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Impact of healthy and sustainable diets on the mortality burden from cardiometabolic diseases and colorectal cancer in Mexican adults: a modeling study

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Abstract

Background Healthy and sustainable diets (HSDs) have been associated with reduced mortality from chronic diseases, particularly in high-income countries. However, evidence from Mexico is limited, and no study has assessed the potential impact on mortality of adopting different HSD scenarios. This study aimed to assess the impact of various HSD scenarios on the mortality burden from cardiometabolic diseases and colorectal cancer (CRC) in Mexican adults.

Methods Using a comparative risk assessment model, we examined six HSD scenarios: Mexican Healthy and Sustainable Dietary Guidelines 2023 (MHSDG), EAT-Lancet healthy reference diet (EAT-HRD) and its Mexican adaptation (EAT-HRD-Mx), vegan, vegetarian, and pescatarian diets, compared with the current diet. Disease-related relative risks for food groups were derived from dose-response meta-analyses. The current diet was based on 24-hour dietary recall data from the Mexican National Health and Nutrition Survey (ENSANUT) 2016. HSDs were simulated following intake recommendations for each scenario and the current intake distribution from ENSANUT. Mortality data from type 2 diabetes (T2D), cardiovascular disease (CVD), cerebrovascular disease (CeVD), and CRC were sourced from the 2016 Mexican National Institute of Statistics and Geography (INEGI). Premature deaths were defined as those between 20 and 75 years of age. Years of life lost were estimated by multiplying age-specific deaths by life expectancy. Averted deaths were estimated using potential impact fractions, with 95% uncertainty intervals (UI) derived through bootstrapping.

Results Compared with current diets, the HSD scenarios led to reductions in premature (25.1–30.5%) and total (26.6–33.1%) mortality, with greater reductions associated with vegan diets. The MHSDG ranked third with 29·6% of the premature deaths averted (42,470; 95%UI 39,940–45,045) and 31.9% of total deaths (89,337; 95%UI 84,446–94,244). A vegan diet could lead to a major reduction in CVD deaths (62,290; 95%UI 60,271–64,321), whereas pescatarian diets resulted in the highest number of avoided deaths from CeVD (9,791; 95% UI 9,243–10,340). The EAT-HRD was associated with greater reductions in T2D deaths (23,793; 95%UI 21,733–25,859) and CRC (941; 95% UI 838–1,046).

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Increased consumption of plant-based foods and reduced intake of red meat and sugar-sweetened beverages were the primary contributors to lower mortality rates.

Conclusions These findings support the implementation of policies promoting HSDs in Mexico to reduce the burden of cardiometabolic and CRC mortality. Particularly, the MHSDG is a relevant strategy due to its food-system approach, local applicability and cultural alignment.

Keywords Sustainable diets, Mortality, Cardiometabolic diseases, Colorectal cancer, Plant-based diets, Dietary guidelines, Cardiovascular disease, Cerebrovascular disease, Diabetes

Introduction

The increasing prevalence of obesity has become a major global public health concern over the past three decades, leading to a growing burden of chronic diseases, especially in low- and middle-income countries [1]. Dietary patterns characterized by a high intake of energy-dense, nutrient-poor foods that are rich in sugars, fat, and sodium (most of which are ultra-processed foods (UPFs)) [2], along with the excessive inclusion of animal-based foods, including red and processed meats, and a low intake of fruits, vegetables, or whole grains, are associated with an increased risk of cardiovascular disease (CVD) [2, 3], cerebrovascular disease (CeVD) [4], type 2 diabetes (T2D) [5], and malignant tumors such as colorectal cancer (CRC) [6]. Additionally, these dietary patterns have a significant environmental impact [7, 8]. By 2017, such dietary risks contributed to 11 million global deaths, nearly 255 million disability-adjusted life years (DALYs), and approximately 155 million years of life lost (YLLs) due to premature death compared with the potential life span of a population [9, 10].

In Mexico, the consumption of UPF and sugar-sweetened beverages (SSB) accounts for nearly 26% of total energy intake [11], while the intake of fruits, vegetables, and legumes remains below recommended levels for a healthy diet [12]. These dietary patterns have contributed to a high prevalence of obesity and T2D, affecting 37.1% and 18.3% of adults, respectively, during the 2020–2023 period [13, 14]. Additionally, diet-related chronic diseases such as CVD, T2D, and cancers were the leading causes of mortality and disability in the country, representing 68% of DALYs and 75% of the mortality burden as of 2013 [15]. Healthy and sustainable diets (HSDs) have been proposed to address malnutrition while fostering a sustainable food system [16]. HSDs are low-environmental-impact diets that promote food and nutritional security for present and future generations; they are affordable, nutritionally adequate, socially acceptable, and environmentally friendly [16–18]. One popular approach to HSD is the flexitarian diet, which encourages a transition toward plant-based foods and a reduction in the consumption of animal-based foods. This aligns with the principles outlined by the EAT-Lancet Commission, which published a universal framework in 2019 for a healthy reference diet (EAT-HRD) within a sustainable food production system based on scientific targets for environmental sustainability and human health [19].

Several studies have shown the significant health and environmental benefits of HSDs featuring lower or no animal-based food consumption, such as flexitarian, vegan, vegetarian, or pescatarian diets [20–22]. A global simulation study estimated that adopting flexitarian or vegan diets could reduce premature mortality from chronic diseases by 19–22% by 2050, being more pronounced in high-income countries [20]. Similarly, adhering to the EAT-HRD could lead to a reduction in premature deaths of 19.7% worldwide, whereas following national food-based dietary guidelines may reduce premature mortality by 15% [21].

Mexico has proven to be strongly committed to promoting HSDs, as reflected in various publications of dietary recommendations firmly grounded in the EAT-HRD approach. For example, the reference diet known as EAT-HRD-Mex stands out as a key contribution that has been carefully tailored to suit the specific context of Mexico [23] and has served as a basis for the development of the recent Mexican Healthy and Sustainable Dietary Guidelines 2023 (MHSDG) [24]. However, there is still a significant gap in the understanding of the potential health benefits and effects of HSDs on mortality compared with those of the current diet. Furthermore, research on the mortality burden associated with plant-based alternatives such as vegan, vegetarian, or pescatarian diets, supported by country-specific diet and mortality data, has yet to be thoroughly explored in low- and middle-income countries such as Mexico. Therefore, this study aimed to estimate the mortality burden (total deaths, premature deaths, and YLL) of cardiometabolic diseases (CVD, T2D, and CeVD) and CRC associated with the consumption of different HSD scenarios compared with the current diet among Mexican adults. This approach is crucial for providing valuable evidence for implementing strategies and policies to foster the adoption of HSDs and for future updates of dietary guidelines, considering major contributions to preventing premature mortality from diet-related diseases in Mexico.

Methods

Study design and population

We conducted a modeling study to estimate the impact of different HSD scenarios on the mortality burden from cardiometabolic diseases and CRC among Mexican adults aged > 20. The analysis was based on a Comparative Risk Assessment framework, which evaluates changes in population health resulting from modifying the distribution of exposure to one or more risk factors [25]. In this case, we estimated the mortality burden attributable to specific food groups by comparing the observed distribution (current diet) with counterfactual distributions aligned with recommendations from different HSDs, using Potential Impact Fractions (PIFs) to quantify the proportion of avoidable deaths under each scenario. This study focused on CVD, CeVD, T2D, and CRC because of the convincing evidence of their association with specific food consumption [26, 27] and the high morbidity and mortality rates they represent in the country's adult population [15]. CRC was specifically chosen because substantial evidence links it to dietary factors [28]. Other types of cancer (e.g., breast cancer and stomach cancer) were previously considered, but evidence of their relationship with the consumption of diverse food groups was weak or scarce.

Dietary information

Current diet and food groups

Dietary information was obtained for 1421 Mexican adults (> 20 years) who participated in the Mexican National Health and Nutrition Survey (ENSANUT 2016), a nationally representative probabilistic multistage stratified cluster survey that was carried out between May and October 2016 [29]. A five-step 24-hour dietary recall (24 HR) questionnaire administered by trained and standardized personnel was used [30]. For the analysis, 51 pregnant women and 33 adults with implausible consumption values were excluded. The latter was determined by calculating the ratio between daily energy intake (EI) and the estimated energy requirement (EER) for each individual on a logarithmic scale and removing values above 3 standard deviations. The EER was estimated using equations from the Institute of Medicine (IOM) [31], and included age, weight, height, and physical activity level variables. Specifically, a low physical activity level was applied for men, and a sedentary level was applied for women [32]. Log-transformation of the ratio allows for a more symmetric distribution and facilitates the removal of extreme values. This approach has been previously applied in studies using ENSANUT 2012 and 2016 dietary data to ensure consistency in sample quality and comparability across analyses [33, 34]. The final analytical sample included 1337 individuals aged > 20 years. Further details about the 24 HR adapted method and the data-cleaning procedure can be found elsewhere [33–35].

For this analysis, we selected ten food groups based on the level of evidence for their association with morbidity/mortality from cardiometabolic disease and CRC (see the mortality burden section and Additional file 1: Table S1) [27]. We included fruits, vegetables, whole grains, legumes, nuts, red meats, processed meats, fish, SSB, and UPF. However, UPF was included in a sensitivity analysis due to variations in exposure definitions across studies [4, 36]. From these ten groups, we obtained the total consumption (grams/day) using the previously estimated net grams consumed, which considers the edible portion factor and the density factors for beverages to convert their volume in milliliters into grams. We also calculated energy intake (kcal/day) using the 18.1.1 version of the BAM (Mexican Food Database) [37]. We used the mean consumption and energy obtained in each group. Additionally, we estimated the consumption of refined grains, tubers, poultry, and other foods; eggs; dairy fats; and oils; however, these food groups were not considered in the analysis owing to the low-level evidence of their association with specific mortality from cardiometabolic diseases and CRC [38–40]. Although there is evidence of significant associations between dairy consumption and T2D and CRC incidence or mortality [26, 27], dairy foods were excluded from the analysis due to residual confounding by other dietary factors, such as red and processed meat, as highlighted meta-analyses by Aune et al. (2012, 2013) [38, 39]. Moreover, other studies have reported substantial heterogeneity in the associations between dairy consumption and health outcomes, particularly due to differences in the type of dairy foods consumed, further complicating their inclusion in the current analysis [40, 41]. The classification of food groups is provided in Additional file 1: Table S2.

Healthy and sustainable diet scenarios (HSDs)

We evaluated six HSD scenarios, four associated with international dietary recommendations, including a flexitarian diet as proposed by the EAT-Lancet (EAT-HRD) [19]; plant-based scenarios, including vegetarian, vegan, and pescatarian diets associated with reduced mortality in previous modeling studies [20, 21]; and two scenarios for specific dietary recommendations in Mexico, which included the EAT-HRD-Mex [23] and the MHSDG 2023 [24]. A brief description of each scenario is provided in Table 1.

Each food group's recommended grams and kcal were adjusted to 1990 kcal, reflecting the EER for healthy adults in Mexico. This estimate was calculated using adapted equations from the IOM [31], incorporating average adult height in Mexico and a reference weight based on a normal BMI (22 kg/m^2), assuming low or

Table 1 Description of healthy and sustainable dietary scenarios (HSDs)

HSDs scenarios	Description
2023 MHSDG	The guidelines were designed to improve the population's dietary habits by addressing public health and nutrition priorities. They consider sustainability dimensions such as environmental impact, cultural relevance, and affordability. Based on the EAT-HRD-Mex, the guidelines focus on making plausible short- and medium-term changes to promote sustainable eating patterns and completely exclude SSBs and UPFs (only keeping sweeteners) from the diet. The methodology for estimating portion sizes of food groups for the population (> 5 years) followed an eight-step process: (1) reviewing international dietary guidelines; (2) selecting reference age groups for dietary estimates; (3) estimating energy and nutrient requirements; (4) selecting and adapting food groups from the EAT-HRD and EAT-HRD-Mex diets; (5) creating a food composition database based on ENSANUT 2016 data (sentinel foods were identified for reference in each group); (6) estimating specific food quantities and servings (grams were calculated, and portion sizes were adjusted based on sentinel foods for each group); (7) ensuring compliance with nutritional criteria; and (8) calculating the number of portions per food group. For this scenario, we averaged the recommendations for daily adult consumption by age and sex, as proposed by MHSDG [24], along with the kcals per food group and the whole diet adjusted to 1990 kcal. MHSDG grouped cereals, grains, and tubers into one food category. Therefore, we assumed that all recommendations for this group refer to whole grains as promoted in the guidelines. Additionally, we grouped the quantities of beef and other red meats into one group because they are presented separately in the MHSDG.
EAT-HRD	The flexitarian scenario (EAT-HRD) was based on the criteria set by the EAT-Lancet Commission for a planetary health diet [19]. In this diet, half of the plate consists of vegetables and fruits, while the other half includes whole grains, sources of plant-based proteins such as legumes and nuts, unsaturated vegetable oils, and optional moderate amounts of animal-based proteins such as meats, fish, and dairy products. Recommendations are presented as scientific targets for a diet with possible ranges for an intake of 2500 kcal/day. Energy and food group consumption in EAT-HRD are presented as averages; thus, we adjusted the proposed average kcal intake of the total diet to 1990 kcal. Then, we calculated the corresponding grams, adjusting consumption to the obtained kcal for each food group. All food groups were maintained as presented in the EAT-Lancet report, including all grains as whole.
EAT-HRD-Mex	The diet incorporates the recommendations for a healthy diet from the EAT-HRD, tailored specifically for the Mexican population as Castellanos et al. (2020) suggested [23]. The adaptation involved adjusting the quantities of food groups better to reflect the current eating habits of the population. This allows for the inclusion of small amounts of food groups that were not part of the original EAT-HRD but are commonly consumed in Mexico, such as grains with added sugar or saturated fats, dairy with added sugar, confectionery and desserts, and SSB. The average daily calorie intake recommended in the EAT-HRD-Mex diet was initially estimated at 1947 kcal and was adjusted to 1990 kcal. Subsequently, the corresponding grams for each food group were calculated to match the revised calorie intake. To align with the EAT-HRD, reducing the intake of all added sugars by 60% is suggested, while allowing sweeteners within the EAT-HRD limit (< 5% kcal or 93 kcal). This allowance is distributed between homemade sweeteners and processed foods that contain sweeteners and desserts, as well as SSB. In our analysis, the food groups were largely maintained as described in the recommendations, except added sugars, renamed UPFs, where the guidance for sweeteners and cereals containing added sugar and fat was consolidated, while SSBs were categorized separately.
Vegan	This diet was based on the recommendations of the EAT-HRD-Mex [23], considering that they provide more aligned recommendations with the planetary diet adapted to the Mexican context. It does not include animal products such as meat, poultry, fish, eggs, or dairy. To obtain the final recommendations, we used the kcal intake (1990 kcal) and replaced 2/3 of the kcal from animal-based foods with plant-based proteins and 1/3 with fruits and vegetables, according to proposals in other global studies [20, 21].
Vegetarian	This diet was based on the recommendations of the EAT-HRD-Mex [23], considering that they provide more aligned recommendations with the planetary diet adapted to the Mexican context. It does not include animal products such as meat, poultry, or fish, but includes dairy and eggs. To obtain the final recommendations, we used the kcal intake (1990 kcal) and replaced 2/3 of the kcal from animal-based foods, including meats (poultry, pork, beef, fish) with plant-based proteins (legumes, nuts, and seeds) and 1/3 with fruits and vegetables, according to proposals in other global studies [20, 21].
Pescatarian	This diet was based on the recommendations of the EAT-HRD-Mex [23], considering that they provide more aligned recommendations with the planetary diet adapted to the Mexican context. It does not include animal products such as red meat, poultry, or pork, only fish and seafood. To obtain the final recommendations, we used the kcal intake (1990 kcal) and replaced 2/3 of the kcal from animal-based foods with fish and seafood, and 1/3 with fruits and vegetables, according to proposals in other global studies [20, 21].

MHSDG: Mexican Healthy and Sustainable Dietary Guidelines 2023

EAT-HRD: EAT Healthy Reference Diet

The recommended grams and kcal consumption for each food group were adjusted to 1990 kcal, which was the energy requirements estimated for healthy adults in Mexico. The energy requirements calculations was estimated using validated equations from the Institute of Medicine [34] sedentary physical activity levels as previously described [32]. The total energy content of the diet´s scenarios was kept constant to isolate the effects of changes in dietary composition. The recommended grams for the HSDs were calculated based on the kcal proposed in each scenario by food group, adjusted according to the estimated grams outlined in the MHSDG 2023 (see Table 1). The compositions of the food groups for the current diet and recommended HSD scenarios are shown in Table 2.

Mortality burden

We used a modeling approach within Comparative Risk Assessment [25, 42] and evaluated total and premature mortality from CVD, T2D, CeVD, and CRC attributable to the intake of ten food groups (high consumption of red meat, processed meat, SSB and UPF; low consumption of fruits, vegetables, whole grains, nuts and seeds; fish; and legumes) according to the recommendations of the six HSD scenarios and compared them with the current diet among adults. We defined dietary risk factors as the intake levels of specific food groups associated with cardiometabolic diseases and CRC. We considered the significance of the risk factor for disease burden and policy decision-making, the availability of sufficient data, the strength of epidemiological evidence, and the quantifiability of the relationship between exposure and disease for this food group [9].

We identified associations between food group consumption and specific health outcomes (CVD, CeVD, T2D, and CRC) based on meta-analyses of prospective studies. We considered studies that provided dose−response data to quantify how different levels of food group intake affect the risk of these diseases. For this purpose, we conducted a comprehensive search of meta-analyses published between 2015 and 2023 in PubMed. The selected studies analyzed the association between the consumption of one or more of the identified food groups and the mortality (or morbidity if there were no mortality data available) of the proposed diseases in adult populations. Only meta-analyses that provided dose−response analysis data (tables or figures) were considered. When multiple meta-analyses were available, we prioritized those utilized in previous studies [27] and those that met moderate-to-high-quality criteria and credibility of evidence on different quality scales, such as the NutriGrade scale and the Newcastle−Ottawa Quality Assessment Scale [26, 43]. Additionally, we gave preference to studies reporting relative risks (RRs) for different intake levels of specific food groups and causes of mortality, adjusted for energy intake.

The selected dietary risk factors and their associations with diseases were supported by established criteria used to assess evidence certainty and quality, such as the Bradford−Hill criteria used in Miller et al. [27], the Nutrition and Chronic Diseases Expert Group (NutriCODE) [26], the World Cancer Research Fund (WCRF) [28], and the NutriGRADE evidence level [3, 5, 6, 43, 44]. We considered the evidence for a causal association of each risk disease graded as probable or convincing by the NutriCODE [26], moderate or high quality according to the NutriGrade and/or probable or convincing (strong) according to the WCRF [28]. The food groups included according to the quality of the evidence are shown in Additional file 1: Table S1.

Relative risks

We extracted RRs with 95% confidence intervals (CIs) for each food group-disease relationship from moderate-high quality dose-response selected meta-analyses [3, 5, 6, 26, 27, 43–46]. RRs and 95% CIs were obtained for each level of consumption proposed in the dose−response analyses (i.e., increases in the intake of 15 g, 30 g, 50–100 g per person/day) of the selected meta−analyses. In cases where data were unavailable from tables, RRs were extracted from published graphs of those studies via WebPlotDigitizer software [47]. To ensure accuracy, all digitized data were independently verified by two reviewers. Discrepancies were resolved by consensus. Nonlinear interpolation techniques were employed to estimate the RR for each disease according to each food group consumption level observed in adults from ENSANUT 2016. Maximum exposure values were capped using the highest dose−response data provided in the meta-analysis. The RRs extracted from the selected meta-analyses are shown in Additional file 1: Table S3, and the RRs used for each risk-related disease are shown in Additional file 2: Tables S1-4.

Mortality and years of life lost (YLL)

Mortality from specific causes according to the International Statistical Classification of Diseases and Related Health Problems (ICD-10), including CVD (I10-I13, I20-I25), T2D (E10, E11, E13, E14), CeVD (I60-I69) and CRC (C18-C20, C21), was obtained from vital statistics databases of the National Institute of Statistics and Geography (INEGI) [48] for the year 2016 in Mexican adults > 20 years. Premature deaths were defined as those occurring before reaching the observed maximum potential life expectancy at the age of the deceased, which was 76 years for both sexes in 2016; thus, we considered all deaths between 20 and 75 years old. Additional file 1: Table S4 shows the classification of the underlying causes of death according to the International Classification of Disease-10 (ICD-10) [49] standards. YLL due to premature mortality from chronic diseases and cancer was calculated by multiplying age-specific deaths for each disease by the life expectancy at that age, considering the average age of both sexes, using life tables provided by

Table 2 Food groups composition of healthy and sustainable diet scenarios and the current diet of Mexican adults

Food groups	Food groups	Current diet of Mexican adults ENSANUT 2016 (*n* = 1337)		MHSDG 2023		EAT- HRD-Mex[1]		EAT-HRD2		Vegetarian		Vegan		Pescatarian	
		Kcal/day	Grams/day	Kcal/day	Grams/day	Kcal/day	Grams/day	Kcal/day	Grams/day	Kcal/day	Grams/day	Kcal/day	Grams/day	Kcal/day	Grams/day
Included groups	Fruits	83	148	122	229	100	188	100	188	123	231	152	286	118	222
	Vegetables	66	153	104	258	62	154	62	154	86	215	114	284	80	200
	Whole grains*	415	176	689	289	505	212	646	271	505	212	505	212	505	212
	Legumes	58	20	247	73	258	76	226	67	305	90	362	107	258	76
	Oilseeds	14	2	90	19	129	27	233	49	176	37	233	49	129	27
	Total meat**	138	65	63	30	24	11	24	11	0	0	0	0	0	0
	Processed meat	37	14	0	0	5	2	0	0	0	0	0	0	0	0
	Fish and shellfish	10	9	20	17	32	27	32	27	0	0	0	0	105	95
	SSB	128	293	0	0	92	115	0	0	92	115	92	115	92	115
	UPF***	370	113	90	21	127	30	96	22	127	30	97	23	97	23
No included groups	Refined grains	200	73	0	0	55	20	0	0	55	20	55	20	55	20
	Tubers	20	25	-	-	24	30	31	39	24	30	24	30	24	30
	Poultry	83	55	78	44	80	46	49	28	0	0	0	0	0	0
	Eggs	47	32	63	44	48	33	15	10	48	33	0	0	48	33
	Dairy	117	135	188	302	93	149	122	197	93	149	0	0	93	149
	Fats	138	16	232	27	334	39	354	41	334	39	334	39	334	39
	Others	81	145	-	-	22	23	-	-	22	23	22	23	22	23
Total kcal		2005		1990		1990		1990		1990		1990		1990	

For UPF, the percentage of calories was considered instead of grams for models, 18% for the current diet, and 5% for HSDs scenarios

1. Castellanos et al., 2020; 2. Willet et al., 2019

SSB: Sugar-sweetened beverages; UPF: Ultra-processed foods

*Including whole grain or high-fiber cereals with a ratio of CHO/Fiber > 0.1;

**Total meat includes red meat and pork

***For EAT-HRD and MHSDG scenarios, UPF only included sweeteners the National Population Council (CONAPO) [50]. Our study followed the guidelines for accurate and transparent health estimates reporting (GATHER) (Additional file 3) [51].

Statistical analysis

The mortality burden (total and premature deaths and YLL) attributable to dietary risk factors for each disease was estimated using the calculation of PIFs. The PIF quantifies the reduction in deaths or YLL in the population that would occur if the exposure to a specific dietary risk factor were changed from a reference situation [52], in this case, the average intake in the current Mexican diet, to a counterfactual scenario such as the recommended intake in each of the HSD scenarios. When the exposure is continuous, the PIF is defined as (1):

$$PIF = \frac{\int_{l}^{h} RR(x)\,P(x)\,dx - \int_{l}^{h} RR(x)\,P^{*}(x)\,dx}{\int_{l}^{h} RR(x)\,P(x)\,dx} \quad (1)$$

where *RR(x)* is the relative risk of disease for the level of risk factor *x (food groups)*, *P(x)* is the original distribution of risk factor *x*, and *P*(x)* is the distribution of *x* in the counterfactual or HSD scenario. Moreover, *h* and *l* are the lower and upper limits of the integral, respectively, corresponding to the highest and lowest thresholds of dietary intake parameters, beyond which no evidence is available for further risk reduction [53]. To estimate the PIF for our analysis, we approximated the first term of the equation by using the average RR of the current diet. For the second term, we used the average RR of HSDs scenarios and expressed it relative to the average RR of the current diet. Specifically, we calculated this value as (mean RR current diet - mean RR HSDs)/mean RR current diet [53].

We assumed that changes in the RR followed a nonlinear dose−response relationship [54] and that PIFs were combined multiplicatively, considering that diseases are affected by more than one dietary risk factor [9, 27]. For dietary risk factors under a particular counterfactual HSD scenario (e.g., MHSDG, vegetarian, vegan, etc.), we assumed that the entire population is subject to dietary risk given an intake distribution, with which PIFs were calculated for each disease, considering the distribution of *x* as a continuous variable, with consumption in grams for each level of exposure. Thus, for each counterfactual scenario, consumption in grams of each food group was simulated (%kcal for UPF), assuming a mean equal to the recommended consumption of each HSD scenario, with a gamma distribution similar to that observed in the 24 HR of ENSANUT 2016. From each food group intake distribution, a random value was obtained to simulate consumption in a sample of 10,000 adults, which was then scaled up to the total adult national population in Mexico in 2016 (*n* = 78,265,370 adults according to INEGI).

The changes in the number of total and premature deaths, Δdeaths*i*, due to the change in exposure to risk factors (*i*) were calculated by multiplying the PIF by disease-specific deaths in the population (Eq. 2).

$$\Delta \mathrm{deaths}_{id,\,s} = PIF_{id,\,s} * \mathrm{deaths}_{d} \quad (2)$$

where *d* is a specific disease or cause of death, *i* represents a dietary risk factor, and *s* represents the HSD scenario. Additionally, changes in YLLs were calculated by multiplying disease-specific deaths by the corresponding life expectancy in the population (E) via Eq. 3.

$$\Delta \mathrm{YLL}_{i\ d,\,s} = \mathrm{PIF}_{d,\,s} * \mathrm{deaths}_{d} * \mathrm{E} \quad (3)$$

The calculation of averted deaths and Years of life saved (YLS) due to changes in dietary risk factors (i.e., *fruits*, *vegetables*, *red meat*, *processed meat*, *fish*, *whole grains*, *nuts and seeds*, *legumes and SSB*) according to the disease and HSD scenarios was performed using the following formula:

$$PIF_{d,s} = 1 - \prod_{i} (1 - PIF_{d,i,s})$$

The total number of averted deaths, premature deaths, and YLLs from all chronic diseases and CRC were calculated by summing the corresponding totals across diseases for each HSD scenario. The percentage of averted deaths was calculated by dividing the number of prevented deaths by the total number of deaths in 2016 for each disease and scenario. The percentage of deaths avoided by food groups was calculated by dividing the total number of reduced deaths per food group by scenario and disease by the overall number of deaths per disease. All reported percentages refer to relative reductions compared with the current diet, while the numbers of deaths and YLL avoided represent absolute differences.

Sensitivity analysis

As a sensitivity analysis, we estimated reduced mortality, including in the UPF group, in the estimations of PIF; as we previously mention, these food groups were not considered to be exposed in the main estimations but had evidence of associations with CVD and T2D [4, 55], recently supported by NutriGrade [56].

Uncertainty - confidence intervals

Uncertainty intervals (UIs) were generated via bootstrapping and 10,000 simulations, accounting for variability in RR estimates and dietary intake. The parameter RR was considered to have a normal distribution, with variance given by the squared standard error obtained from the reported 95% CI from meta-analyses. Simulations used nonlinear interpolation and gamma distributions for dietary consumption to estimate RRs and PIFs under counterfactual scenarios. Replicate bootstrap weights reflected the complex survey design. All analyses were conducted using R software (version 4.2.1) [57], with the following packages: srvyr [58], tidyverse [59], survey-bootstrap [60], survey [61], foreach [62], doParallel [63], readxl [64], and haven [65].

Results

In 2016, a total of 279,732 Mexicans died from CVD, CeVD, T2D, or CRC, 143,334 of whom died prematurely (Additional file 1: Table S3). Compared with the current diet, following HSDs could reduce total deaths by 26.6% (95% UI: 24.8–28.5) for the EAT-HRD-Mx diet, 29.4% (UI: 27.6–31.2) for the EAT-HRD diet, 30.2% (95% UI: 28.5–31.9) for the vegetarian diet, 31.9% (95% UI: 30.1–33.6) for the MHSDG diet, 32.2% (95% UI: 30.6–33.9) for the pescatarian diet, and 33.1% (UI: 31.4–34.7) for the vegan diet (Fig. 1a). Relative premature deaths avoided showed similar results across the scenarios, but with slightly lower percentages than total deaths (Fig. 1b). In general, if the entire adult Mexican population were to shift their current diet to any of the evaluated HSD scenarios, between 74,396 (95% UI: 69,393–79,558) and 92,540 (95% UI: 87,922–97,163) total deaths could be prevented, and between 35,994 (95% UI: 33,419–38,680) and 43,735 (95% UI: 41,320–48,095) premature deaths from CVD, T2D, CeVD, and CRC could be averted across the HSD scenarios (Fig. 2a and b and additional file 1; Table S5a). Furthermore, YLL decreased between 584,118 (95% UI: 542,169–627,455) and 711,017 (95% UI: 672,090–750,026) (Fig. 3 and additional file 1: Table S5b).

The vegan diet had the greatest reduction in mortality burden, followed by the pescatarian diet, but these differences were not statistically significant (Fig. 2). The MHSDG ranked third, with an absolute reduction of 89,337 (95% UI: 84,446–94,244) total deaths and 42,470 (95% UI: 39,940–45,045) premature deaths (Figs. 2 and 3; Table 5), which was similar to the number of deaths averted by the EAT-HRD and vegetarian diet scenarios. Compared with the MHSDG, pescatarian, and vegan diets, the EAT-HRD-Mex showed the lowest number of total and premature deaths avoided (Fig. 2a, b; Table 5). Sensitivity analysis revealed that reducing the consumption of UPFs could further prevent deaths and YLL by up to 2.3% in all the scenarios, contributing to an overall reduction of 29.1–35.5% in total deaths and 27.6–32.9% in premature deaths averted across all the HSD scenarios (Fig. 1a, b).

The food groups that contributed the most to the relative reduction in mortality burden across all the scenarios were the increased consumption of nuts and seeds (5.9–6.8% total deaths averted), along with reductions in the consumption of SSB (4.4–7.4% total deaths averted) and red meat (3.5–6.4% total deaths averted) (Fig. 1). On the other hand, an increase in fish consumption contributed to a 4.9% reduction in deaths in the pescatarian diet scenario but led to small increases in total and premature deaths of 0.5% in the vegan and vegetarian diet scenarios (Fig. 1a-b).

Additional file 4: Tables S1–S3 show the percentages of averted deaths and years of life saved (YLS) from CVD, CeVD, T2D, and CRC through HSD scenarios and food groups in Mexican adults. For CVD, the vegan diet had the greatest number of total averted deaths (62,290; 95% UI: 60,271–64,321), which was significantly higher than that of the EAT-HRD-Mex (47,740; 95% UI: 45,450–50,107), EAT-HRD (50,452; 95% UI: 48,205–52,747), and vegetarian diets (56,188; 95% UI: 54,028–58,361) (Fig. 2a; additional file 4:Table S1). The increase in nuts and seeds, legumes, fruits, and vegetables, coupled with reductions in SSB intake and UPF, contributed the most to the prevention of CVD-related deaths across scenarios (Additional file 1: Figure S1-S2).

In terms of CeVD, the pescatarian diet yielded the highest reduction in both total and premature deaths (Fig. 1a, b), mainly due to increased fish consumption (9.6% of deaths averted) and reduced red meat intake (6.2%) (Additional file 1: Figure S3). The EAT-HRD had the greatest impact on reducing total and premature deaths from T2D and CRC (Fig. 1). Reductions in red meat (3.8–9.4%), processed meat (5.7–6.3%), and SSB (3.0–7.3%) intake contributed to the greatest percentage of T2D-related deaths across the various scenarios (Additional file 1: Figure S4-S5). Increased consumption of whole grains (6.1%), coupled with a reduction in red and processed meats (5.9% and 4.0%, respectively), contributed to the greatest number of avoided CRC deaths (Additional file 1: Figure S6).

Discussion

In this study, we modeled HSD scenarios and their potential impact on mortality burden compared with current diets in Mexican adults. Our findings suggest that adopting any HSD scenario could yield health benefits, resulting in substantial reductions in overall mortality from cardiometabolic diseases and CRC. We found that the mortality burden from CVD, CeVD, T2D, and CRC could be reduced by 26.6–33.1% for total deaths, 25.1–30.3% for premature deaths, and 25.1–30.5% for YLL among all the scenarios. The most significant reductions were observed under vegan and pescatarian diets, followed closely by the MHSDG.

Our findings are consistent with previous global modeling studies. For instance, Springmann et al. [20]

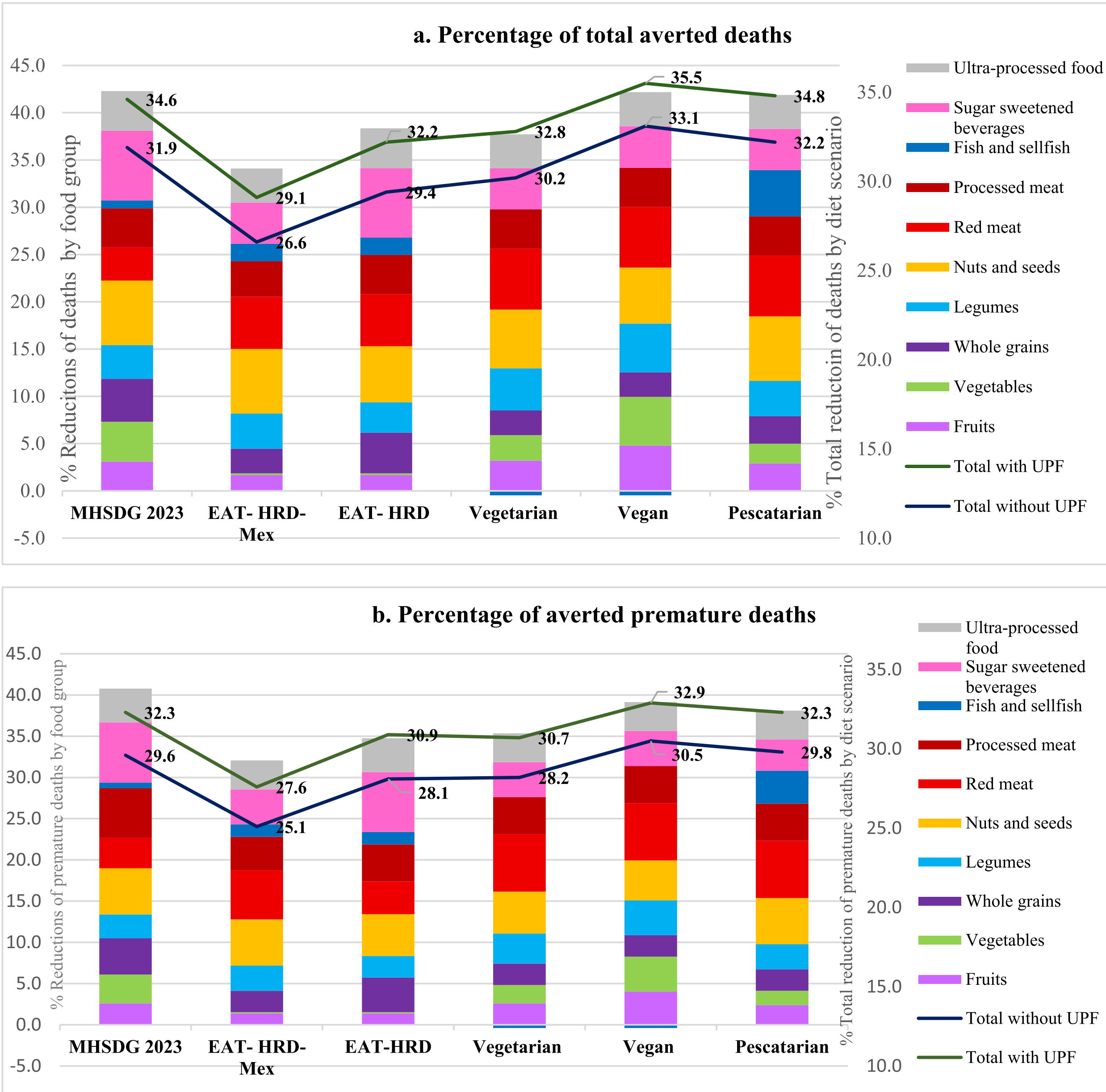

Fig. 1 Percentage of averted deaths from cardiometabolic diseases and colorectal cancer by Healthy and Sustainable diet scenarios (HSDs) and food groups in Mexican adults. *Compared with the current diet. The total number of deaths due to cardiometabolic diseases and colorectal cancer (CRC) in 2016 was 279,732 deaths (>20 years). The number of premature deaths due to chronic diseases and CRC in 2016 was 143,334 premature deaths (20-75 years). We considered cardiometabolic diseases CVD (ICD-10 I10-I13, I20–I25), CeVD (I60-I69), T2D (E10, E11, E13, E14), and CRC (C18–C20, C21). The bars indicate the reduction in deaths by individual food group (%) in each scenario, while the green and brown lines show the total mortality reduction associated with each Healthy and Sustainable diet scenario (HSDs); the green line includes estimates when ultra-processed foods (UPF) are incorporated into the model. The bars in the graph represent HSDs characterized by increased consumption of fruits, vegetables, whole grains, legumes, nuts, and seeds, as well as decreased consumption of red and processed meat, sugar-sweetened beverages (SSBs), and UPF. The health impacts attributed to the combined effect of all the risks are smaller than the sum of the individual risks. This is because it considers coexposure, where each death is attributed exclusively to a single risk factor

projected that shifting to vegan and pescatarian diets could reduce premature mortality by up to 22% globally by 2030, among adults aged 30–69 years. Another similar study reported a 15% global reduction in premature mortality associated with food-based dietary guidelines, with regional variations ranging from 6.5% in Africa to 19% in North America [21]. In our study, adopting the MHSDG, which incorporates health and sustainability criteria, could prevent 29.6% premature deaths in adults, while the EAT-HRD scenario could avert 28.1% of premature

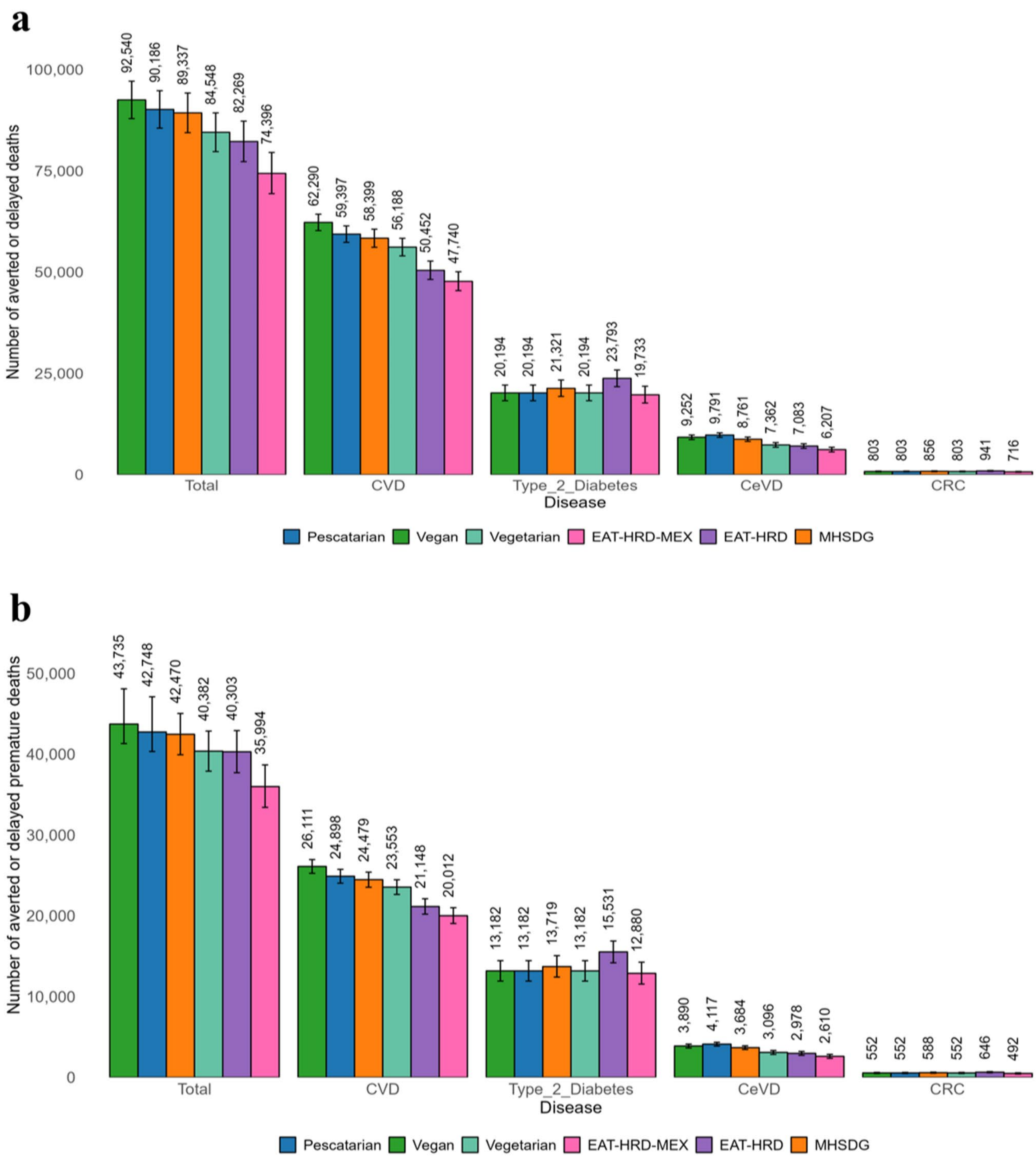

Fig. 2 (See legend on next page.)

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Fig. 2 **a** Total averted deaths by disease and HSD scenario: The number of deaths (> 20 years) that could be prevented or delayed if Mexican adults changed their current diets to healthy and sustainable diets (HSDs) (excluding ultra-processed foods [UPFs]). Potential deaths that could be averted or delayed were estimated using the population impact fraction (PIF), with uncertainty quantified using bootstrap resampling. For 2016, mortality data associated with cardiometabolic diseases and cancer (cardiovascular diseases [CVDs], type 2 diabetes [T2D], cerebrovascular diseases [CeVD], and colorectal cancer [CRC]) were obtained from the National Institute of Statistics and Geography (INEGI). We considered chronic diseases as CVD (CIE-10 I10-I13, I20–I25), CeVD (I60-I69), T2D (E10, E11, E13, E14), and CRC (C18–C20, C21). In 2016, the total number of deaths from cardiometabolic disease and CRC among Mexican adults was 279,732, with 134,383 related to CVD, 34,782 related to CeVD, 104,511 related to T2D, and 6,056 related to CRC. **b** Total averted premature deaths by disease and HSD scenario: The number of premature deaths (> 20 years and < 75 y) that could be prevented or delayed if Mexican adults changed their current diets to healthy and sustainable diets (HSDs) (excluding ultra-processed foods (UPFs)). Potential deaths that could be averted or delayed were estimated using the population impact fraction (PIF), with uncertainty quantified using bootstrap resampling. For 2016, mortality data associated with cardiometabolic diseases and cancer (cardiovascular diseases [CVDs], type 2 diabetes [T2D], cerebrovascular diseases [CeVD], and colorectal cancer [CRC]) were obtained from the National Institute of Statistics and Geography (INEGI). We considered chronic diseases CVD (CIE-10 I10-I13, I20–I25), CeVD (I60-I69), T2D (E10, E11, E13, E14), and CRC (C18–C20, C21). In 2016, the total number of premature deaths from cardiometabolic diseases and CRC among Mexican adults was 143,334, with 56,30 related to CVD, 14,625 related to CeVD, 68,219 related to T2D, and 4,160 related to CRC

deaths. Globally, the EAT-HRD scenario has also been projected to prevent up to 104,000 deaths in the UK (20.3%) and 1.8 million in China (19.5%), with reductions in premature mortality of up to 23.2% in Europe and North America by 2030 [21].

Overall, transitioning to any HSD scenario could significantly reduce mortality. For instance, both the EAT-HRD and vegetarian diets were associated with reductions in premature mortality, consistent with findings by Wang et al. [66], who reported a 27% reduction in premature deaths when transitioning to a high-quality healthy diet in the country. Similarly, the EAT-HRD-Mex, which allows limited amounts of SSB and UPF while considering environmental sustainability, demonstrated reductions comparable to the old Mexican dietary guidelines (2015) (approximately 25%) [66].

Our findings suggest that the most significant health benefits in each scenario stemmed from the increased consumption of plant-based foods, especially nuts and seeds, whole grains, legumes, and fruits and vegetables (mainly in CVD mortality). These foods contain fiber, antioxidants, phytonutrients, and other bioactive compounds that protect against chronic diseases and cancer [67–69]. In Mexico, the consumption of nuts and seeds is lower than that reported in global data (2 g vs. 15 g) [20], the consumption of legumes has considerably decreased in adults over the last ten years [12], and the consumption of whole grains, other than tortillas, has not met the recommendations for healthy diets [70]. Moreover, fewer than half of adults consume the recommended intake of fruits and vegetables (≥ 400 g/day) [12]. In 2017, the Global Burden of disease collaborators identified low consumption of whole grains, fruits, nuts, and vegetables as the four main dietary causes of death and DALYs worldwide [9]. In Mexico, low consumption of nuts and seeds emerged as the most critical dietary factor contributing to deaths and YLLs from chronic diseases [9], underscoring the urgent need to promote these and other plant-based foods through national dietary policies and strategies.

Our study, along with others that have assessed the health impact of HSDs, aligns with the health effects of vegan diets and their potential to reduce mortality [20, 71]. However, consuming plant-based diets does not necessarily guarantee a healthy diet, as it may compromise the adequacy of some micronutrients such as B12, zinc, and calcium [22], or promote the consumption of UPFs to offset the energy from omitted animal-origin foods [72]. In Mexico, although national strategies have been implemented, such as mandatory fortification of maize and wheat flours with iron and folic acid [73], and the distribution of Liconsa milk enriched with B12, iron, and zinc [74], their impact remains limited due to restricted coverage (focused on vulnerable groups) and potentially insufficient intake levels of micronutrients, especially among older adults and women of reproductive age. Most adults, including those voluntarily adopting plant-based diets, may not benefit from these programs, either due to limited access or the absence of tailored formulations. Supporting a population-wide transition to plant-based diets will require strengthening current policies by expanding mandatory fortification (e.g., inclusion of B12 in vegan-appropriate products), scaling up the biofortification of staple crops like maize and beans, and maintaining targeted supplementation strategies for high-risk groups [75]. On the other hand, pescatarian diets, which replace other animal-source foods with fish and seafood, also demonstrated significant health benefits in our findings. Fish are a fundamental component of the diet and provide vitamins, minerals, polyunsaturated fatty acids, and essential fatty acids such as omega-3 [76]. However, Mexico's average fish and seafood consumption is only 10 g/day, with canned tuna as the main source [77]. While canned tuna contributes significantly to the intake of omega-3 fatty acids in the Mexican diet, it also contributes to at least 75% of the estimated population's exposure to methylmercury, which is associated with severe health damage [78]. Therefore, the recommendation to switch from a current diet to a pescatarian diet should be made carefully.

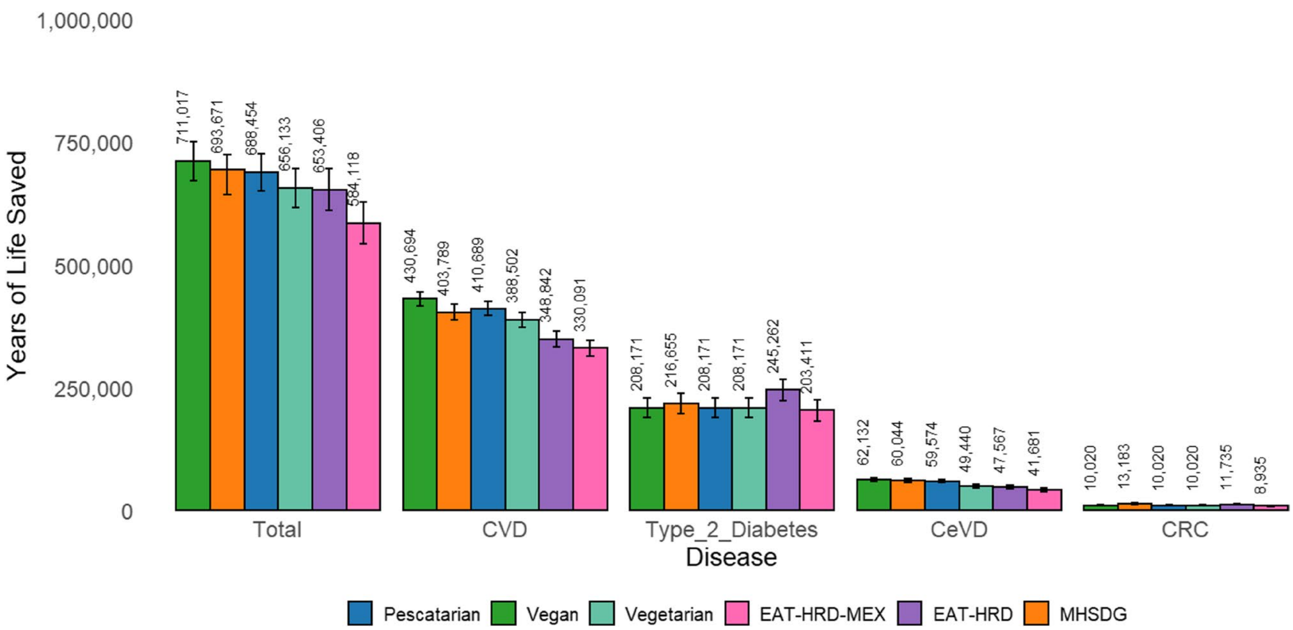

Fig. 3 Total years of life saved (YLS) by disease and HSD scenario: The number of YLS that could be prevented or delayed if Mexican adults changed their current diets to healthy and sustainable diets (HSDs) (excluding ultra-processed foods (UPFs)). Potential deaths that could be averted or delayed were estimated using the population impact fraction (PIF), with uncertainty quantified using bootstrap resampling. In 2016, mortality data associated with chronic diseases and cancer (cardiovascular diseases [CVDs], type 2 diabetes [T2D], cerebrovascular diseases [CeVD], and colorectal cancer [CRC]) were obtained from the National Institute of Statistics and Geography (INEGI). Years of life lost (YLL) were calculated by multiplying age-specific deaths for each disease by the life expectancy expected at that age, considering the average age of both sexes (76.3 y), using life tables provided by CONAPO. (We subtract the average age range from the life expectancy of 76.3 for 2016, multiplied by the number of deaths). In 2016, the YLL from cardiometabolic diseases and colorectal cancer (CACO) among Mexican adults was 2,315.607, with 929,164 related to CVD, 233,573 related to CeVD, 1,077,332 related to T2D, and 75,538 related to CRC

Moreover, we recognize that the practical adoption of plant-based diets in Mexico involves addressing complexities such as the transition period and adherence to these diets. On the other hand, there are no specific data on the percentage of the Mexican population that follows a plant-based diet or is classified as vegan, vegetarian or pescatarian. The low or no consumption of animal-based foods reported in national surveys may be related to high levels of food insecurity in the population, rather than intentional dietary choices, resulting in less diverse diets with inadequate animal protein [79]. Additionally, in rural areas and some regions, such as the southern region, people tend to consume HSDs as traditional Mexican foods centered around staples such as maize, beans, squash, chili and other plant-based foods, with lower intakes of animal-source foods, refined grains, added sugars, and fats [80]. Nevertheless, the overall quality of these diets remains suboptimal, and these diets are adopted by only 10.2% of Mexican adults [80].

Despite the above, our findings highlight that MHSDG 2023 significantly reduces mortality and YLL across all disease categories, establishing it as a crucial benchmark for transitioning to HSD in Mexico. However, the ideal scenario of the MHSDG we modeled, which assumes that all recommended grains and cereals are whole grains according to the guidelines, may not fully align with the current consumption patterns in the country. Therefore, the EAT-HRD-Mex scenario might provide a more practical approach. Achieving adherence to these dietary guidelines and other HSD scenarios remains challenging due to the considerable deviation of current dietary patterns from the recommendations [70]. In fact, compliance with the MHSDG among Mexican adults is low, particularly in the consumption of legumes, nuts, and seeds, while the intake of red and processed meat often exceeds recommended levels [81]. Emphasizing this gap between dietary recommendations and current consumption is essential for assessing the feasibility of policy implementation and for identifying priority areas for intervention. In this sense, the MHSDG considers consumption recommendations that are more plausible to achieve in the medium term, although in the long term, the goal would be to achieve the EAT-HRD recommendations. Also, promoting other traditional diets aligned with the HSDs principles, such as the milpa diet, which is inherently plant-based and low in UPF and red meat [82], may enhance cultural acceptability and feasibility of MHSDG in specific Central and South regions in the country, representing a culturally relevant and policy-leveraged entry point for advancing sustainable food systems in Mexico.

Our research suggests that increasing the consumption of plant-based foods while reducing the intake of SSB and red meat are key dietary changes for lowering mortality rates in Mexico. Furthermore, reducing UPF could amplify these health benefits. Multilevel and multisectoral efforts should boost sustainable production and consumption of plant-based foods and fish while reducing red and processed meats. Policies addressing unhealthy foods, such as SSB taxes have successfully decreased its purchases [83] and front-of-package nutrition labeling contributed to the reformulation of unhealthy products [84], but need stronger measures like higher taxes on unhealthy foods, including processed meat, and stricter digital marketing regulation [85, 86]. Equally important is advancing policies promoting healthy, plant-based diets, such as aligning agricultural subsidies with nutrition and sustainability goals, implementing economic incentives for nutrient-rich crops, and designing culturally sensitive educational strategies to overcome adoption barriers [87, 88]. Strengthening regulations, including those on red meat and processed meat consumption, is crucial to fostering HSDs and addressing the public health challenges associated with chronic diseases [86, 88].

This is the first study in Mexico to evaluate the health impact of HSDs on mortality using specific dietary data from a nationally representative survey and reliable mortality databases for Mexico. Additionally, we included new dietary guidelines and recommendations from the EAT-HRD adapted to the Mexican context. For the current diet, we used a 24 HR five-step method conducted by trained personnel to minimize memory and underreporting bias. We focused on food groups strongly associated with chronic disease risk based on high-quality cohort studies and meta-analyses with dose−response data. The data years align with the dietary survey year (2016), facilitating comparability in our analyses.

However, our study has several noteworthy limitations that should be considered in future research. First, dietary information was based on 24 HR from the ENSANUT 2016 survey, as more recent nationally representative data were not available at the time of analysis. Additionally, the use of a single 24 HR may not capture intra-individual variability in dietary intake. Nonetheless, given that our objective was to model population-level changes in average dietary intake and the associated mortality burden, we relied on mean intakes and simulated intake distributions derived from nationally representative data, consistent with comparative risk assessment methodologies [20]. Future modeling studies could enhance intake distribution estimates by applying statistical methods that account for usual intake, such as measurement error models or two-part models (e.g., the NCI method), when repeated 24 HR are available [89, 90]. Second, the reliability of our findings may be compromised by the use of data from observational studies in meta-analyses, which can affect causal inference owing to issues such as inconsistency in defining dietary exposures, a high likelihood of residual confounding, and inadequate adjustment for known confounders. Additionally, meta-analyses often include studies from high-income populations, and RRs may differ in our context. Similarly, the number of meta-analyses reviewed was limited because we included only those providing dose−response information, which may have affected the comprehensiveness of our findings. Nevertheless, the RR information was sourced from studies of moderate to high methodological quality [3, 5, 6, 44–46] and was used in similar studies [20, 21]. Moreover, randomized controlled trials are scarce in diet analyses. Third, we did not include certain food groups in our estimations, such as dairy products for T2D or whole grains for CeVD. This decision was based on studies that revealed no significant association with the risk of these diseases [27, 38–41]. Fourth, we used webplot digitizers to obtain RRs of some meta-analyses, which can introduce inaccuracies and potentially overestimate or underestimate RR values. Therefore, our findings should be interpreted cautiously, although previous research suggests that interpolated data from this tool can yield valid results [91]. Additionally, to minimize errors, two collaborators carefully reviewed the graphs to acquire the RR data. Fifth, estimations for crucial nutrients, like sodium, identified as the second cause of global deaths and disability [9], were not included. This omission may underestimate the number of deaths prevented by transitioning to any HSD scenario. A recent study documented that following WHO sodium intake recommendations in Mexico could prevent up to 27,700 cardiovascular disease deaths [92]. Hence, the potential to reduce deaths from HSD would be greater, as these scenarios advocate for low sodium and UPF consumption overall. However, it should be noted that estimates of UPF may not be entirely accurate, as the consistency or definition of UPF varied among the studies; thus, it was included as a sensitivity analysis. Finally, this study modeled the impact of HSDs on chronic disease mortality using an average adult diet and did not disaggregate results by sex. This decision was based on the methodological complexity and the substantially higher number of simulations and scenarios that would have been required to produce sex-specific estimates within the scope of this analysis. However, given the well-documented differences in dietary patterns [93] and disease burden between men and women in Mexico [15], future studies should explore sex-specific impacts of HSDs to better inform targeted public health strategies.

The interpretation of our findings should take into account recent contextual changes in Mexico. The

COVID-19 pandemic may have temporarily altered dietary habits and food access, potentially widening health disparities and delaying progress toward healthier eating patterns [94]. At the same time, the implementation of policies such as front-of-package warning labels and taxes on SSB, along with the release of the 2023 MHSDG and the publication of the Adequate and Sustainable Food Law [95] reflects growing national efforts to promote HSDs. These policy interventions align with key elements of the modeled HSD scenarios and may partially reinforce or accelerate the adoption of HSDs and the projected health benefits identified in our study. However, the actual adoption and long-term effectiveness of some of these policies remain uncertain, and the implementation of other relevant policies for transforming the food system should be considered in further studies to assess their impact on population health [85].

Conclusion

In conclusion, adopting HSDs could reduce mortality from chronic diseases, specifically CVD, T2D, CeVD, and CRC in Mexican adults. Our findings provide valuable insights for allocating resources and guiding decisions on diet-based interventions and public health policies to prevent chronic diseases and reduce mortality. They also underscore the importance of promoting HSDs through strategies tailored to the Mexican context, such as the MHSDG. Future efforts should prioritize increasing the intake of plant-based foods and reducing red and processed meat consumption, while adapting implementation to local and regional contexts to effectively promote healthy diets within sustainable food systems across Mexico.

Abbreviations

24HR	24-hour dietary recall
CRC	Colorectal cancer
CVDs	Cardiovascular diseases
CevD	Cerebrovascular diseases
EAT-HRD	EAT-LancetHealthyReferenceDiet
EAT-HRD-Mx	Mexican adaptation of the EAT-LancetHealthyReference Diet
EER	Estimated energy requirement
ENSANUT	Mexican National Health and Nutrition Survey
HSD	Healthy and sustainable diets
INEGI	Mexican National Institute of Statistics and Geography
MHSDG	Mexican Healthy andSustainable Food-based Dietary Guidelines 2023
NutriCODE	Nutrition and Chronic Diseases Expert Group
RRs	Relative risks
SDs	Standard deviations
SSB	Sugar-sweetened beverages
T2D	Type 2 diabetes
UPFs	Ultra-processed foods
WCRF	World Cancer Research Fund
YLL	Years of life lost
YLS	Years of life saved
ICD-10	International Statistical Classification of Diseases and Related Health Problems
CONAPO	National Population Council
PIF	Potential impact fraction

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23988-3.

Additional file 1: This file includes detailed supplementary information supporting the main text, such as the certainty of evidence for statistically significant associations between food groups and each disease, the classification of food groups, relative risk parameters extracted from dose-response meta-analyses, and the total number of deaths, premature deaths, and years of life lost (YLLs) from chronic diseases for each disease in Mexican adults. Additionally, it contains graphs illustrating the averted deaths by healthy and sustainable diet (HSD) scenario and food group for each disease considered. S Table 1: Certainty of evidence for statistically significant associations between food groups and diseases. S Table 2: Classification of food groups. S Table 3: Relative risk parameters for dietary exposures and diseases extracted from dose-response meta-analyses. S Table 4: Number of deaths, premature deaths, and YLLs from cardiometabolic diseases and colorectal cancer in Mexican adults (INEGI, 2016). S Figure 1: Percentage of averted deaths from chronic diseases by HSD scenario and food groups in Mexican adults. S Figures 2–5: Percentage of averted deaths by specific disease (cardiovascular diseases, cerebrovascular diseases, type 2 diabetes, and colorectal cancer) and food groups in each HSD scenario.

Additional file 2: This file presents the relative risks (RRs) selected from dose-response meta-analyses for each disease and dietary exposure. S Table 1: RRs for cardiovascular diseases. S Table 2: RRs for cerebrovascular diseases (stroke). S Table 3: RRs for type 2 diabetes. S Table 4: RRs for colorectal cancer.

Additional file 3: This file contains the checklist following the ***Guidelines for Accurate and Transparent Health Estimates Reporting*** (GATHER), detailing the information included in the study's global health estimates.

Additional file 4: This file includes tables with detailed estimates of the impact of HSD scenarios on mortality and YLLs from chronic diseases: S Table 1: Number of averted deaths from cardiovascular diseases, cerebrovascular diseases, type 2 diabetes, and colorectal cancer by food groups and HSD scenarios in Mexican adults. S Table 2: Number of averted premature deaths from cardiovascular diseases, cerebrovascular diseases, type 2 diabetes, and colorectal cancer by food groups and HSD scenarios in Mexican adults. S Table 3: Number of years of life saved from cardiovascular diseases, cerebrovascular diseases, type 2 diabetes, and colorectal cancer by food groups and HSD scenarios in Mexican adults.

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Authors' contributions

AAA, MUM, CB and JR conceived the project. AAA and MUM were responsible for developing the overall research plan and overseeing the study. AAA and RZT analyzed the data, and AAA wrote the draft. MUM, RZT, CB, and JR added important intellectual content. AAA and MUM are primarily responsible for the final content. All the authors read and approved the final manuscript for submission.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate
The protocol for Ensanut2016 received approval from the Research, Ethics, and Biosafety Committees of the Mexican National Institute of Public (INSP for its Spanish acronym) (No 1401 y CI-188-2016), and written informed consent was obtained from all participants involved in the study. The study adhered to the principles of the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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