The risk of forced labor in food supply chains

College of William & Mary

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What we know

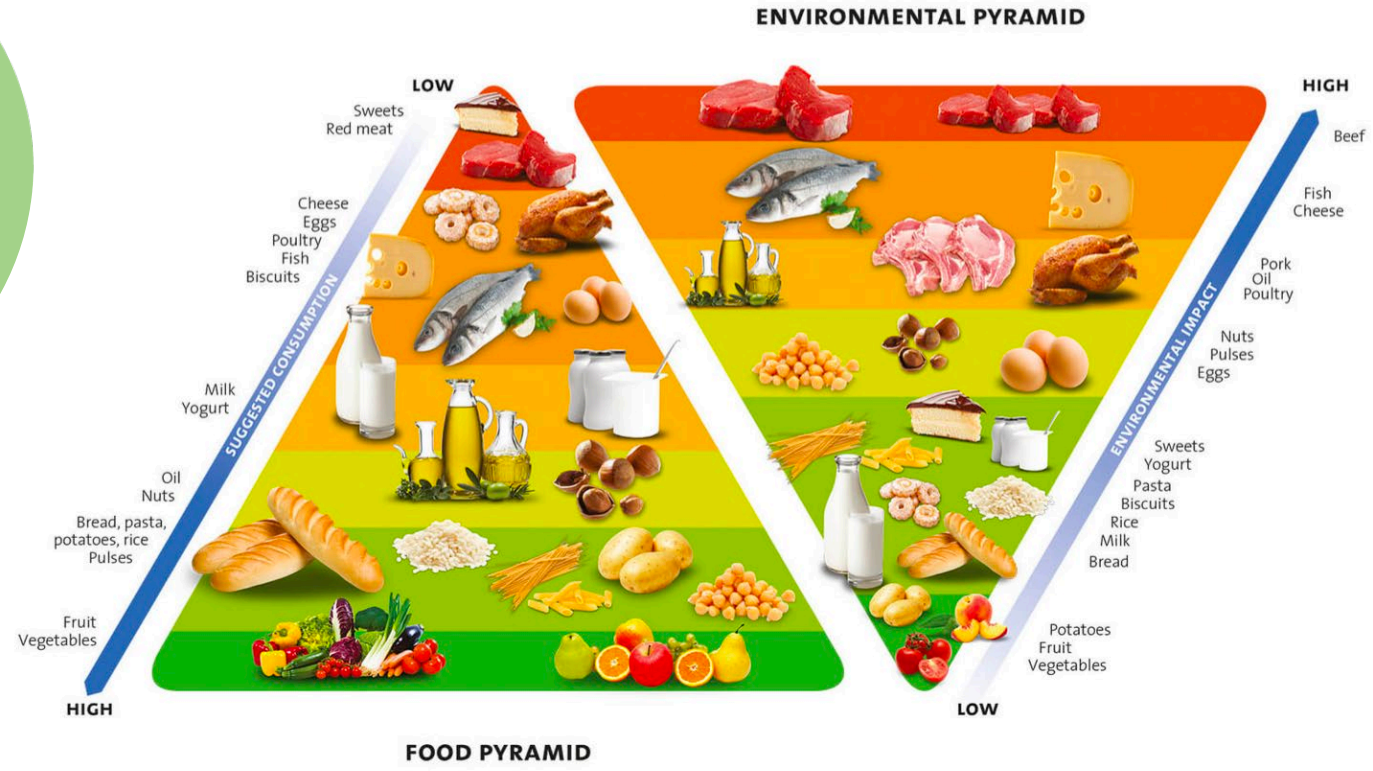

Image: Fondazione Barilla

What we know

Research

JAMA | Original Investigation

Association Between Dietary Factors and Mortality From Heart Disease, Stroke, and Type 2 Diabetes in the United States

Renata Micha, RD, PhD; Jose L. Peñalvo, PhD; Frederick Cudhea, PhD; Fumiaki Imamura, PhD; Colin D. Rehm, PhD; Dariush Mozaffarian, MD, DrPH

IMPORTANCE In the United States, national associations of individual dietary factors with specific cardiometabolic diseases are not well established.

OBJECTIVE To estimate associations of intake of 10 specific dietary factors with mortality due to heart disease, stroke, and type 2 diabetes (cardiometabolic mortality) among US adults.

DESIGN, SETTING, AND PARTICIPANTS A comparative risk assessment model incorporated data and corresponding uncertainty on population demographics and dietary habits from National Health and Nutrition Examination Surveys (1999-2002: n = 8104; 2009-2012: n = 8516); estimated associations of diet and disease from meta-analyses of prospective studies and clinical trials with validity analyses to assess potential bias; and estimated disease-specific national mortality from the National Center for Health Statistics.

EXPOSURES Consumption of 10 foods/nutrients associated with cardiometabolic diseases: fruits, vegetables, nuts/seeds, whole grains, unprocessed red meats, processed meats, sugar-sweetened beverages (SSBs), polyunsaturated fats, seafood omega-3 fats, and sodium.

MAIN OUTCOMES AND MEASURES Estimated absolute and percentage mortality due to heart disease, stroke, and type 2 diabetes in 2012. Disease-specific and demographic-specific (age, sex, race, and education) mortality and trends between 2002 and 2012 were also evaluated.

RESULTS In 2012, 702 308 cardiometabolic deaths occurred in US adults, including 506 100 from heart disease (371 266 coronary heart disease, 35 019 hypertensive heart disease, and 99 815 other cardiovascular disease), 128 294 from stroke (16 125 ischemic, 32 591 hemorrhagic, and 79 578 other), and 67 914 from type 2 diabetes. Of these, an estimated 318 656 (95% uncertainty interval [UI], 306 064-329 755; 45.4%) cardiometabolic deaths per year were associated with suboptimal intakes—48.6% (95% UI, 46.2%-50.9%) of cardiometabolic deaths in men and 41.8% (95% UI, 39.3%-44.2%) in women; 64.2% (95% UI, 60.6%-67.9%) at younger ages (25-34 years) and 35.7% (95% UI, 33.1%-38.1%) at older ages (≥75 years); 53.1% (95% UI, 51.6%-54.8%) among blacks, 50.0% (95% UI, 48.2%-51.8%) among Hispanics, and 42.8% (95% UI, 40.9%-44.5%) among whites; and 46.8% (95% UI, 44.9%-48.7%) among lower-, 45.7% (95% UI, 44.2%-47.4%) among medium-, and 39.1% (95% UI, 37.2%-41.2%) among higher-educated individuals. The largest numbers of estimated diet-related cardiometabolic deaths were related to high sodium (66 508 deaths in 2012; 9.5% of all cardiometabolic deaths), low nuts/seeds (59 374; 8.5%), high processed meats (57 766; 8.2%), low seafood omega-3 fats (54 626; 7.8%), low vegetables (53 410; 7.6%), low fruits (52 547; 7.5%), and high SSBs (51 694; 7.4%). Between 2002 and 2012, population-adjusted US cardiometabolic deaths per year decreased by 26.5%. The greatest decline was associated with insufficient polyunsaturated fats (−20.8% relative change [95% UI, −18.5% to −22.8%]), nuts/seeds (−18.0% [95% UI, −14.6% to −21.0%]), and excess SSBs (−14.5% [95% UI, −12.0% to −16.9%]). The greatest increase was associated with unprocessed red meats (+14.4% [95% UI, 9.1%-19.5%]).

CONCLUSIONS AND RELEVANCE Dietary factors were estimated to be associated with a substantial proportion of deaths from heart disease, stroke, and type 2 diabetes. These results should help identify priorities, guide public health planning, and inform strategies to alter dietary habits and improve health.

JAMA. 2017;317(9):912-924. doi:10.1001/jama.2017.0947

Editorial page 908
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Erratum 22 February 2019. See Erratum.

RESEARCH

SUSTAINABILITY

Reducing food's environmental impacts through producers and consumers

J. Poore[1,2]* and T. Nemecek[3]

Food's environmental impacts are created by millions of diverse producers. To identify solutions that are effective under this heterogeneity, we consolidated data covering five environmental indicators; 38,700 farms; and 1600 processors, packaging types, and retailers. Impact can vary 50-fold among producers of the same product, creating substantial mitigation opportunities. However, mitigation is complicated by trade-offs, multiple ways for producers to achieve low impacts, and interactions throughout the supply chain. Producers have limits on how far they can reduce impacts. Most strikingly, impacts of the lowest-impact animal products typically exceed those of vegetable substitutes, providing new evidence for the importance of dietary change. Cumulatively, our findings support an approach where producers monitor their own impacts, flexibly meet environmental targets by choosing from multiple practices, and communicate their impacts to consumers.

With current diets and production practices, feeding 7.6 billion people is degrading terrestrial and aquatic ecosystems, depleting water resources, and driving climate change (*1*, *2*). It is particularly challenging to find solutions that are effective across the large and diverse range of producers that characterize the agricultural sector. More than 570 million farms produce in almost all the world's climates and soils (*3*), each using vastly different agronomic methods; average farm sizes vary from 0.5 ha in Bangladesh to 3000 ha in Australia (*3*); average mineral fertilizer use ranges from 1 kg of nitrogen per ha in Uganda to 300 kg in China (*4*); and although four crops provide half of the world's food calories (*4*), more than 2 million distinct varieties are recorded in seed vaults (*5*). Further, products range from minimally to heavily processed and packaged, with 17 of every 100 kg of food produced transported internationally, increasing to 50 kg for nuts and 56 kg for oils (*6*).

Previous studies have assessed aspects of this heterogeneity by using geospatial data sets (*6*–*8*), but global assessments using the inputs, outputs, and practices of actual producers have been limited by data. The recent rapid expansion of the life cycle assessment (LCA) literature is providing this information by surveying producers around the world. LCA then uses models to translate producer data into environmental impacts with sufficient accuracy for most decision-making (*9*–*11*).

To date, efforts to consolidate these data or build new large-scale data sets have covered greenhouse gas (GHG) emissions only (*8*, *12*, *13*), agriculture only (*13*–*16*), small numbers of products (*8*, *14*–*16*), and predominantly Western European producers (*12*–*16*) and have not corrected for important methodological differences between LCAs (*12*–*16*). Here, we present a globally reconciled and methodologically harmonized database on the variation in food's multiple impacts. Our results show the need for far-reaching changes in how food's environmental impacts are managed and communicated.

Building the multi-indicator global database

We derived data from a comprehensive meta-analysis, identifying 1530 studies for potential inclusion, which were supplemented with additional data received from 139 authors. Studies were assessed against 11 criteria designed to standardize methodology, resulting in 570 suitable studies with a median reference year of 2010 (*17*). The data set covers ~38,700 commercially viable farms in 119 countries (fig. S2) and 40 products representing ~90% of global protein and calorie consumption. It covers five important environmental impact indicators (*18*): land use; freshwater withdrawals weighted by local water scarcity; and GHG, acidifying, and eutrophying emissions. For crops, yield represents output for a single harvest. Land use includes multicropping (up to four harvests per year), fallow phases (uncultivated periods between crops), and economic allocation to crop coproducts such as straw. This makes it a stronger indicator of both farm productivity and food security than yield.

The system we assess begins with inputs (the initial effect of producer choice) and ends at retail (the point of consumer choice) (fig. S1). For each study, we recorded the inventory of outputs and inputs (including fertilizer quantity and type, irrigation use, soil, and climatic conditions). Where data were not reported, for example, on climate, we used study coordinates and spatial data sets to fill gaps. We recorded environmental impacts at each stage of the supply chain. For GHG emissions, we further disaggregated the farm stage into 20 emission sources. We then used the inventory to recalculate all missing emissions. For nitrate leaching and aquaculture, we developed new models for this study (*17*).

Studies included provided ~1050 estimates of postfarm processes. To fill gaps in processing, packaging, or retail, we used additional meta-analyses of 153 studies providing 550 observations. Transport and losses were included from global data sets. Each observation was weighted by the share of national production it represents, and each country by its share of global production. We then used randomization to capture variance at all stages of the supply chain (*17*).

We validated the global representativeness of our sample by comparing average and 90th-percentile yields to Food and Agriculture Organization (FAO) data (*4*), which reconcile to within ±10% for most crops. Using FAO food balance sheets (*4*), we scaled up our sample data. Total arable land and freshwater withdrawals reconcile to FAO estimates. Emissions from deforestation and agricultural methane fall within ranges of independent models (*17*).

Environmental impacts of the entire food supply chain

Today's food supply chain creates ~13.7 billion metric tons of carbon dioxide equivalents (CO_2eq), 26% of anthropogenic GHG emissions. A further 2.8 billion metric tons of CO_2eq (5%) are caused by nonfood agriculture and other drivers of deforestation (*17*). Food production creates ~32% of global terrestrial acidification and ~78% of eutrophication. These emissions can fundamentally alter the species composition of natural ecosystems, reducing biodiversity and ecological resilience (*19*). The farm stage dominates, representing 61% of food's GHG emissions (81% including deforestation), 79% of acidification, and 95% of eutrophication (table S17).

Today's agricultural system is also incredibly resource intensive, covering ~43% of the world's ice- and desert-free land. Of this land, ~87% is for food and 13% is for biofuels and textile crops or is allocated to nonfood uses such as wool and leather. We estimate that two-thirds of freshwater withdrawals are for irrigation. However, irrigation returns less water to rivers and groundwater than industrial and municipal uses and predominates in water-scarce areas and times of the year, driving 90 to 95% of global scarcity-weighted water use (*17*).

Highly variable and skewed environmental impacts

We now group products by their primary dietary role and express impacts per unit of primary nutritional benefit (Fig. 1 and fig. S3). Immediately apparent in our results is the high variation in impact among both products and producers. Ninetieth-percentile GHG emissions of beef are 105 kg of CO_2eq per 100 g of protein, and

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The Lancet Commissions

Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems

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Executive summary

Food systems have the potential to nurture human health and support environmental sustainability; however, they are currently threatening both. Providing a growing global population with healthy diets from sustainable food systems is an immediate challenge. Although global food production of calories has kept pace with population growth, more than 820 million people have insufficient food and many more consume low-quality diets that cause micronutrient deficiencies and contribute to a substantial rise in the incidence of diet-related obesity and diet-related non-communicable diseases, including coronary heart disease, stroke, and diabetes. Unhealthy diets pose a greater risk to morbidity and mortality than does unsafe sex, and alcohol, drug, and tobacco use combined. Because much of the world's population is inadequately nourished and many environmental systems and processes are pushed beyond safe boundaries by food production, a global transformation of the food system is urgently needed.

The absence of scientific targets for achieving healthy diets from sustainable food systems has been hindering large-scale and coordinated efforts to transform the global food system. This Commission brings together 19 Commissioners and 18 coauthors from 16 counties in various fields of human health, agriculture, political sciences, and environmental sustainability to develop global scientific targets based on the best evidence available for healthy diets and sustainable food production. These global targets define a safe operating space for food systems that allow us to assess which diets and food production practices will help ensure that the UN Sustainable Development Goals (SDGs) and Paris Agreement are achieved.

We quantitatively describe a universal healthy reference diet to provide a basis for estimating the health and environmental effects of adopting an alternative diet to standard current diets, many of which are high in unhealthy foods. Scientific targets for a healthy reference diet are based on extensive literature on foods, dietary patterns, and health outcomes. This healthy reference diet largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes a low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables. The global average intake of healthy foods is substantially lower than the reference diet intake, whereas overconsumption of unhealthy foods is increasing. Using several approaches, we found with a high level of certainty that global adoption of the reference dietary pattern would provide major health benefits, including a large reduction in total mortality.

The Commission integrates, with quantification of universal healthy diets, global scientific targets for sustainable food systems, and aims to provide scientific boundaries to reduce environmental degradation caused by food production at all scales. Scientific targets for the safe operating space of food systems were established for six key Earth system processes. Strong evidence indicates that food production is among the largest drivers of global environmental change by contributing to climate change, biodiversity loss, freshwater use, interference with the global nitrogen and phosphorus cycles, and land-system change (and chemical pollution, which is not assessed in this Commission). Food production depends on continued functioning of biophysical systems and processes to regulate and maintain a stable Earth system; therefore, these systems and processes provide a set of globally systemic indicators of sustainable food production. The Commission concludes that quantitative scientific targets constitute universal and scalable planetary boundaries for the food system. However, the uncertainty range for these food boundaries remains high because of the inherent complexity in Earth system dynamics.

Diets inextricably link human health and environmental sustainability. The scientific targets for healthy diets and sustainable food systems are integrated into a common framework, the safe operating space for food systems, so that win-win diets (ie, healthy and environmentally sustainable) can be identified. We propose that this framework is universal for all food cultures and production systems in the world, with a high potential of local adaptation and scalability.

Application of this framework to future projections of world development indicates that food systems can provide healthy diets (ie, reference diet) for an estimated global population of about 10 billion people by 2050 and remain within a safe operating space. However, even small increases in consumption of red meat or dairy foods would make this goal difficult or impossible to achieve. Within boundaries of food production, the reference diet can be adapted to make meals that are

How do your food choices impact on the environment?

Which food would you like?

- Select a food or drink -

How often do you have it?

- Select how often -

Find out

Choose Food Category

Choose Food Type

Servings: 1

Weight(g):

ENTER FOOD SELECTION

Food	Weight (g)

CALCULATE DAILY FOOD EMISSIONS

COOL FOOD*

WORLD RESOURCES INSTITUTE

PROTEIN SCORECARD

What you put on your plate has a large impact on the environment. Research by WRI and its partners shows that meat and dairy are generally more resource-intensive to produce than plant-based foods, increasing pressure on land, water and the climate. Small dietary shifts—such as switching from beef to pork, or poultry to beans—can significantly reduce agricultural resource use and greenhouse gas (GHG) emissions. Use this scorecard to lower your diet's impacts in a way that works for you.

Read more at **wri.org/shiftingdiets** join the conversation **#ShiftingDiets**

	FOOD	IMPACT (GHG emissions per gram of protein)	COST (Retail price per gram of protein)
LOW	Wheat		$
	Corn		$
	Beans, chickpeas, lentils		$
	Rice		$
	Fish		$$$
	Soy		$
	Nuts		$$$
	Eggs		$$
MEDIUM	Poultry		$$
	Pork		$$
	Dairy (milk, cheese)		$$
HIGH	Beef		$$$
	Lamb & goat		$$$

Lighter shade shows emissions from agricultural production, darker shade shows emissions from land-use change.

How Much Protein Do You Need?

The average daily adult protein requirement is 56g for a man and 46g for a woman but many people consume much more than they need.

REQUIREMENT | OVERCONSUMPTION

0g — average daily adult protein requirement 51g — average US daily protein consumption 83g

Sources: GlobAgri-WRR model developed by CIRAD, Princeton University, INRA, and WRI (GHG data); USDA and BLS (2016) (US retail price data). *Notes:* see www.wri.org/proteinscorecard.

Images: BBC, WRI, foodemissions.com

Environment

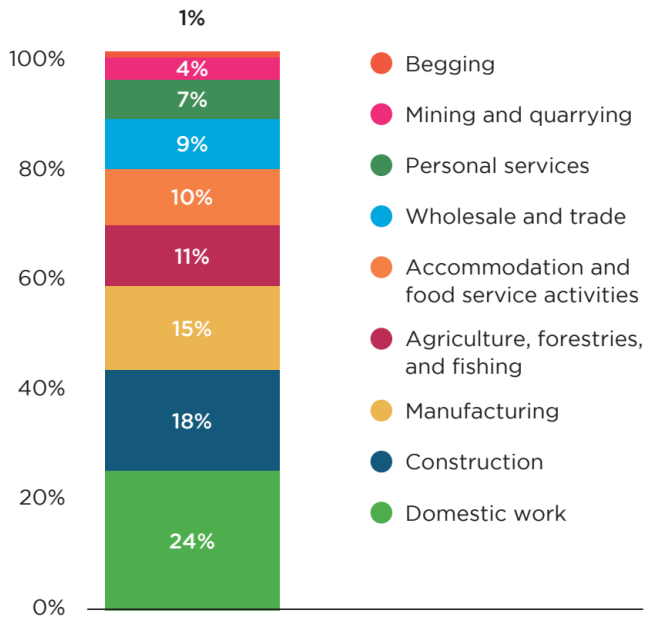
Social

Health

Economic

Image: PBS Frontline

What is forced labor?



"situations in which persons are coerced to work through the use of violence or intimidation, or by more subtle means such as accumulated debt, retention of identity papers, or threats of denunciation to immigration authorities"*(ILO 2014)*

In 2016: 1.8 million victims of forced labor in agriculture, fishing, forestry *(ILO and Walk Free Foundation 2017)*

SDG 8.7: "Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking…"

Objective

Assess the risk of forced labor associated with fruits and vegetables consumed in the US by compiling distinct datasets and developing a new forced labor risk scoring method

Image: NYT

Blackstone, N.T., Benoit Norris, C,. Robbins, T., Jackson, B., & Decker Sparks, J.L. (2021). Risk of forced labour embedded in the U.S. fruit and vegetable supply. *Nature Food.* https://doi.org/10.1038/s43016-021-00339-0

What is Social LCA (S-LCA)?

- Method to assess the potential social impacts of a product or service across its life cycle
- Combines some of the modeling capabilities of environmental LCA with social science methods
  - Quantitative and qualitative data

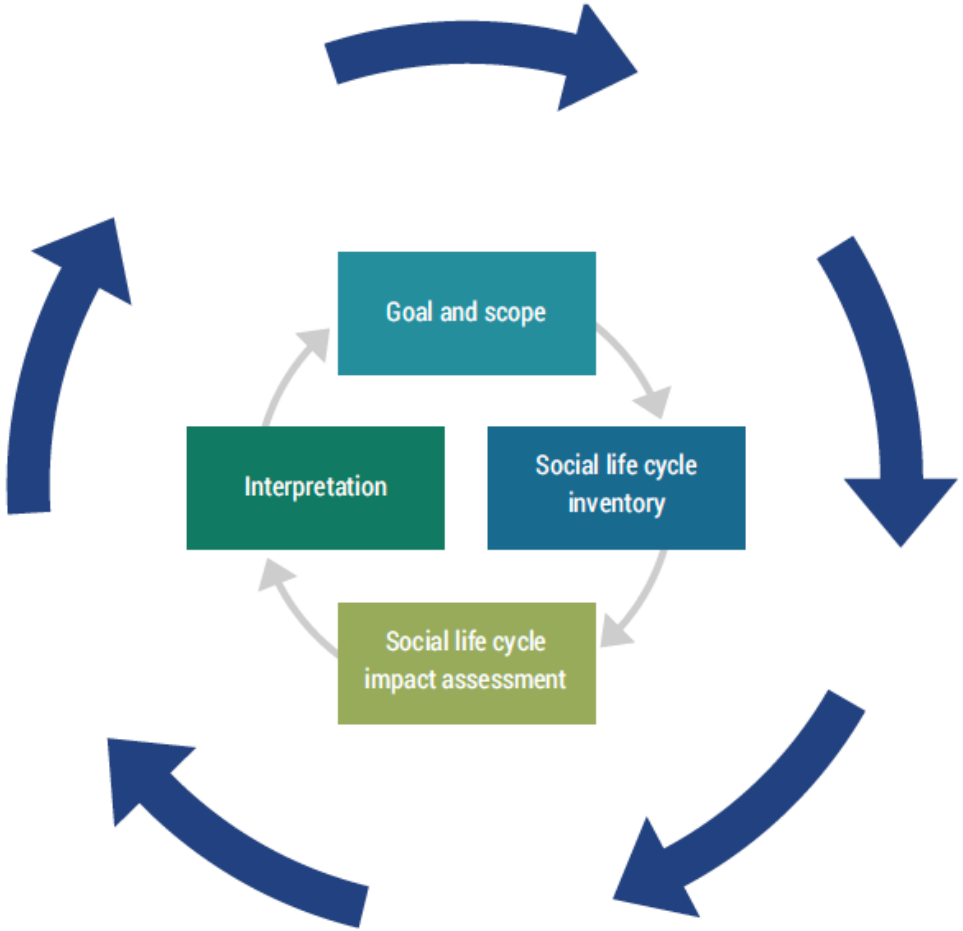
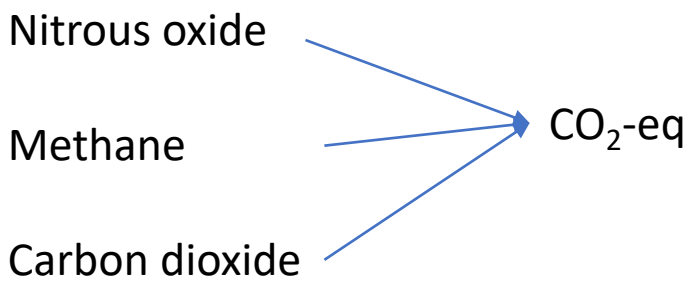


Image: UNEP 2020

Social LCA approach

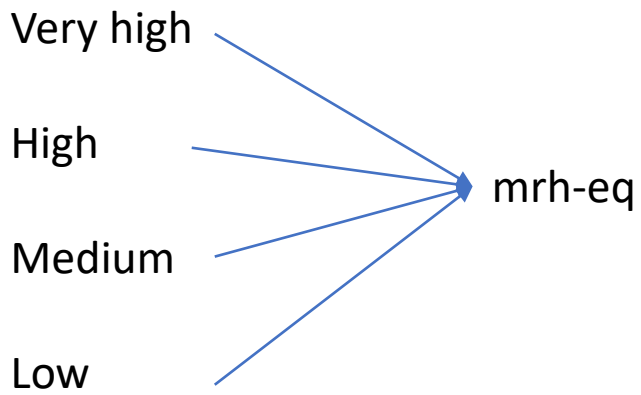
ENVIROMENTAL LCA

Area of protection	Category	Units
Ecosystem quality	Climate change	kg CO_2-eq
Natural resources	Land use	m^2

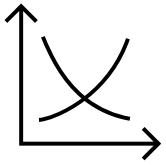


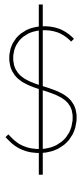
SOCIAL LCA

Stakeholder	Category	Subcategory	Units
Workers	Working conditions	Forced labor	Medium risk hours eq.



Methods





Several steps and sources to compute risk:

- Supply and origin data
- Labor intensity
  - Hours worked/$1 of country-specific sector output
  - Producer prices
- Qualitative risk coding for each commodity-country combination
- Qualitative codes ⇨ quantitative scores

Methods: qualitative risk coding

Table 1 | Qualitative coding of forced labour risk levels

Risk level	Known occurrences (85% of score)			Government response[d] (15% of score)
	Step 1: commodity–country[a]	Step 2: sector–country[b]	Step 3: country[c]	
Very high	Commodity reportedly produced with forced labour; at least one account of forced labour	NA	NA	Tier 3 rank
High	Commodity is hand harvested and evidence of sector–country risk exists	Forced labour, debt bondage or labour trafficking occurs in the sector	>0.70% of people enslaved	Tier 2W rank
Medium	Concern/ indicators of risk present	At least one account or report of forced labour, debt bondage or trafficking for labour in the sector	>0.30% of people enslaved	Tier 2 rank
Low	NA	Concern/ indicators of risk present	>0.20% of people enslaved	Tier 1 rank
Very low	NA	NA	<0.19% of people enslaved	NA

[a]Data from refs. [6,24,56–59]. [b]Data from refs. [53,54]. [c]Data from ref. [55]. [d]Data from ref. [54].

Blackstone et al. 2021, *Nature Food*

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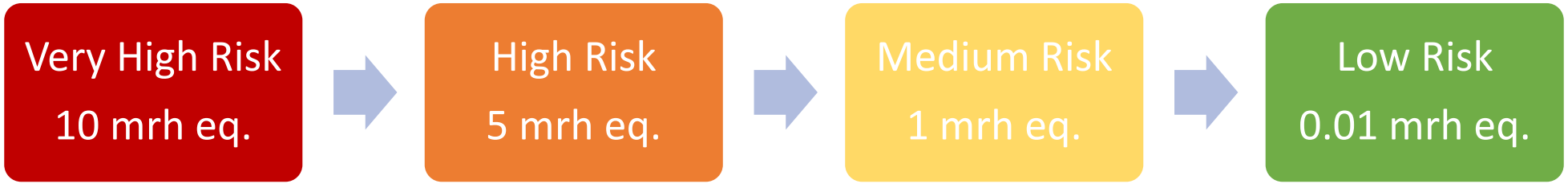
Methods: quantitative scoring

Applied characterization factors from the Social Hotspots Database to convert qualitative codes ⇨ quantitative risk scores

Units: medium-risk hour equivalent (mrh-eq)



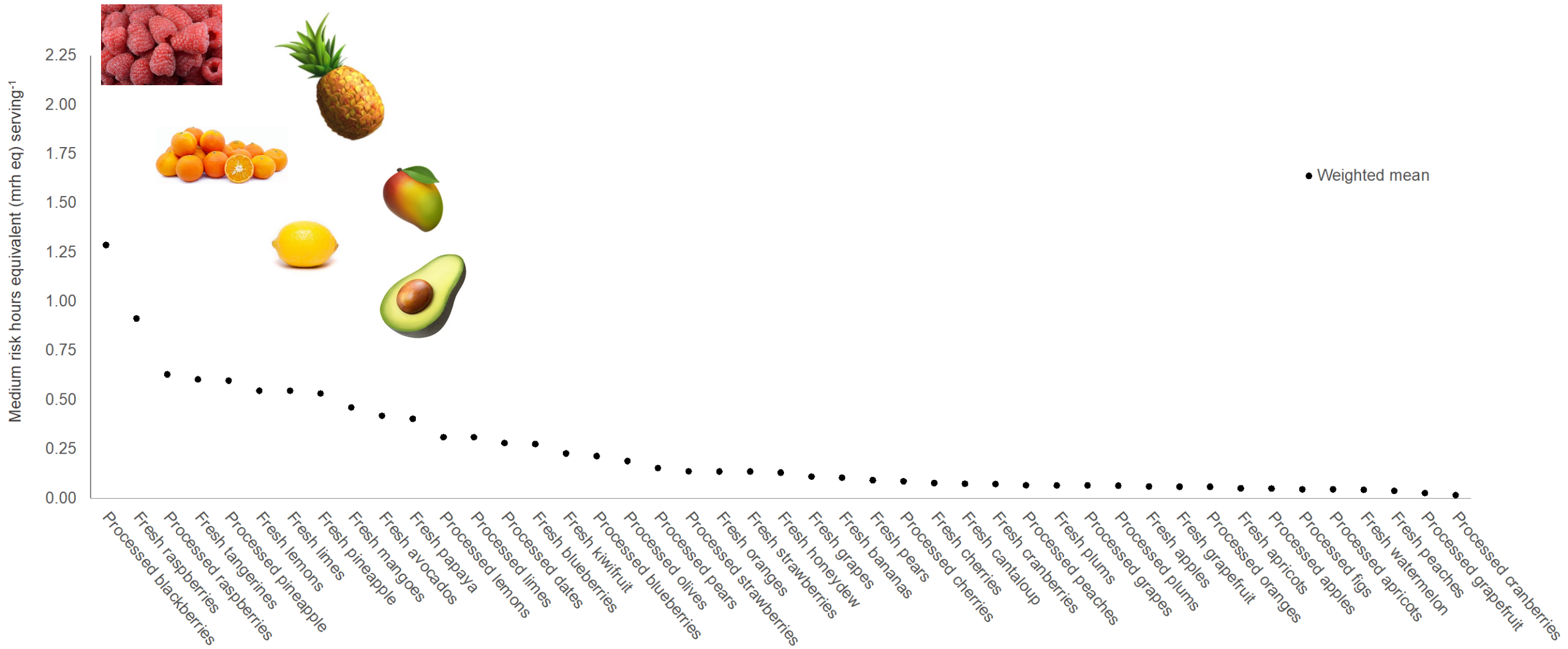


Figure 1: Weighted mean, maximum, and minimum estimated risk of forced labor per serving of fruits consumed in the US

(Blackstone et al., 2021, *Nature Food*)

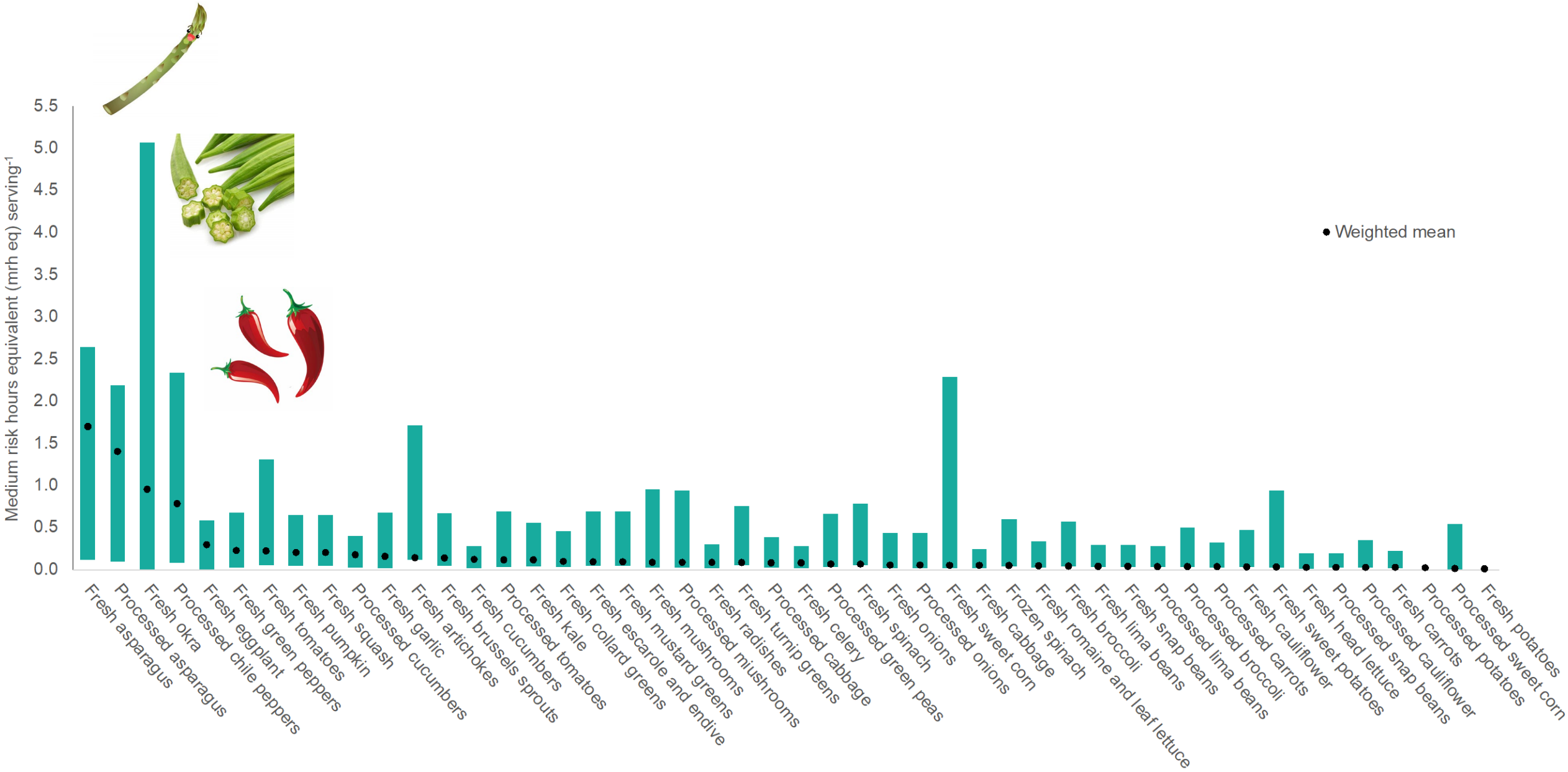
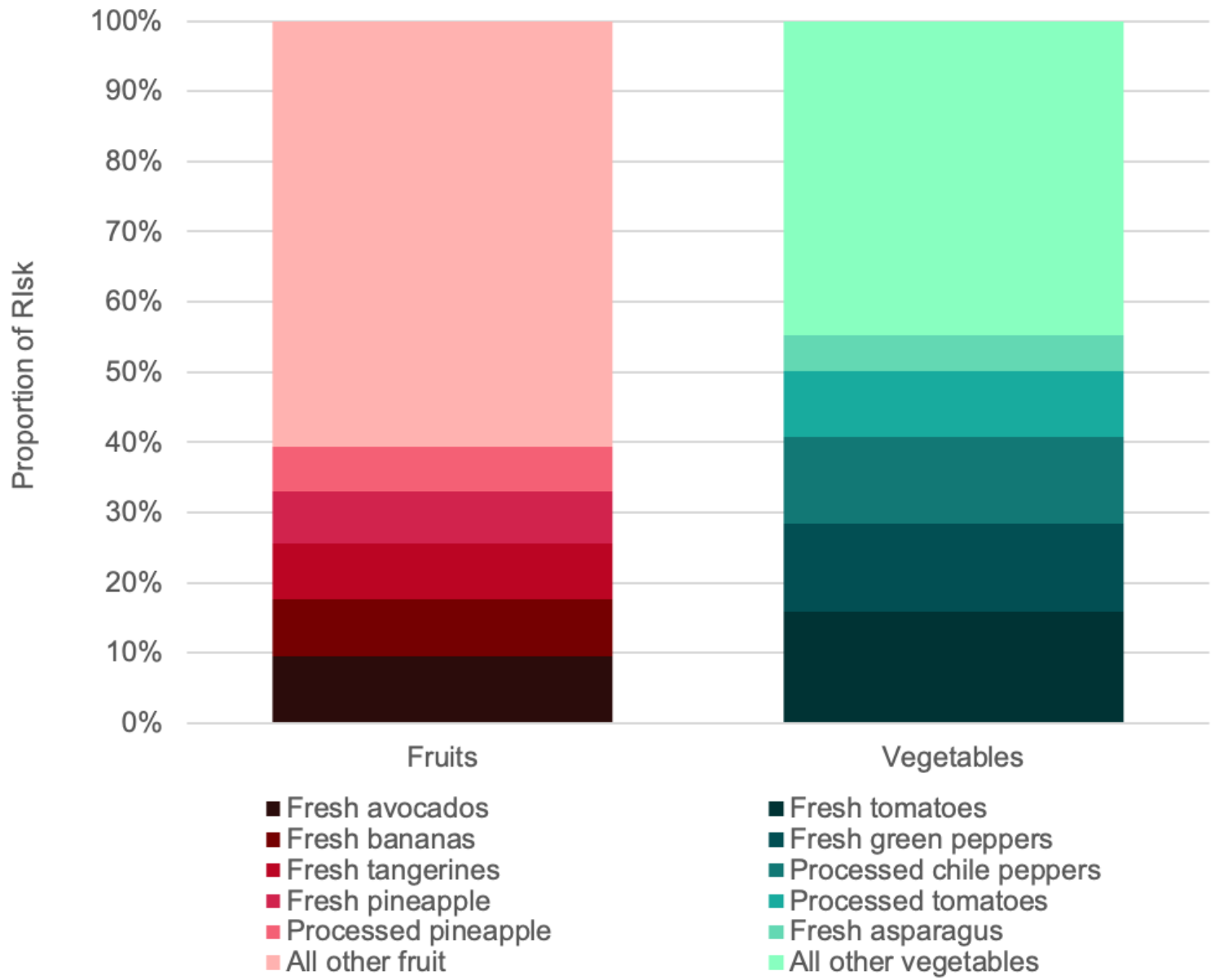


Figure 2: Weighted mean, maximum, and minimum estimated risk of forced labor per serving of vegetables consumed in the US



Includes **wasted risk:**

13% of fruit
12% of vegetables

Figure 3: Top five commodities as proportion of total forced labor risk in the fruit and vegetable supplies

(Blackstone et al., 2021. *Nature Food*)

Discussion

Risk identified in a broader set of fruits and vegetables than previously represented

- 85% qualitatively coded as high risk, 7% as very high risk

Importance of supply-level view

- Allows for targeted response by retailers
- Helps prevent displacement of risk
- Makes additional “cost” of food waste visible

Discussion

Companies: use for risk-based human rights due diligence

40% do not have public commitments (WBA 2021)

Consumers: demand produce with proven certifications, such as the Fair Food Program

Governments: invest in M&E, inform public procurement

Image: Fair Food Program

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Limitations

Labor intensity data only available at country-sector level (e.g., fruit and vegetable production in US)

Data gaps

- Absence of data ≠ absence of risk
- 57% of commodity-country combinations relied on Step 1 data…

Addressing data gaps

Expanding the risk dataset | Assessing data quality transparently

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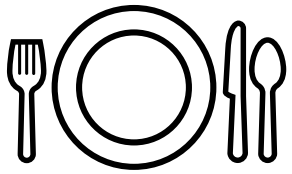
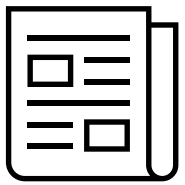
Expanding the risk dataset



F&V ⇨ all food commodities



Investigative journalism search

- Initial search (n=86,116): completed
- First round screen (n=38,207): completed

Qualitative hand coding (n= 709): in process

- 2016-2019 inclusive
- Coding by two investigators; differences reconciled through discussion
- Covering 99 commodities

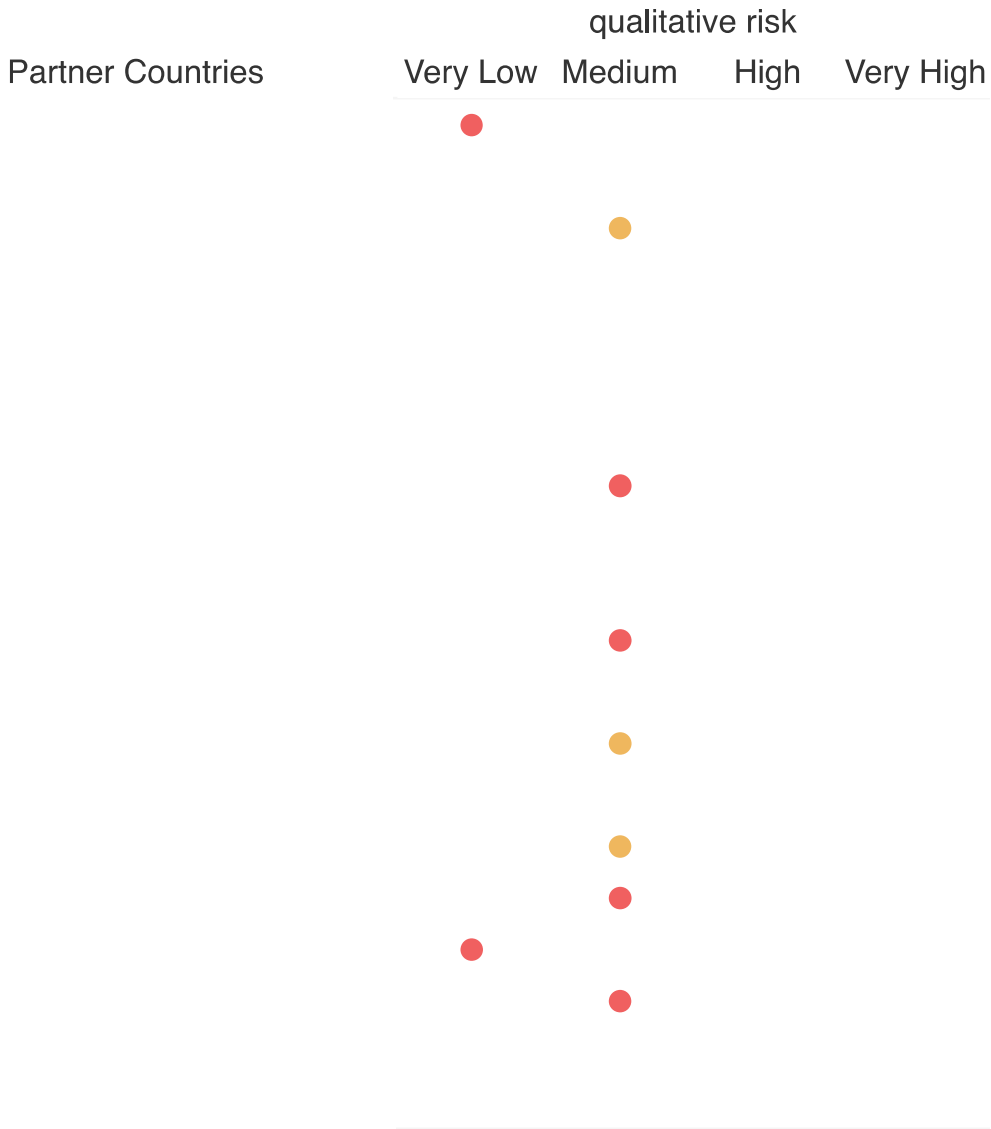
Blueberries example

Country	Low	Medium	Very High	Risk Level
United States	1	5	1	Medium
Argentina	-	1	-	Medium
Canada	-	3	-	Medium
Australia	-	1	-	Medium

Forced labor risk of blueberries

Sorted by data quality, risk level

Bubble size = % of supply (by mass)



Next Steps

Expanding the analysis to the US food supply

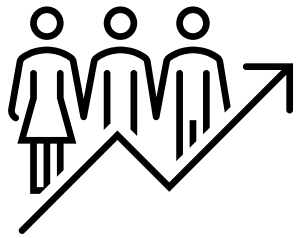
Integration with upstream data for full supply chain risk

Assessing forced labor risk of dietary patterns

The LASTING Project

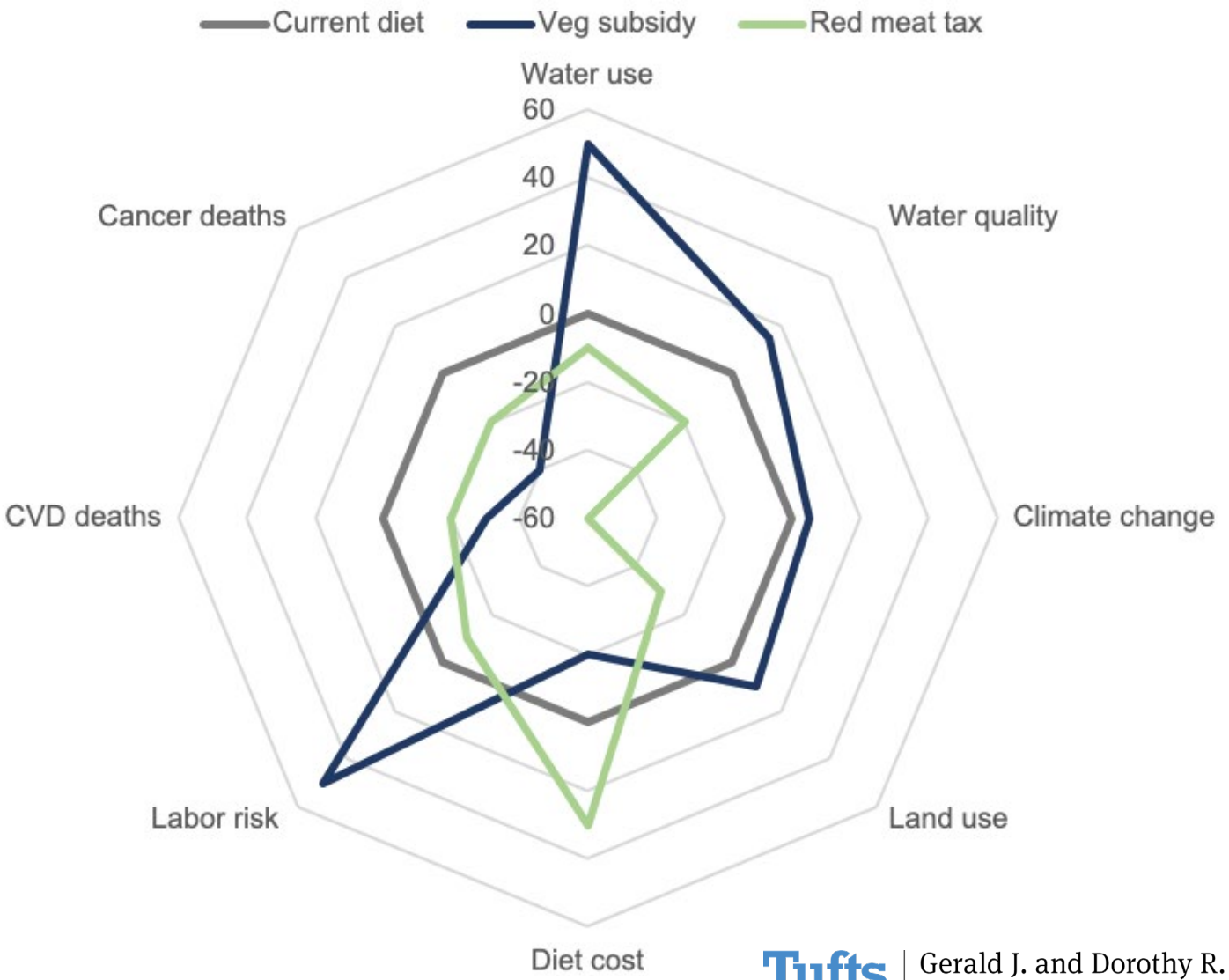
LASTING vision

Identify tradeoffs



Evidence-based

decision making



Our team and support

Team

- Dr. Jess Sparks (Rights Lab)
- Dr. Nicole Tichenor Blackstone (Tufts)
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Q&A

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Bringing it together

Origin country (supply proportion)	Risk code	Impact assessment	Labor intensity	Price	Risk per serving (weighted)
U.S. (0.93) →	Very High →	10 mrh-eq ×	0.0096 hours/$1 produced ×	$0.85/serving fresh strawberries =	0.084 mrh-eq/average serving
Mexico (0.07) →	Medium →	1 mrh-eq ×	0.149 hours/$1 produced ×		

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