(0.026)	(0.035)	(0.039)	(0.062)
Constant	2.911***	3.033***	2.858***	2.546***	2.562***	0.665
	(0.289)	(0.261)	(0.225)	(0.318)	(0.305)	(0.509)
R^2	0.105	0.043	0.083	0.051	0.030	0.104
Mean (Control)	2.40	2.72	2.84	2.24	2.15	-0.23

Notes: OLS estimations and observations equal to 1,433 in all columns (1,432 in 4,6). Variables in columns 1-5 are measured in a scale from 1 to 3. Standard errors clustered at the school class level shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [Y]Constructed as the first principal component of the dependent variables in columns 1-5. All regressions include school and grade fixed effects. Intra-cluster correlation (ICC) ranged from 0.00 to 0.11.

5.4.3 Evaluating the impact of meditation on food choices

Table 4 reports the effect of the meditation program on the primary outcome. In general, 33% of the sample selected the heathy snack. Students that practiced meditation were slightly more likely to choose the healthy snack than those in the control group, but the effect was not statistically significant. The effect was slightly larger when dropping the clusters where the protocol was violated (e.g., students heard about the snack choice from family members in other class), but still non-significant. Among the associations with the demographic variables, we observed that girls and those with well-educated mothers were more likely to choose the healthy snack than boys and those with less-educated mothers, respectively. Altogether, our main estimates did not support our primary hypothesis:

Result 2: Meditation does not improve children's food choices.

Table 4
Effect of meditation on healthy snack choice.

Dependent variable	Healthy snack chosen				
	(1)	(2)	(3)	(4)	(5)
Meditation	0.004	0.004	0.003	0.006	0.006
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Girl		0.046*	0.047*	0.046	0.046
		(0.028)	(0.028)	(0.028)	(0.028)
Age		0.029	0.029	0.028	0.028
		(0.024)	(0.024)	(0.024)	(0.024)
Well-educated mother			0.057**	0.058**	0.058**
			(0.027)	(0.027)	(0.027)
Mother's age			0.003	0.003	0.003
			(0.002)	(0.002)	(0.002)
Female teacher				-0.041	-0.041
				(0.029)	(0.029)
Constant	0.285*	-0.009	-0.110	-0.085	-0.085
	(0.164)	(0.278)	(0.284)	(0.280)	(0.280)
R^2	0.035	0.038	0.042	0.044	0.044

Notes: OLS estimations and observations equal to 1,432 in all columns. Standard errors clustered at the school class level shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01 . All regressions include school and grade fixed effects. Intra-cluster correlation (ICC) was equal to 0.04.

Regarding the reasons for choosing the snacks, we observed that most of the participants said that they selected their snack because they like it more in general than the alternative (54%) or for taste reasons (19%). We did not estimate the effectiveness of the nutrition information provided, but identified that 16% of the subjects chose either of the snacks for health or nutrition reasons, in almost all cases this concerned the healthy snack. Surprisingly, students in the control group mentioned such aspects more often than those in the treatment group ((Prob>*t*=0.005).

5.4.4 Consistency of choices

Table 5 depicts the impact of the meditation intervention on the likelihood of switching the original snack choice. We found that 11% of the sample changed their initial choice at the moment of snack collection. As expected, a slight majority of those changes (52%) were from the healthy to the unhealthy snack. However, the likelihood of a healthy-unhealthy switch did not differ by treatment status. On the other hand, overall switches were more likely among treated than for non-treated children, which was driven by changes from the unhealthy to the healthy option (+2.6%-points). 6% of the students who did such a "healthy switch" may have shown some biases (e.g., social desirability

and/or experimenter demand effects), as they originally chose the chocolate bar because they do not appreciate some sensory attributes (e.g., texture, taste) of amaranth snacks in general. Yet, the treatment effects were robust to the exclusion of those observations. Likewise, the results were robust to the exclusion of clusters where the protocol was violated (e.g., students saw the snack collection process on a previous day) and in a probit regression (Appendix 5). Thus, our estimates did not support hypothesis 3:

Result 3: Children practicing mediation do not make fewer dynamically inconsistent choices in the direction of unhealthy foods.

Table 5
Effect of meditation on time inconsistent food choices.

Dependent variable	Healthy switch[Y]		Unhealthy switch[YY]		All switches	
	(1)	(2)	(3)	(4)	(5)	(6)
Meditation	0.027**	0.026**	0.007	0.005	0.034**	0.031**
	(0.011)	(0.011)	(0.013)	(0.012)	(0.016)	(0.015)
Girl		0.007		-0.023*		-0.016
		(0.013)		(0.012)		(0.016)
Age		0.014		0.005		0.020
		(0.012)		(0.012)		(0.017)
Well-educated mother		-0.007		-0.000		-0.007
		(0.016)		(0.013)		(0.021)
Mother's age		-0.001		0.001		-0.001
		(0.001)		(0.001)		(0.001)
Female teacher		0.025**		0.025		0.050**
		(0.012)		(0.017)		(0.020)
Constant	0.292***	0.188	0.102	0.019	0.394***	0.207
	(0.105)	(0.157)	(0.080)	(0.139)	(0.057)	(0.178)
R^2	0.035	0.040	0.027	0.032	0.049	0.055
Mean (Control)	0.04		0.06		0.10	

Notes: OLS estimations and observations equal to 1,432 in all columns. Standard errors clustered at the school class level shown in parentheses. [Y]Exchanges from the chocolate bar to the amaranth bar after the choice experiment. [YY-] Exchanges from the amaranth bar to the chocolate bar after the choice experiment * p<0.1, ** p<0.05, *** p<0.01. All regressions include school and grade fixed effects. Intra-cluster correlation (ICC) equal to 0.01 in all cases.

5.4.5 Heterogenous effects

First, we tested if the impact on the main secondary and primary outcomes differed by gender (see Table 6). The meditation treatment tended to have more positive effects for girls regarding indicators such as stress reduction and healthy snack choice, but the differences were always statistically insignificant. Second, we assessed if there were

heterogenous effects by level of income (see Table 7). We highlighted that meditation reduced stress for students that attend both schools in lower- and higher-income areas, but the effect was larger in lower-income areas. The effects just mentioned remained significant after correcting for multiple hypothesis testing. Third, almost all students who chose their snack for health/nutrition reasons selected the healthy snack, so we explored the treatment effects for the rest of students (84% of the sample) choosing for other motives (see Table 8). Within this sub-sample, we observed that the meditation program was effective in increasing (+4%-points) the healthy snack choice. This effect was robust to the multiple hypothesis adjustments, exclusion of clusters where the protocol was violated and in probit regressions (Appendix 5). We did not identify particular motives (e.g., past consumption, sensory attributes, dietary restrictions) that explained the mentioned effect (Appendix 5).

Table 6
Heterogenous effect of meditation for girls.

Dependent variable	**Stress reduction score**[Y]	**Time inconsistent food choices**		**Healthy snack choice**
		Healthy switch	Unhealthy switch	
	(1)	(2)	(3)	(4)
Meditation	0.401***	0.034**	-0.009	-0.000
	(0.078)	(0.016)	(0.017)	(0.039)
p-value	0.000	0.038	0.581	0.994
FWER p-value	0.000	0.034	0.738	0.992
Girl	0.004	0.016	-0.039**	0.039
	(0.086)	(0.017)	(0.016)	(0.040)
Meditation x Girl	0.025	-0.016	0.029	0.014
	(0.103)	(0.025)	(0.024)	(0.056)
p-value	0.806	0.530	0.218	0.808
FWER p-value	0.932	0.785	0.319	0.932
Constant	0.675	0.181	0.031	-0.080
	(0.507)	(0.160)	(0.141)	(0.279)
R^2	0.105	0.041	0.033	0.044

Notes: OLS estimations and observations equal to 1,432 in all columns. Standard errors clustered at the school class level shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [Y]Constructed as the first principal component of variables relaxed, happy, enjoys school, reductions in frequency of stomach-ache and emotional eating. All regressions include controls for age, mother completed tertiary education, mother's age, teacher's gender, school and grade fixed effects. * p<0.1, ** p<0.05, *** p<0.01, based on p-values shown above. FWER corrected p-values based on Clarke et al. (2019), with 3000 replications.

Table 7

Heterogenous effect of meditation for schools in lower-income areas.

Dependent variable	**Stress reduction score[Y]**	**Time inconsistent food choices**		**Healthy snack choice**
		Healthy switch	Unhealthy switch	
	(1)	(2)	(3)	(4)
Meditation	0.315***	0.014	0.008	0.011
	(0.076)	(0.014)	(0.015)	(0.030)
p-value	0.000	0.309	0.586	0.703
FWER p-value	0.001	0.629	0.802	0.802
Lower-income	0.012	0.215**	0.038	0.063
	(0.176)	(0.097)	(0.093)	(0.153)
Meditation x Lower-income	0.300***	0.035	-0.009	-0.015
	(0.106)	(0.024)	(0.025)	(0.055)
p-value	0.006	0.141	0.730	0.788
FWER p-value	0.018	0.316	0.914	0.914
Constant	0.522	-0.043	-0.015	-0.141
	(0.482)	(0.122)	(0.116)	(0.248)
R^2	0.109	0.042	0.032	0.044

Notes: OLS estimations and observations equal to 1,432 in all columns. Standard errors clustered at the school class level shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [Y]Constructed as the first principal component of variables relaxed, happy, enjoys school, reductions in frequency of stomach-ache and emotional eating. All regressions include controls for gender, age, mother completed tertiary education, mother's age, teacher's gender, school and grade fixed effects. * p<0.1, ** p<0.05, *** p<0.01, based on p-values shown above. FWER corrected p-values based on Clarke et al. (2019), with 3000 replications.

Table 8

Heterogenous effect of meditation for students that chose for reasons other than health/nutrition

Dependent variable	**Stress reduction score[Y]**	**Time inconsistent food choices**		**Healthy snack choice**
		Healthy switch	Unhealthy switch	
	(1)	(2)	(3)	(4)
Meditation	0.379***	0.025*	0.014	0.040**
	(0.063)	(0.013)	(0.011)	(0.020)
p-value	0.000	0.058	0.208	0.048
FWER p-value	0.000	0.086	0.174	0.086
Constant	0.557	0.164	-0.043	-0.166
	(0.525)	(0.164)	(0.130)	(0.231)
R^2	0.106	0.044	0.031	0.035

Notes: OLS estimations and observations equal to 1,200 in all columns. Standard errors clustered at the school class level shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. [Y] Constructed as the first principal component of variables relaxed, happy, enjoys school, reductions in frequency of stomach-ache and emotional eating. All regressions include controls for gender, age, mother completed tertiary education, mother's age, teacher's gender, school and grade fixed effects. * p<0.1, ** p<0.05, *** p<0.01, based on p-values shown above. FWER corrected p-values based on Clarke et al. (2019), with 3000 replications.

5.5 DISCUSSION AND CONCLUSION

This paper analysed the impact of six sessions of meditation shaped towards healthier food choices, on the dietary decisions of students in grades 4-6 at 27 schools in southern Mexico. In terms of overall preferences, our data showed that a considerable majority of the participants chose the chocolate over the amaranth bar in our experiment. This is aligned with the chocolate bar being more appealing to children in our sample than the amaranth bar. In general, our estimates revealed that students practicing meditation were not more likely to choose the healthy amaranth snack than those in the control group. Nonetheless, we highlighted that meditation effectively aided students who chose for reasons other than health or nutrition to increase the healthy snack choice. Thus, meditation seems to make a difference for children that are otherwise less health conscious. Based on the reasons of choice stated by the participants, we did not identify a particular attribute that explained this effect, such as past consumption, sensory qualities or dietary restrictions. In this sense, it is possible that meditation just gave them further "motivation" to take more effortful and deliberative decisions. The majority of these participants stated that they chose their snack because they "like it" more than the other, which is a vague response that may hide their true intrinsic motivations. On the other hand, the prices of the snacks used in the experiment were similar in the market, but it is unclear if students had different monetary valuations of the products and if they took them into account when doing their choice. We did not capture overall daily intakes of our participants, but a similar study found that meditation does not affect the overall intakes of unhealthy foods among adults (Alem et al., 2021). Unlike the latter study, we did find a significant effect on experimentally measured stated preference food choice.

In line with our expectations in the pre-analysis plan, our only significant treatment effect on food choice of 4%-points was substantially lower than the effects in past school interventions. For the studies on incentives, the effect sizes varied from 11 to 28%-points increases in choices of fruits (Belot et al., 2016; Just & Price, 2013; Loewenstein et al., 2016), whereas those in the goal setting study varied from 10 to 18%-points increases in choices of milk (Samek, 2019). The effect in other school experiments in a middle-income country such as Indonesia, was also larger, around 13%-points for nudges (i.e., emoji faces) to increase fruit selections (de Vries Mecheva et al., 2021). While we did not measure the impact of information, based on the relatively low effect size, we posit that meditation may serve as an effective complement for other strategies. Further studies are warranted to disentangle the interaction effects of information and meditation, as sometimes information does not have a positive synergy with other strategies to improve dietary decisions among children as in de Vries Mecheva et al. (2021).

We predicted that meditation would also affect the dynamic consistency of food choice. Our results only indicated that students practicing meditation were more likely to exchange the unhealthy for the healthy snack (i.e., healthy switch) when given the chance to do that after the original choice. Children in general did more unhealthy than healthy switches, but the shares did not differ by treatment group. Compared to a study with a similar experimental design with adults, the share of participants in our research that exhibited dynamic inconsistencies was smaller (46%vs11%) (Sadoff et al., 2020). Had the second choice happened days apart from the experiment, perhaps unhealthy switches would be more prevalent, thereby giving more room for meditation to reduce the likelihood of such biases. In this sense, our results are similar to Alem et al. (2021), who found that meditation had weaker effects on time preferences.

Considering the mechanisms behind the effects of meditation, our analysis revealed that mediation reduced stress among treated participants. The effect was larger for those children attending schools in lower-income areas. Participants from such backgrounds may had more room to reduce stress levels, as they were likely experiencing higher stress than those from higher-income areas, due to long-term exposure to economic worries in their households (Bruijn, 2021; Kremer et al., 2019). Additionally, such students had prolonged school closures and lack of access to resources to attend online schooling, to cope with emotional impact of the pandemic (e.g., a therapist) and to a similar meditation program as in some of the private schools in the sample. This mechanism is backed by research linking stress with eating behaviours (Beenackers et al., 2018; Blissett et al., 2010), which we now generalize to the field of healthier diets in school settings. Again, our results are in line with Alem et al. (2021) in terms of the impact of meditation on perceived stress. Yet, further evidence is needed with alternative stress measurement techniques, as the mentioned authors had less conclusive evidence based on cortisol measures.

A few aspects are unclear in terms of the impact of meditation on our stress measures. First, the economic and pandemic-related stress sources were the most salient in the context of this study, but we are cognizant that there are other causes of worry among children such as schoolwork, bullying and violence in their communities. With this in mind, it is unclear which specific sources of stress were lessened by meditation. Second, there was an unexpected negative effect of the intervention on the reported frequency of stomach aches. Yet, assuming that this is indicator did not differ by treatment group at baseline, it is possible that the increased frequency was due to improved body awareness on treated participants, which is typically the case with meditation (Gallant, 2016). In fact, our meditation audios included practices were children mentally scanned their bodies. In any case, it is also possible that such techniques may trigger some pre-existing emotional issues that may need some guidance by a specialist, aspect that shall be recommended for future meditation interventions (de Lara Perez & Delgado-Rios, 2022).

Our findings are relevant for the ongoing debate in the field of food choices about the relative effectiveness of strategies influencing individual's self-control such as ours, relative to more paternalistic approaches such as bans on unhealthy foods (de Vries Mecheva et al., 2021; Loewenstein, 2018). Here, we posit that strategies like meditation may well complement other approaches in a package of policies to attain healthier diets. In fact, the large availability of unhealthy foods in the market may actually be the consequence of the predominantly affective nature of consumers' dietary behaviours, which is usually reinforced by stressors (Ruhm, 2012). Consequently, strategies influencing self-control are particularly relevant in low- and middle-income countries due to large shares of the population experiencing poverty-related stressors, which have been recently complemented by the negative psychological effects of the ongoing COVID-19 pandemic. At the same time, the reality is that a comprehensive package of paternalistic policies such as large taxes and bans on unhealthy foods are hardly implemented in countries like Mexico, as they face strong push back from the food industry (Rivera-Dommarco et al., 2018). That being the case, meditation programs fit well in the existing student curricula and could be shaped towards the healthy choice to equip children to take better dietary decisions (INSP, 2020).

We highlight some limitations of this work. The main results of this work cannot be generalized to Oaxaca or southern Mexico because the set of schools available for the study was constrained by the availability of open schools in the context of the COVID-19 pandemic. The sample of students was also biased becuase some minorities following only online schooling were not captured in our study. Parents of the latter children were typically more concerned with COVID-19 contagion and had the means, willingness to prolong such schooling scheme. Likewise, we had differential attrition at least in terms of gender, but other characteristics may have also varied. Altogether, we had a relatively large, heterogenous sample and expect that our results would hold for similar schools in low-income areas of Mexico, but this can only be assessed by replicating our design in other schools and other regions.

In terms of internal validity, we expect risks such as treatment diffusion to be limited, as the schedules by class differed within each school due to the pandemic regulations and it is unlikely that students would put other peers to meditate. On the other hand, we cannot discard experimenter demand effects particularly at the moment of snack collection[8]. To reduce the possibility of such biases, we switched the enumerators that monitored the meditation and those applying the survey and delivering the snacks, so they were less familiar with the experimenters when providing their responses (like the control group).

8 Such aspects may coincide with social desirability bias, as healthier food choices are an obvious normatively positive behaviour. Likewise, Hawthorne effects may be interconnected with the same biases at the moment of snack collection.

We also emphasized to students that there were no right or wrong answers and that we just wanted their true opinions. In any case, the existing evidence has shown that such effects are likely modest, and our results held when removing those observations deemed as the most suspicious of such biases (de Quidt et al., 2018; Mummolo & Peterson, 2019). Finally, we could not appropriately identify non-compliers in the treatment group so additional analyses such as intention to treat were not possible. Yet, it is certain that all treated participants in the analytical sample did the last meditation, thereby ensuring that they received to some extent the positive effects of the program.

In light of our findings, stress reduction strategies framed in the direction of healthier food choices improve dietary decisions among children that are otherwise not driven by health/nutrition motivations. Our study proved that with a considerably large and heterogenous sample compared to similar studies in other strands of literature. In contrast with a similar experiment with adults in Alem et al. (2021), we also shed light on the higher chances of influencing food choices with meditation at earlier stages in life. At the same time, strategies such as meditation may work as a *self-built* internal mechanism that leads to *beneficial* dynamic inconsistency in food choice. These strategies are especially of great assistance to improve the psychological well-being of children with a lower-income background, even more now in post-pandemic times.

APPENDICES

Appendix 1. Instructions for teachers

The meditations that will be played to your students are audio recording that last around 7 minutes. Listen to them previously to become familiar with them and to be able to explain to your students what a meditation is, so that they are interested on the activity.

For this exercise, you will require the meditation audios, a speaker and a schedule for the meditations:

A. The meditations (*the Spanish version also included a QR code to access the audios*)

Download the mediations clicking on the following link: atahualpairigoyen.com/meditaciones-para-ninos/

The order of the files corresponds to the order in which the meditations will be played each day. The file named "Intro" is an introduction to the exercise and is played before the first meditation. The file "Cierre" is played after the sixth meditation.

B. The speaker

Once you have downloaded the meditations, test them in your classroom with a speaker that can be linked to your phone or a computer (where you downloaded the meditations) to verify that you can listen the audios and that they can be listened from the location of every student.

C. Schedule of the meditations

Reserve the same schedule to play the audios every day in coordination with the team that supervises the execution of the meditation program.

Turn off your phone's notifications and follow the exercise with your students, with you breathing and attention to the recording. Take care that your participation is neutral while your students listen to the audio.

Below are some instructions that other teachers that had done this exercise with their students, had used before playing the meditations to their group:

1. *"Stop doing what you are doing right now. Let's listen to the meditation of the day".*
2. *"Pack away the things that you have on the desk and put your backpack aside".*
3. *"Let's start the meditation, remember to close your eyes and to listen with attention".*
4. *"Please sit quietly in your place"*

You know your students, so we are sure that you will find the instructions that work best and that you will ensure that the meditations will be a fulfilling experience for all the group, including you.

Thank you for your support and for the effort you make for the children.

Appendix 2. Script for the start of the meditation program.

INSTRUCTIONS: THE TEXT IN UPPERCASE IS INFORMATION ONLY FOR THE ENUMEARTOR. THE TEXT IN LOWERCASE ARE INSTRUCTIONS THAT ARE READ TO THE CHILDREN OR THE TEACHER.

ENUMERATOR: ENTER THE CLASSROOM TO REMIND THE TEACHER ABOUT THE AUDIOS OF THE DAY (INTRO+AUDUI 1). ONLY ONE TEAM MEMBER IS REQUIRED TO ENTER EACH CLASSROOM.

ENUMERATOR: INVITE THE TEACHER TO DO THE MEDITATION WITH THE CHILDREN.

As part of the program, I want to mention that you are being invited to do the meditation together with your students, we believe that the program will have better results.

ENUMERATOR: INTRODUCE YOURSELF WITH THE CHILDREN BY SAYING THE FOLLOWING:

Girls and boys, I belong to the "program meditate together to eat better". DO A PAUSE TO SAY YOUR NAME. As part of this program, you will do a series of guided meditations during the following days. The meditations will be guided with an audio recording that will change every day. Your teacher will be in charge of telling you every day the right moment to do the meditation. Your teacher will play the audio. Also, he/she will ask you to do a pause, put your things away and to place yourselves in a comfortable position to start the meditation.

Thank you for your attention

ENUMERATOR: ENSURE THAT THE TEACHER HAS EVERYTHING READY AND LEAVE THE CLASSROOM BEFORE THE AUDIOS OF THE DAY ARE PLAYED.

END

Appendix 3. Survey

Name of the student:_____

Age: _____

Gender (boy/girl)_____

A snack will be given to you as a thank you token for filling in this questionnaire. The enumerator will show you the snack options that you can choose:

Which of the two snacks do you choose?

☐ Nutritious amaranth bar

☐ Chocolate bar

Please, keep your answer in secret.

Flip the paper

1. Why did you choose that snack in the previous page?

_____

2. Which of the two snacks do you think that is more filling? *(encircle the answer)*
   a. Amaranth bar b) Chocolate bar

3. Did you eat an amaranth bar last week? *(encircle the answer)*
   a. Yes b. No

4. How much do you crave the amaranth bar that the enumerator showed you? *(Cross out the answer)*

Not at all	Very little	Somewhat	Rather much	Very much
				

5. Did you eat a chocolate bar last week? *(encircle the answer)*
   a. Yes b. No

6. How much do you crave the chocolate bar that the enumerator showed you? *(Cross out the answer)*

Not at all	Very little	Somewhat	Rather much	Very much
				

7. Do you feel relaxed? *(encircle the answer)*
   a. Yes b. Sometimes c. No

8. Do you feel happy? *(encircle the answer)*
   a. Yes b. Sometimes c. No

9. How frequently do you have stomach aches? *(encircle the answer)*
   a. Never b. Sometimes c. Very frequently

10. How frequently do you eat something when you feel stressed? *(encircle the answer)*
    a. Never b. Sometimes c. Very frequently

11. Do you enjoy going to school? *(encircle the answer)*
    a. Yes b. Sometimes c. No

Many thanks? You can go for your snack when the enumerator tells you.

Appendix 4. Script for the closure of the meditation program.

INSTRUCTIONS: THE TEXT IN UPPERCASE IS INFORMATION ONLY FOR THE ENUMEARTOR. THE TEXT IN LOWERCASE ARE INSTRUCTIONS THAT ARE READ TO THE CHILDREN OR THE TEACHER. THIS SCRIPT SHOULD BE USED AFTER THE LAST MEDITATION.

4.1 FILLING OUT SURVERY

ENUMERATOR: UPON ENTERING THE CLASSROOM, ASK THE PERMISSION OF THE TEACHER TO ENTER. APPROACH THE TEACHER AND KINDLY ASK HIM/HER TO WAIT OUTSIDE OR NOT TO INTERVENE IN THAT MOMENT.

INTRODUCE YOURSELF WITH THE CHILDREN BY SAYING THE FOLLOWING:

Hello girls and boys. Today we will ask you to help us filling in a questionnaire. While answering this questionnaire keep in mind that we are not expecting right or wrong answers. We just want to know your opinion about the questions shown in the questionnaire.

ENUMERATOR: PROVIDE THE QUESTUIONNAIRES WITH THE FIRT QUESTION FACING UP AND AKS THEM TO FILL IN THE QUESTIONNAIRE WITH PENCIL. CONTINUE BY READING THE FOLLOWING:

On the first page, as you will see, you should choose one of these two snacks, which will be given to you as a thank you token for filling in the questionnaire.

ENUMERATOR: SHOW THE SNACKS. THE CHOCOLATE SNACK IS SHOWN TAKING CARE THAT THE BRAND IS NOT VISIBLE[9] (BY THE BACK). CONTINUE READING THE FOLLOWING:

Please, annotate your answer and do not share it with your classmates. After answering the question of the first page, continue on the other side of the paper.

ENUMEARTOR: GIVE A MINUTE TO ANSWER THE QUESTIONNAIRE ADN WHILE THEY ARE FILLING IN THEIR ANSWERS MENTION THE FOLLOWING:

After finishing the questionnaire, you should hand it to me, go back to your sit and wait quietly the next instruction.

ENUMERATOR: WHILE COLLECTING THE QUESTIONNAIRES IT IS NECESSARY TO CHECK THAT THE STUDENTS FILLED ALL THE QUESTIONS IN, PRINCIPALLY THE SNACK CHOICE. IF A STUDENT CHOSE AN ANSWER BY MISTAKE, ASK HIM/HER TO WRITE THE FINAL ANSWER WITH A PEN.

9 The chocolate bar was shown without the original packaging (see survey above), but the chocolate itself had the brand written on one side.

ENUMERATOR: AFTER COLLECTING ALL THE SURVEYS AND CHECKING THAT THEY ARE DUELY ANSWERED, GIVE THE FOLLOWING INSTRUCTIONS:

We will call you, one by one, in order, so that you can pick up your chosen snack outside the classroom. Again, we ask you not to share your answers. Thank you for helping us out with this activity.

4.2 SNACK COLLECTION

ENUMERATOR: HAND THE QUESTIONNAIRES TO THE TEACHER AND ASK HIM/HER TO PASS THE STUDENTS, ONE BY ONE, WITH THEIR QUESTIONNAIRE IN HAND. THE REST OF THE STUDENTS REMAIL SEATED AT THEIR DESKS (IF IT IS NOT POSSIBLE TO HAVE A LOCATION IN A BLIND SPOT FOR THE GROUP IN TURN AND OTHER GROUPS PENDING OF DOING THE QUESTIONNAIRE, IT IS POSSIBLE TO MOVE THE CHILDREN OUTSIDE TO ANOTHER LOCATION IN THE SCHOOL.

ENUMERATOR: PROCEED WITH THE FOLLOWING STEPS WITH EACH STUDENT:

1. CHECK THAT THE QUESTIONNAIRE IS COMPLETE, OTHERWISE, ASK THE SUTDENT THE PENDING QUESTIONS.

2. SHOW THE SNACKS AGAIN IN THE TRANSPARENT PACKAGING.

3. SAY THE FOLLOWING IN A *NEUTRAL MANNER:*
    a. *You chose this snack* (POINT TO THE SNACK IN TRANSPARENT PACKAGING).
    b. *I give you the chance to exchange it for this one* (POINT TO THE SNACK IN TRANSPARENT PACKAGING).
    c. *Do you keep the snack that you chose, or do you exchange it for the other one?*

4. GIVE THE SNACK CHOSEN, ASK THE STUDENT TO KEEP IT IN HIS/HER POCKET OR LUNCH BOX AND TO GO TO ANOTHER AREA OUT OF SIGHT FROM THE STUDENTS WAITING FOR THEIR TURN.

5. ONCE THE CHILD IS GONE, UNDERLINE THE LAST CHOICE WITH A PEN IN THE QUESTIONNAIRE.

6. REPEAT THE PREVIOUS STEP WITH THE NEXT STUDENT.

END

Appendix 5. Additional tables

Table 5.1
Principal components obtained to calculate the stress reduction index.

Variable	Component				
	(1)	(2)	(3)	(4)	(5)
Relaxed	**0.593**	-0.185	-0.094	-0.373	**0.683**
Happy	**0.615**	-0.105	-0.113	-0.270	-0.725
Frequency of stomach aches*	0.168	**0.703**	**0.657**	-0.214	0.018
Frequency of emotional eating*	0.244	**0.638**	**-0.626**	0.369	0.075
Enjoys going to school	0.427	-0.233	0.393	**0.779**	0.045
%Total variance	0.313	0.214	0.180	0.170	0.123

Notes: Values shown in the variables' rows are the corresponding loadings. The analysis was performed with orthogonal varimax rotation. Bold indicates the highest loading items on each component (>|0.5|). *Captures a reduction in the frequency of this condition.

Table 5.2
Probit model. Effect of meditation (marginal effects) on binary dependent variables.

Dependent variable	Time inconsistent food choices		Healthy snack choice	
	Healthy switch	Unhealthy switch	*All*	*Non health/ nutrition driven*[Ψ]
	(1)	(2)	(3)	(4)
Meditation	0.028**	0.005	0.007	0.040**
	(0.011)	(0.013)	(0.025)	(0.019)
p-value	0.015	0.713	0.782	0.037
FWER p-value	0.040	0.902	0.902	0.086
R^2	0.073	0.060	0.032	0.033

Notes: Probit estimations and observations equal to 1,432 in all columns. Standard errors clustered at the school class level shown in parentheses. [Ψ]Subsample (N=1,200) that chose their snack for reasons other than health/nutrition. * p<0.1, ** p<0.05, *** p<0.01. All regressions include controls for gender, age, mother completed tertiary education, mother's age, teacher's gender, school and grade fixed effects. * p<0.1, ** p<0.05, *** p<0.01, based on p-values shown above.

Table 5.3
Comparative of pupils that chose the healthy snack for reasons other than health/nutrition by treatment group

Variable	Meditation program		*p*-value[Y]
	Yes	No	
Consumed an amaranth snack last week (dummy)	0.27	0.26	0.865
Consumed a chocolate snack last week (dummy)	0.23	0.18	0.376
Healthy snack is the most filling (dummy)	0.79	0.86	0.192
Level of craving for the healthy snack (scale 1-5)	4.15	4.08	0.414
Level of craving for the unhealthy snack (scale 1-5)	2.94	2.96	0.871
Reason to choose the healthy snack:			
Appearance	0.01	0.00	0.235
I like it	0.58	0.54	0.556
Taste	0.23	0.28	0.437
Dietary restriction	0.02	0.01	0.508
Other	0.15	0.17	0.699
N	150	105	

Notes: [Y]If dummy variable, p-value is based on Pearson $\chi 2$ test for the independence between variables, otherwise, it is based on a t-test on equality of means between groups.

CHAPTER 6

6

General Discussion

Current diets in Mexico are far from being healthy nor sustainable (Castellanos-Gutiérrez et al., 2021). Substantial health and environmental benefits would be expected if the country transcends the latter issues, such as reductions in both total mortality rates and greenhouse-gas emissions (Willett et al., 2019). As proposed by Willet and co-authors, a diet high in whole plant-based foods (e.g., fruits, vegetables, high-fiber grains, plant-based proteins) with limited amounts of animal source foods (e.g., red and processed meats, poultry, fish) would aid to reach both health and sustainability goals. For countries such as Mexico, this implies reversing the ongoing trend towards copying the dietary pattern of high-income countries (Giuntella et al., 2020).

Multiple factors may facilitate or hinder the efforts to reach the desired dietary shift. The traditional view is that affordability, the available information and food availability are key determinants of food choice (Ford et al., 2017). Recently, other factors emerged and have gained increased popularity as drivers of food decisions, such as stress and cognitive load, which exacerbate impulsive consumer behaviours (Hunter et al., 2018; van Kleef & van Trijp, 2018; van Rongen et al., 2019). Such array of factors influencing food choice may call for a mix of tools to tackle the problem at hand. Economic instruments such as fiscal policies can make healthy foods more affordable relative to unhealthy foods, which may incentivize individuals to increase the purchases of the former and to reduce those of the latter (Afshin et al., 2017; Thow et al., 2014). Understandable nutrition information may alter attitudes and intentions towards healthier foods, but biases in consumer behavior induced by persistent stress may override its effectiveness (Just & Gabrielyan, 2018; Wilson et al., 2016). Thus, an alternative approach particularly in poverty contexts is to rather target stress directly, as a means to counteract its negative consequences on decision-making processes (Haushofer & Fehr, 2014).

Under the above-mentioned context, this thesis sought out to assess the influence of the following strategies and barrier on food choice: fiscal policies, information, poverty stress and stress reduction. Below, I provide an integrated assessment of the research questions posed in this thesis.

6.1 REVISITING THE RESEARCH QUESTIONS

The studies included in this thesis showcased that fiscal policies, information, poverty stress and stress reduction can lead to healthier (unhealthier with higher stress) and more sustainable diets. As defined in recent food systems research, a healthier diet is defined as an improvement with respect to the existing diets in the population (de Brauw et al., 2019). In the same way, more sustainable diets may mean better environmental outcomes in the food system with respect to the current situation.

Chapter 2 tried to test if fiscal policies would aid to attain an ideal healthy and sustainable dietary pattern in the coming decades. It was highlighted that attaining the intake targets of the ideal diet is only partially possible with a combination of sizeable but feasible taxes and subsidies and consumer preference changes. Further gains are expected in the environmental domain, with reduced emissions and land pressure in the food system. In other words, the mentioned strategies will not lead to the full attainment of the reference diet, but imply a substantial improvement with respect to the nutrition and environmental outcomes in a future scenario where business-as-usual conditions prevail.

The goals in chapters 3 and 4 were to determine if information and poverty stress influence the willingness to pay for healthier foods in low-income communities. The findings revealed that nutrition and health information increase healthier processed foods' valuations only among a very specific and small consumer market segment. Furthermore, poverty stress negatively affects the valuations for some of these products. Such stress does not override the effect of nutrition and health information. The same concept of reaching healthier (unhealthier) diets applies here, as the breads used as products of choice in chapters 3-4 have a better macronutrient, micronutrient and ingredients profile with respect to the default breads (e.g., white) in the market.

Chapter 5 complemented the view in chapter 2 on the role of stress by attempting to shed light on the impact of stress reduction strategies on children's food choices. The results exposed that more thoughtful food decisions among school-age children are tentatively possible through such strategies. The effect in this case was small and cannot be generalized to the whole sample, but only applies to individuals with certain characteristics, in this case, those making food selections for reasons other than health or nutrition (most of the sample). Moreover, dynamically inconsistent food choices among children were not reduced with lower stress levels, but rather increased in benefit of healthy food choices. Altogether, if students opt to eat the amaranth bars used in the study instead of a standard chocolate bar at school, their intake of sugar and saturated fat would be reduced, and their iron and calcium consumption would increase.

Potential long-term impacts of reaching healthier and more sustainable diets are foreseen in chapters 2 and 3. The findings in chapter 2 showed that the impact of such diet transition on nutrition, economy, affordability and environmental dimensions is mixed. As said before, reaching such diets is in general positive from a nutritional and environmental perspective. Yet, other environmental outcomes call for complementary actions, such as water use in the primary sectors, as the production of plant-based foods is water intensive. Also, further developments are needed to ensure positive outcomes in the economy dimension in general and in the affordability dimension for poorer populations. On the other hand, based on the considerable number of potential shoppers willing to

pay healthier processed foods' market prices, chapter 3 revealed that it may make sense from a business perspective to expand the availability of such foods to lower-income communities. Thus, it was hypothesised that once these communities are consistently exposed to such products, overtime mechanisms at the neighbourhood level (e.g., role models, social norms) may trigger a generalized consumption of these products.

There were heterogenous effects by socioeconomic background identified in most of the chapters. With regards to the likelihood of reaching the EAT reference diet with the introduction of fiscal measures, it was determined that the lowest income and rural households would be closer to the intake targets for the least healthy and sustainable food groups, than the highest income and urban households (Chapter 2). The opposite was true for the most healthy and sustainable food groups. Chapter 4's findings were suggestive that poverty concerns affect healthy foods' demand more for lower-income households more than for higher-income households. This further complicates traditional constraints on food choice, such as the affordability of healthy foods for the former households. Stress reduction strategies are more effective in reducing stress among children attending schools in lower-income areas, relative to those attending schools in higher-income areas (Chapter 5). Thus, the findings from chapters 4-5 shed light about targeting emotional well-being among individuals from low-socioeconomic status as a strategy to steer their food preferences.

6.2 CONTRIBUTION TO SCIENCE

This work as a whole has an added value for the research on food choice in terms of the diversity of methods, the populations analysed and the recommendations for the composition of future intervention strategies. Specific knowledge gaps were discussed in the context of each of the chapters. Therefore, below I intend to provide a synthesis of the contributions made in the four core chapters. Yet, some recurrence in the main contributions mentioned in each chapter is purposely made to provide an overview of the results for the readers interested in reading this chapter only.

The thesis was enriched with distinct levels of analysis of the development problem at hand, which complemented each other. Chapter 2 provides an assessment at the country level and for aggregated sets of households, which offers a full panorama of the possibilities of reaching healthy and environmentally sustainable diets. The modelling exercise in the mentioned chapter revealed that substantial population-wide behaviour changes are key to reach such diets, but specific policies on that strand of strategies were not modelled. The latter gap was partially addressed in chapters 3 and 5, where the role of information and stress reduction strategies on adult consumers was examined, with the added value

of testing actual consumer behaviour, as compared to the simulation performed in chapter 2. Furthermore, the age profile of the samples employed was diversified with an experiment at primary schools (chapter 5). Chapters 4 and 5 complemented each other and enriched the discussion on the role of stress by providing a view of both its negative consequences and the benefits of counteracting its effects on food choice.

There are a number of contributions in context of lower-income populations and developing country contexts. First, past evidence has shown that affordability of healthy and sustainable diets seems to be ensured for the average citizen in upper-middle income countries like Mexico (Castellanos-Gutiérrez et al., 2021; Springmann et al., 2021). Yet, it was shown here that for individuals in the base of the pyramid, affordability would be compromised in the future (Chapter 2). This matches the findings based on the current costs of diets (Hirvonen et al., 2020).

Second, it is shown that there is a profitable market for some healthy processed foods in lower-income areas, which to date was only identified for less processed, staple foods in lower-income countries and for similar processed foods in higher-income countries (Chege et al., 2019; Teuber et al., 2016). Within the same low-income areas, educating consumers is a valuable strategy only for certain individuals. This is in line with the consumer behaviour and behavioural economics literatures, which have recently questioned the overall effectiveness of information as an instrument to change food choice (Bauer & Reisch, 2019; Just et al., 2016).

Third, it was highlighted that living in persistent financial stress does not only induces biases on economic decision making, but also negatively biases decisions about buying healthy foods. This has been only previously proposed and indirectly tested in research with different objectives (Huijsmans et al., 2019; Kremer et al., 2019; Schofield & Venkataramani, 2021). Thus, on top of standard affordability constraints, there is an additional effect driven by high levels of stress, which furtherly pushes down the willingness to pay for healthy foods among lower-income individuals.

Fourth, emotion regulation techniques are highly effective to reduce stress among children attending schools in lower-income areas, which tentatively benefits their food choices. To our knowledge, this mechanism has not been studied in behavioral economics research at school settings (Madden et al., 2017). Following recent evidence using similar techniques, it was shown that shaping emotion regulation towards the specific outcome of interest has an added value in terms of the intended impact (Haushofer et al., 2021).

Fifth, this thesis had some novelties in a developing country context. The detailed exercise in chapter 2 is the first of its kind for a single country in the mentioned regional context.

Likewise, the type of experimental products (e.g., highly processed foods) used in chapters 3-4 were employed for the first time in a willingness to pay experiment in a developing country. School interventions in general and the type of intervention particularly used here (Chapter 5) are scarce in the same regions.

The joint contribution of all chapters calls for integrated approaches to tackle the predominantly unhealthy food decisions in the population. There are limits to the implementation of isolated strategies (Vellinga et al., 2022). Sizeable taxes and subsidies would not suffice to reach an ideal diet and would not aid individuals from distinct income levels equally to attain such diet. Nutrition information is effective only for small market segments. Stress-reduction strategies are only effective for less health conscious individuals. Similarly, strategies focusing on emotions seem to have significative, yet small impacts on food choice.

On the other hand, this work provides an interesting combination of self- and other-deployed strategies. In the light of the existing dichotomy between both types of strategies in the literature, the findings in this thesis support the notion that a mix rather than relying only on one type of strategy is likely more effective to improve food choices (Duckworth et al., 2018; Marette et al., 2016). For instance, taxes may serve as incentives to reduce unhealthy consumption, but without a deliberate, conscious awareness on the consumer side, such policies may still lead to unhealthy selections due to psychological reactance to forceful policies or substitution effects towards other unhealthy products (Just & Gabrielyan, 2018; Prina & Royer, 2014). The need to understand reactance has been flagged previously in the eating behaviours literature, as this psychological phenomenon has been already identified in other contexts such as authoritative regulations to discourage graffiti in public spaces (Schwartz et al., 2017).

Complementarily, dual-decision models would prescribe other-deployed policies such as selectively constraining the availability of unhealthy foods, as a means of a “time price”, which counteracts the dominance of the impulsive affective system (Ruhm, 2012). In parallel, equipping consumers with self-deployed tools to improve self-control, such as meditation, may diminish the reliance on such paternalistic approaches, which are subject to biases on policy decision-making linked to conflicts of interest, political views or imperfect foresight about citizens preferences (Marette et al., 2016). Altogether, the previous insights are in line with behavioural models, which call to enrich the universe of tools with a common goal to change consumer behaviour, as individuals tend to display heterogenous responses to the different strategies (Just & Gabrielyan, 2016).

In a similar vein, chapters 4 and 5 expanded the menu of existing mechanisms and tools employed in the behavioural economics research on food choices. So far the

main frameworks in the food choice domain and another domains analysed in the field is overly focused on the role of cognitive load as a factor that affects decision making (Carroll et al., 2018; Lichand & Mani, 2020). Chapter 4 showed the influence of stress on purchasing decisions of healthy foods, whereas chapter 5 proposed a tool to deal with this issue. Likewise, the menu of employed strategies to steer food choice behaviours seems to rely mainly on changing the choice architecture or incentives (Belot et al., 2016; List & Samek, 2015; Madden et al., 2017). Particularly, the use of the former instrument raises ethical concerns as consumers are typically unaware of them being guided to make specific choices and rely on the willingness of retailers to rearrange their shops. In this sense, self-deployed strategies as analysed chapter 5, may work as subtle "self-nudges" that give sufficient autonomy to individuals to design and structure their own decision environments, regardless of their external food environment (Reijula & Hertwig, 2022).

6.3 POLICY IMPLICATIONS

The conclusions addressed above support the notion that multipronged, mutually reinforcing polices are needed to leapfrog along the nutrition transition to reach its desired last stage (Popkin & Ng, 2021). In this sense, it is likely that that a mix of comprehensive fiscal policies and widespread consumer awareness would create positive synergies, which may result in the need for smaller taxes/subsidies and less policy efforts than foreseen here to reach dietary and environmental goals (Barigozzi & Villeneuve, 2006; Licari & Meier, 2000; Mason-D'Croz et al., 2019; van Ham et al., 2018). This may require a substantial redesign of the existing nutrition policies to incorporate the environmental dimension, as to date Mexico has only addressed the triple burden of malnutrition. New dietary guidelines tailored towards reaching health and environmental outcomes are hardly needed, while the menus at schools and worksite cafeterias might be aligned with the new guidelines (Schwartz et al., 2017). If the balance in government's revenues and expenses originated from the combined taxes and subsidies implemented is positive, the remanent may be redirected in the form of cash transfers to low-income populations to enable additional purchases of healthy foods.

Nation-wide programs to reduce stress since early stages in life may overcome some of the barriers to the expression of healthy preferences and shape the healthiness of the food supply. It is unclear from chapter 5's findings, but it is possible that long-term exposure to such strategies may lead to healthy habits formation, as individuals may be more concerned about long-term health outcomes. What is clear from the mentioned chapter is that such policies may effectively target a majority of less health conscious individuals, which compared to more health conscious individuals, are usually less responsive to instruments that improve self-control (Sadoff et al., 2020). Furthermore,

stress plays a key role in driving affective motivations towards unhealthy foods, an aspect that has been suggested to incentivize food processors to engineer foods to trigger such consumer motivations towards fattier, sweeter and saltier products (Ruhm, 2012). Thus, by overriding these mechanisms there would be fewer incentives to produce them in such a way.

No single actor will be able to create healthy food choice environments (Schwartz et al., 2017). The involvement of food companies is key in this process of diet transition, as the industry has traditionally put up obstacles to radically transform the food system (Popkin & Ng, 2021). They would need to realize the business opportunities of a radical reconversion towards a widespread availability of healthy foods, particularly in lower-income communities. The findings provided here showed that such consumers have to deal with continuous financial worries, which induces biases in their purchasing behaviour. Evidence from the behavioural economics field can inform about viable strategies to guide such consumers to increase their purchases of nutrient-dense foods, while actually keeping profits untouched (Carroll & Samek, 2018; Just & Gabrielyan, 2018; Schwartz et al., 2017). The bar is quite high in terms of the efforts required from other parties such as policy makers, because food marketers have heavily marketed sugary beverages, candy, fast food, sweets and snacks for decades. As a result, the government is urged to leverage on similar marketing strategies to deliver a dramatic change in consumer behaviour towards the healthy side of the story (Schwartz et al., 2017).

The efforts to change food consumption at population level are not much different from the long-term fight against smoking (Mason-D'Croz et al., 2019; Willett et al., 2019). Although these have not been fully effective, based on that experience it is clear that a mix of evidence dissemination, education programmes, fiscal measures and invasive marketing may aid to reach a certain degree of success. Particularly pricing strategies have been shown to be the most effective strategy to reduce tobacco consumption in the past decades (Mercer et al., 2003). After many years of the implementation of a blend of the mentioned strategies, some social norms such as smoking-free areas are now widespread globally (Schwartz et al., 2017). As posited by Schwartz and co-authors, it may take an indefinite amount of time to realize similar examples in the food domain, such as healthy default side dishes in fast food chains or healthy and sustainable menus offered in school food environments.

6.4 LIMITATIONS AND FUTURE RESEARCH

A number of aspects may aid to have a more nuanced analysis in this study, which opens the door for future research to address them. First, although some sustainability outcomes

were observed at the country level, there were no specific targets to aim for, which complicates providing an overall assessment of this dimension. Second, the sustainability aspect of diets is only addressed in one of the chapters, so there is no output from this study at other levels of analysis to enrich the discussion about possibilities to improve environmental outcomes through better diets. The mentioned aspects are relevant, as Latin American countries may have the largest environmental gains in the world if healthy and sustainable diets are achieved (Philippidis et al., 2021). Third, as mentioned above, in chapter 2 we modelled an artificial change in consumer preferences, but the specific policies that can lead to such change were not particularly modelled, which prevents more substantiated policy recommendations. Fourth, research on the welfare implications of the fiscal measures to attain healthy and sustainable diets is warranted. There may be concerns in terms of income regressivity, but previous evidence has shown that in the long-term, taxes on unhealthy foods have been shown to be progressive once the effects on health are taken into consideration (Härkänen et al., 2014; Popkin & Ng, 2021).

There were also some methodological and relevance constraints. First, the results from the field experiments in chapters 3-5 cannot be generalized to the respective populations analysed, as the samples used were not randomly drawn. Similarly, food purchases may vary depending on the existing economic conditions in a given period, which may have implications for the results obtained depending on the year of the survey employed (Valero-Gil & Valero, 2018). Thus, the generalization of those results can only be tested by replicating the studies in other contexts and years, respectively. Second, the effect sizes in the experiments on the role of stress were deemed as small, which has implications for the relevance of the strategies researched. Yet, the aggregate effect of stress on food purchasing decisions is unclear, which matters as individuals make on average around 200-300 food-related decisions per day (Just & Gabrielyan, 2016). Third, the potential to meaningfully regulate affective influences on food choices *via* long-term exposure to meditation is also unclear. Therefore, more work must be done to shed some light about those aggregate effects to clearly put into perspective the overall effect of stress on food decisions. Fourth, chapters 3-5 lacked additional experimental products and treatment groups. Chapters 3-4 would be enriched by a comparison of the effects on unhealthy products. A larger sample would enable to include an additional "pure" control group to disentangle the effects of information and meditation.

The field experiments increased our understanding about individuals' preferences, but did not provide specific insights at the household level nor potential unintended consequences. It is unclear how other household members would influence the willingness to pay for healthy processed foods, as well as the role of parents on children's food choices. In the first case, it is very likely that as the primary shoppers in the household, the participants may contemplate the preferences of other household members; while to a lower extent

children may influence purchases within the household. Furthermore, results in terms of changes in overall consumption were not provided, which may have actually change as a result of the experiments. This is relevant, as the existing evidence on compensatory behaviors is not conclusive (Schwartz et al., 2017). Individuals that received the healthy bread in our experiment in Mexico City may opt to buy another low-fiber products afterwards, as they would not need to buy a default package bread anymore, which is low in fiber content. Also, children choosing the amaranth bar in Oaxaca City may ask their parents to buy them an unhealthy snack after school, as they are already had a healthy snack during the experiment. Hence, future research may factor in the existence of compensatory behaviors, as well as the influence of the exposure of the whole household to new healthy products and parents to meditation on willingness to pay and students' food selections, respectively.

6.5 CONCLUDING REMARKS

Mexico is well-known for its long-term policy efforts to counteract the negative effects of unhealthy diets on the population. More decisive steps need to be taken to fully achieve this goal, as well as to integrate the environmental repercussions of the existing food systems. Altogether, this thesis showcased that a combination of strong fiscal policies, personalized information and stress reduction among school-age children may get Mexico closer to healthy and environmentally sustainable diets. A striking conclusion is that policies geared towards changing consumer preferences hold more promise than paternalistic strategies such as fiscal policies. In a complementary manner, a synergistic policy perspective is needed to fully attain the goals in the health and environmental dimensions, one that puts agency regulators, food industry and consumers on the same page.

There are a number of overall directions in which to further expand upon the framework presented here. Regarding the attainment of an ideal diet at population level, there is a need to shed light on strategies to deal with parallel aspects, such as the economic repercussions to producers with a reduced production of animal source foods. Perhaps, long-term natural experiments among large samples of communities would be needed to increase our understanding of the role of stress and strategies to reduce it on daily live food choices. Similar research efforts may also provide input on the neighbourhood effects of equating the availability of healthier processed foods between low- and high-income communities.

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ENGLISH SUMMARY

This thesis assesses the effect of fiscal policies, information, poverty stress and stress reduction strategies on the likelihood of reaching healthy and sustainable diets in Mexico. Mexico is a prime example of a nation in the nutrition transition, as diet-related non-communicable diseases emerged there earlier than in most of the regions with a similar economic development. This research comprised two field experiments among adults and children, as well as a long-term simulation exercise at the national level. From a food systems perspective, the analysis focuses on the interaction between consumer behavior and the characteristics of the food environment.

The first chapter presents the background of this research, which revolves around the impact of diets on health and environmental outcomes. Furthermore, in this section I describe how food choices are shaped by multiple factors, which are classified in this thesis as traditional and emerging. This chapter also presents the guiding research questions, which are linked to the strategies and barrier analysed here. The specific research questions are the following: What is the impact of the adoption of a healthy and sustainable diet at population level? Do fiscal policies enable households from different income levels and regions to reach such diet? (Chapter 2); What is the potential demand for healthier foods in low-income communities? Does information increase the willingness to pay for healthier foods in such communities? (Chapter 3); Does poverty-related stress reduce the potential demand for healthier foods in low-income communities? (Chapters 4); Do stress reduction strategies improve food choice of school-age children? Do the same strategies reduce the likelihood of dynamically inconsistent food choices? (Chapter 5). Finally, the introduction chapter discusses the key debates addressed here and describes the main methods used to give an answer to the research questions.

Chapter 2 presents a simulation exercise towards 2050 to determine the impact of reaching a healthy and sustainable diet at population level on several food systems indicators. It also provides a scenario where comprehensive taxes and subsidies are imposed in the model to assess the chances to reach such diet. I employed a global computable general equilibrium model (i.e., macro level) and different demand system models with disaggregated household groups (i.e., micro level) for this modelling exercise. The results showed that feasible fiscal policies alone are insufficient to attain the desired dietary shift. Further developments at the consumer level are paramount to fully attain such healthy and sustainable diet. In any case, subsidies to some healthy foods such as fruits, vegetables and added-fats are strongly recommended for the lower-income households. Likewise, taxes are warranted for unhealthy foods particularly for the higher-income households. In terms of the impact of reaching this diet through fiscal policies, predominately positive effects are expected in the nutrition and environmental domains. On the other hand,

such diets would be affordable in the future for the average household but would remain unaffordable for the those in the bottom income categories. At the same time, the dietary transition would result in an economic contraction of the agri-food sector in general.

Chapters 3 and 4 are based on a field experiment executed in low-income communities of Mexico City. Their objectives were to determine the impact of information strategies and poverty stress on the demand for healthier processed foods. Both studies employed a BDM mechanism to measure the willingness to pay for such foods. In the third chapter, it was determined that there is an untapped market potential for healthier processed foods in these communities. Furthermore, nutrition and health information would increase the willingness to pay for such foods only among specific market segments. Other business strategies to market these products in low-income contexts are detailed in the chapter. In the fourth section, the findings suggested that poverty concerns marginally reduce the willingness to pay for the same food products only for certain variants of these processed foods. The described effect was mediated by increased stress among the adult participants. The same effect did not differ by the income level of the participants.

In Chapter 5, I was interested in investigating the possibilities to improve food choice among children *via* meditation practices. A school intervention was deployed in nearly 30 primary schools in the south of Mexico to test the established hypotheses. Meditation effectively leads to reduced stress levels among children. In general, it was determined that meditation does not lead to more deliberate food choices. An exploratory analysis showed that such practices improve food choices only among certain segments of students. I also tested if meditation has an effect on the consistency of food choices (i.e., violations of revealed preferences). The results suggested that meditation increases dynamically inconsistent food choices in the direction of more healthy foods. Indeed, when given the chance to exchange an already chosen unhealthy snack at another point in time, the students that practiced meditation were more likely to change it for a healthy snack than those who did not meditate. The opposite was not true in the direction of the unhealthy food choice.

In Chapter 6, I provide an integrated assessment of the findings in chapter 2-5. Specific contributions to the literature are discussed in this section, such as a rich set of strategies to tackle unhealthy consumption at the national, household and individual levels of analysis. Altogether, the core chapters are in sync with the notion that integrated approaches are needed to deviate from the existing unhealthy dietary patterns. This section also suggests some policy implications, which call for a radical redesign of the current nutrition policies in Mexico. This concluding chapter also describes some important limitations, for instance, in terms of the generalization of the results and the effect sizes estimated in the field experiments. At the same time, I present some extensions regarding future research

directions, such as deepening our understanding about the potential effect of exposing parents to meditation on their children's food choices at school.

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The seminal idea behind doing a PhD was combining my passion for promoting healthier lifestyles with my skills on the academic side. I feel accomplished by the products developed (i.e., papers) and the experiences gained during the achievement of this goal. The two fieldworks in Mexico and a comprehensive simulation exercise aided me to grow personally and to furtherly polish my skills. Undoubtedly, these outcomes would not be possible without the people that surrounded me over the past five years.

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a few trips together, such as Jamleck, Solomon, Lan, Astrid, Yeshi, Daniel, Farzana, Fan, Jose David, Emmanuel and Chen. The members of the DEC staff have boosted my time at DEC, which includes Erwin, Francesco, Maarten, Janneke, Robert and Nico. I was also fortunate to meet people from other research groups, such as Carlos, Alessandro, Dusan and Muyinatu. Special thanks go to Dineke, who totally supported all my research process and shared her thoughts about the existing issues in the world. The last stretch of the PhD has been enhanced by the presence of my new colleagues at WEcR's MAGNET team, who have welcomed and supported me to further explore my potential in the topics that I like.

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AUTHOR PROFILE

Marcos E. Dominguez Viera was born in Monterrey (Mexico) on May 29th, 1985. He completed a bachelor's and master's degrees in Economics at the *Universidad Autonoma de Nuevo Leon* and the University of Essex in Mexico and the United Kingdom, respectively. His research during those studies was awarded with several prizes at the local and national levels. Regarding his work experience, he had roles in the Governments of Nuevo Leon (State) and Monterrey (Municipality), where his main duties were related to monitoring, evaluation, and accountability processes. From 2018 to 2022 he completed a PhD in Development Economics in the Netherlands. His main research area is about the mechanisms to reach healthy and sustainable diets. Personally speaking, he is a happy husband and dad of a 4-year old daughter and a 10 month old son. Marcos is passionate about having a healthy lifestyle, which involves triathlon, a plant-based diet and cold water immersion. Currently, he works as researcher at Wageningen Economic Research's MAGNET team.

Marcos Esau Dominguez Viera
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Wageningen School of Social Sciences

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
WASS Introduction Course	WASS	2018	1
Writing the research proposal	WUR	2018	3
Research Data Management	WGS	2019	0.45
'Healing myopic eating behaviours: Emotional eating and incentives to eat fruits at schools in Mexico'	Health Economics Workshop, WUR and Erasmus University Rotterdam, Wageningen	2018	1
'Transcending obesity: The role of poverty psychology on the demand for healthy foods'	Amsterdam Institute for Global Health and Development' Master Class 2020, Virtual	2020	1
'Consumer demand for healthier bread in peri-urban Mexico City'	CIMMYT Webinar Series, Virtual	2020	1
'Influence of poverty concerns on the demand for healthier foods'	German Development Economics Conference 2021, Virtual	2021	1
'Economic pathways to affordable and culturally acceptable healthy diets in Mexico'	Internal Economics Seminar, WUR, Wageningen	2021	1
A2 Integrating research in the corresponding discipline			
Advanced Microeconomics (ECH-32306)	WUR	2018	6
Advanced Behavioural Economic Theory	WASS	2018	4
GTAP for Computable General Equilibrium Modelling	GTAP-Purdue University	2021	3
Global Change and the Challenge of Sustainably Feeding a Growing Planet	WASS Summer school	2022	1.5
B) General research related competences			
B1 Placing research in a broader scientific context			
Ethics for Social Sciences Research	WGS	2019	0.5
Impact Assessment of Policies and Programmes (DEC-32806)	WUR	2019	6
B2 Placing research in a societal context			
Writing a blog in Food & Nutrition	WUR	2020	0.3
Managing a Health and Nutrition Podcast	Personal	2020-21	1

C) Career related competences/personal development **C1 Employing transferable skills in different domains/careers**			
Project and Time Management	WGS	2018	1.5
Brain Training	WGS	2018	0.3
Entrepreneurship in and outside Science	WGS	2020	1.1
Teaching assistant - Methodology for Field Research in the Social Sciences (SDC-21306 and SDC-33306)	WUR	2020	2
Total			**37.7**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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