A close-up photograph of a hand holding a green spray bottle, spraying a field of green tomatoes. The tomatoes are arranged in neat rows, and the background is a vast field of similar plants under a bright sky.

Global Metabolism

The Impact of Food Systems on Human Health

An Overview of Interconnections

BIO-413 Planetary Health

14 December 2023

Prof. Giovanni D'Angelo

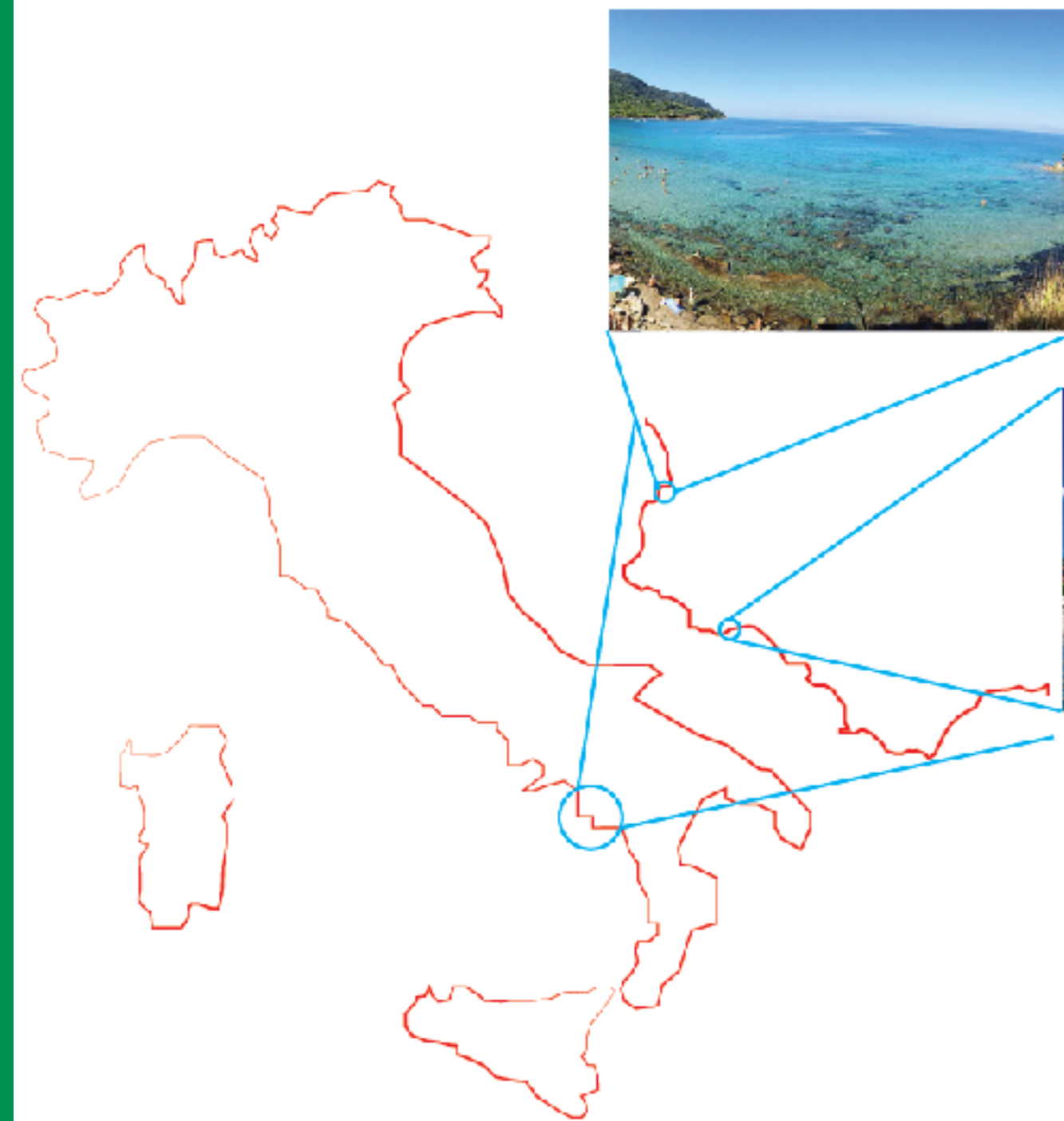
Kristian Gerhard Jebsen Chair on Metabolism

Institute of Bioengineering

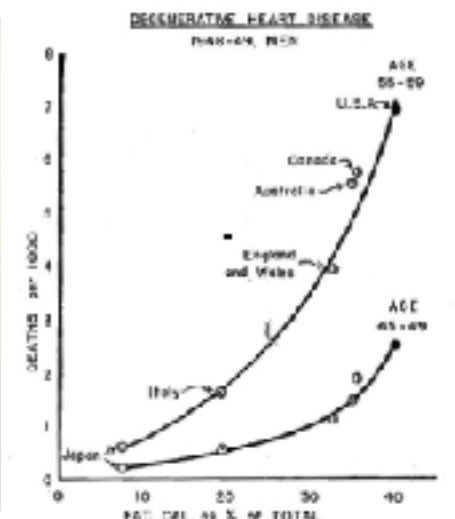
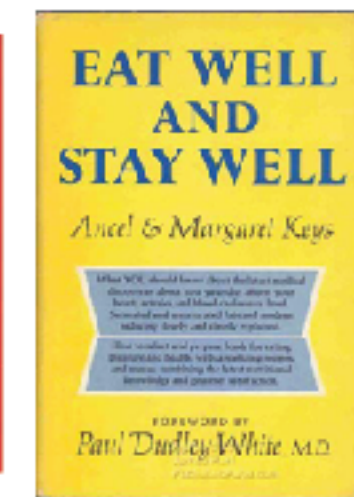
Laboratory of Lipid Cell Biology

giovanni.dangelo@epfl.ch

Angel Keys



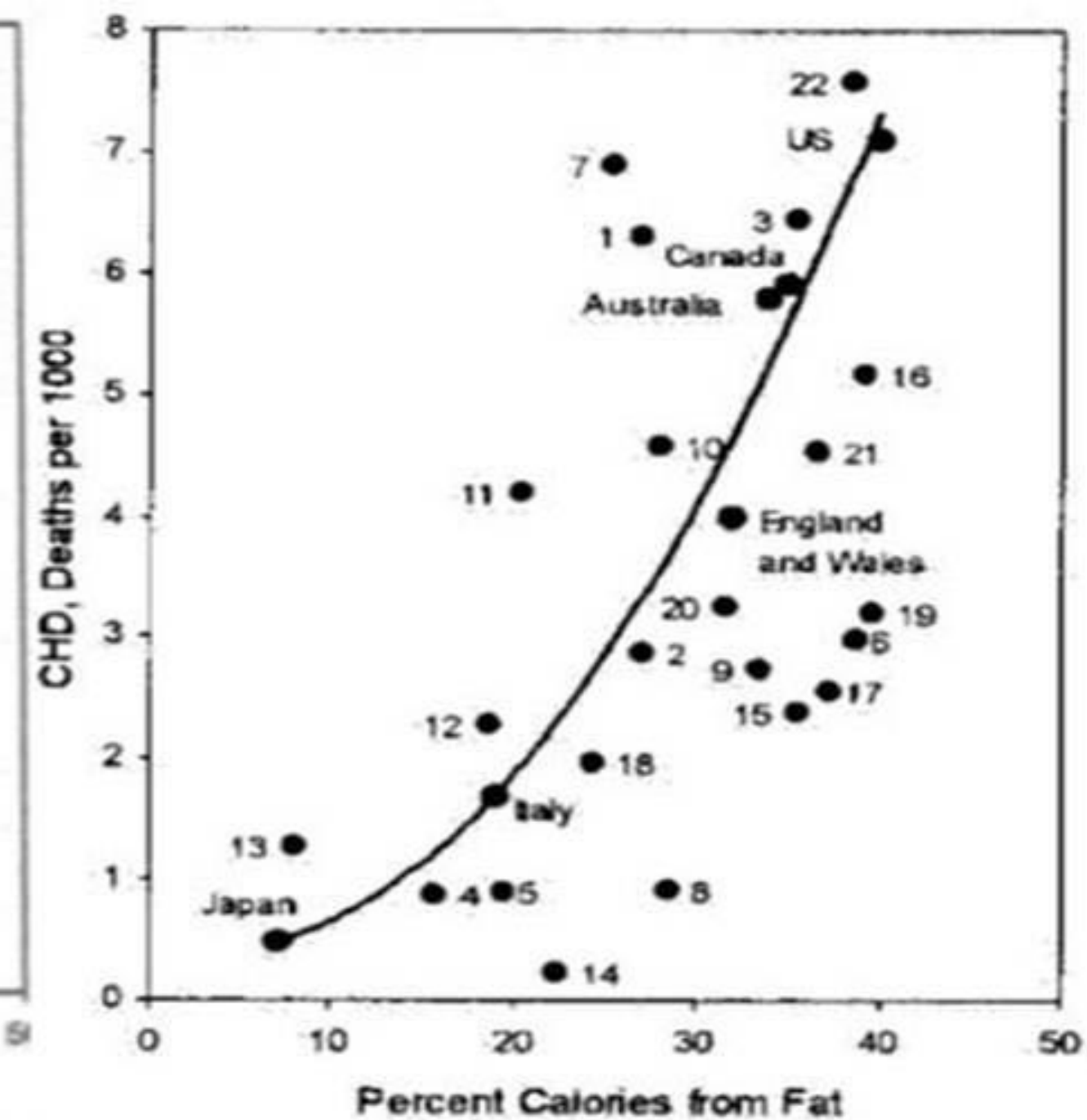
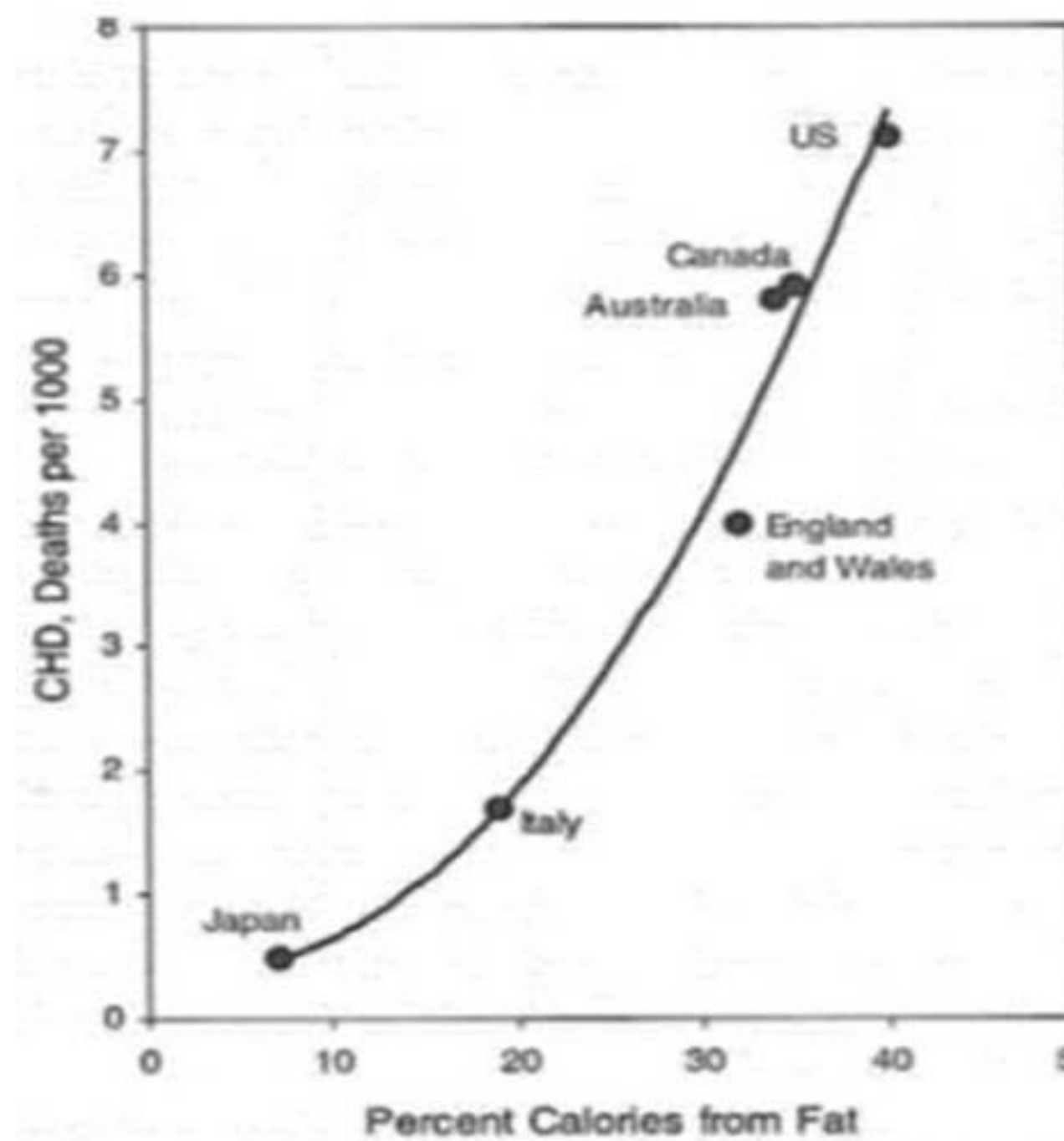
Importance of nutrition for human health



'The major findings were (1) there was a close correlation between the percentage of dietary **calories from total fats** and 10-y **coronary deaths** per 10,000 men; (2) median blood **cholesterol** values were highly correlated with **coronary heart disease** deaths, accounting for 64% of the variance in coronary heart disease death rates among the cohorts'

Angel Keys

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Goldstein and Brown

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1985

Goldstein and Brown

LDL Receptors on Liver Cells

	Normal	FH Heterozygote	FH Homozygote
<i>Plasma LDL Level</i>		↑ 2-3 Fold	↑ 8-10 Fold
<i>Population Frequency</i>		1 in 500	1 in 10 ⁶
<i>Age for Heart Attacks</i>		35-65 years	5-15 years

Global Metabolism

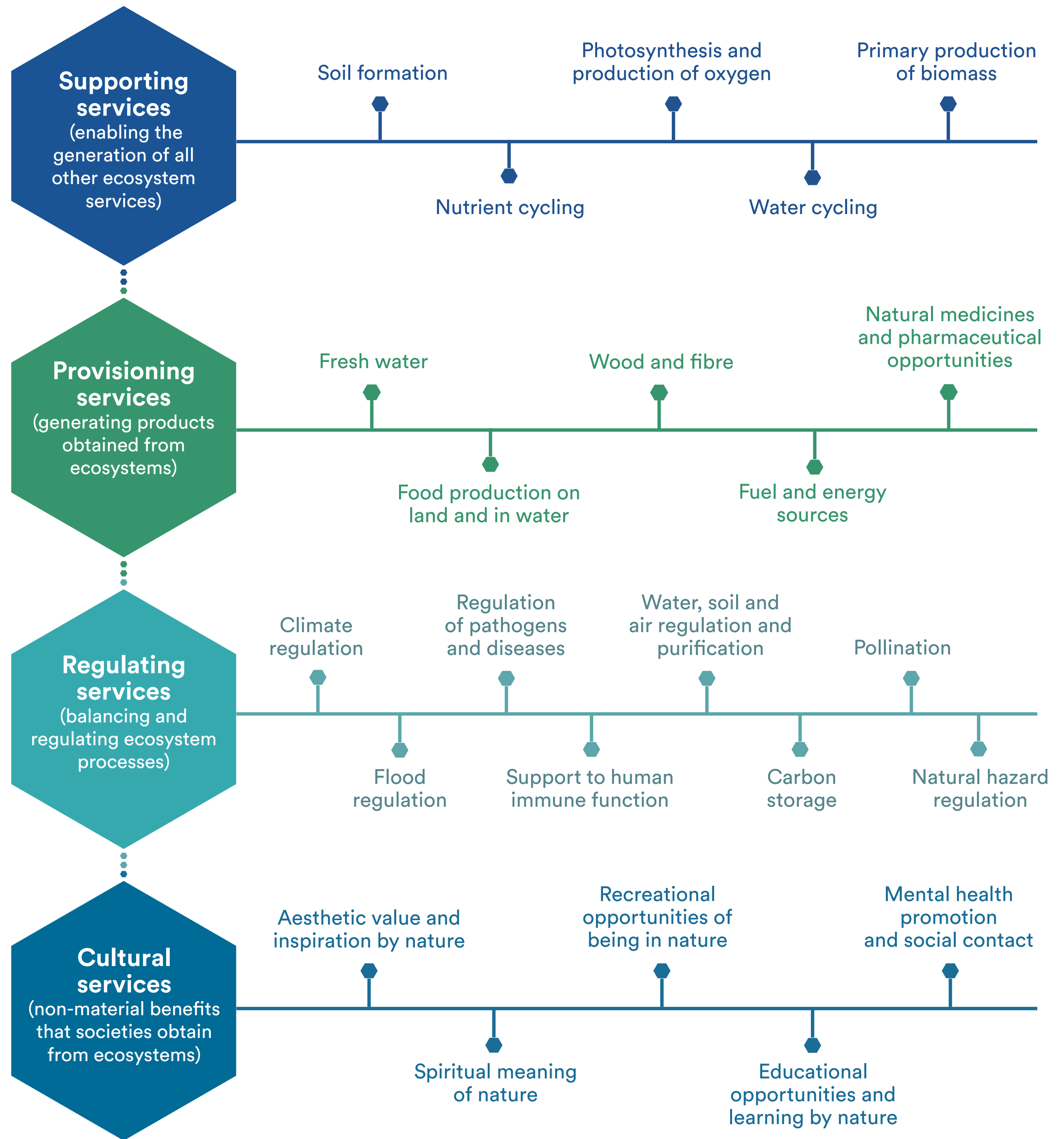
Learning outcomes for today

- Familiarise yourselves with the **interconnections** between **food** and **health**
- Critically analyse how changing **food systems** pose risks to **health**

Human Health

- A **dynamic** state of **physical, mental, and social well-being**
- **NOT** the **absence of disease**
- Responds constantly to **environmental, social, biological, emotional, and cognitive** conditions

Food Systems and Health



Food Systems and Health



Food Systems

Food Systems

Human built systems devoted to production, transportation, processing, and distribution of food.

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Food Systems

Human built systems devoted to production, transportation, processing, and distribution of food.

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Problem !!!

ensure food system transformation amidst globalisation and environmental changes

while

preserving human well-being

Problem !!!

Food Systems

Human built systems devoted to production, transportation, processing, and distribution of food.

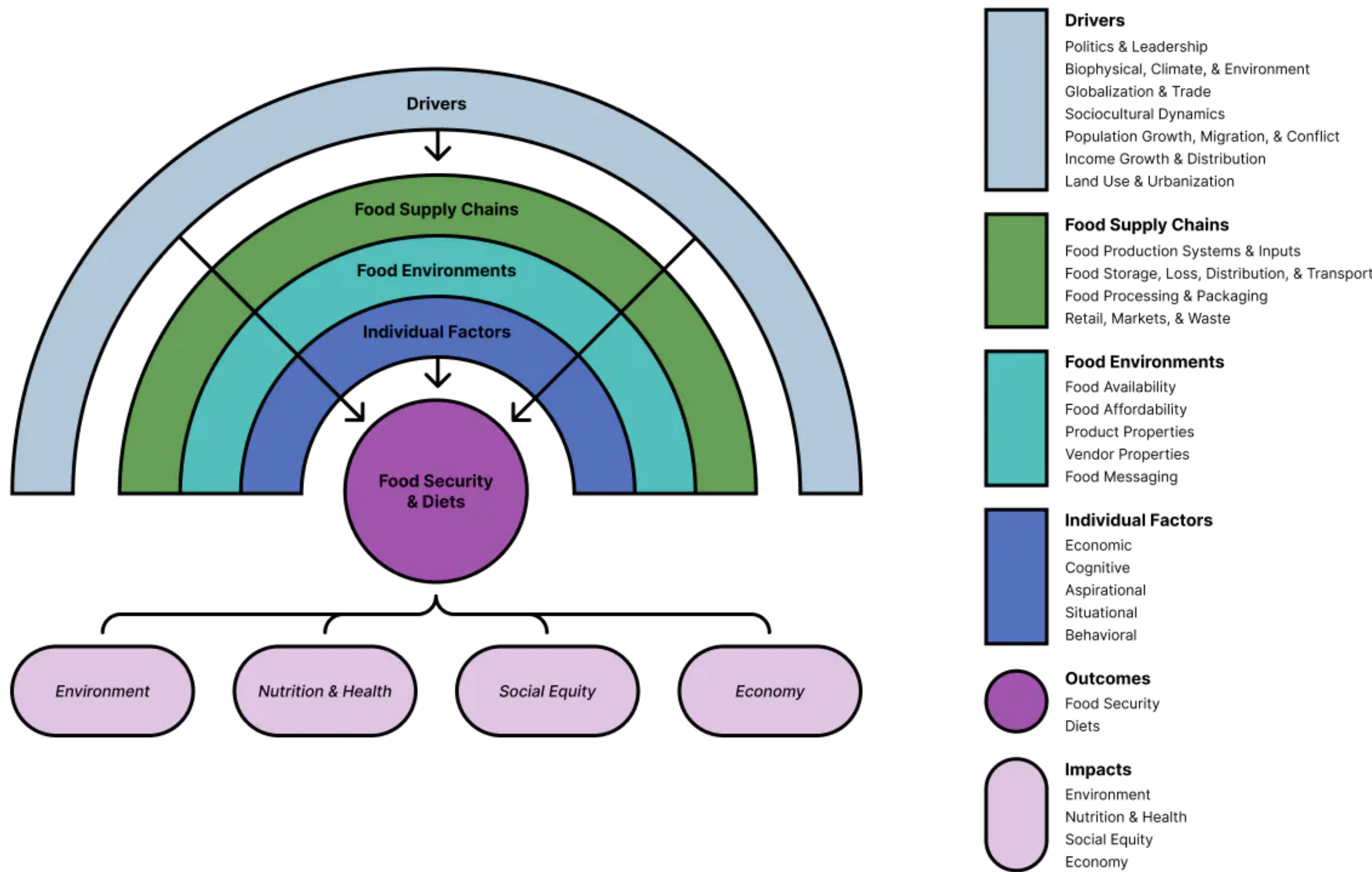
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Food systems affect health in many ways. For example, worldwide

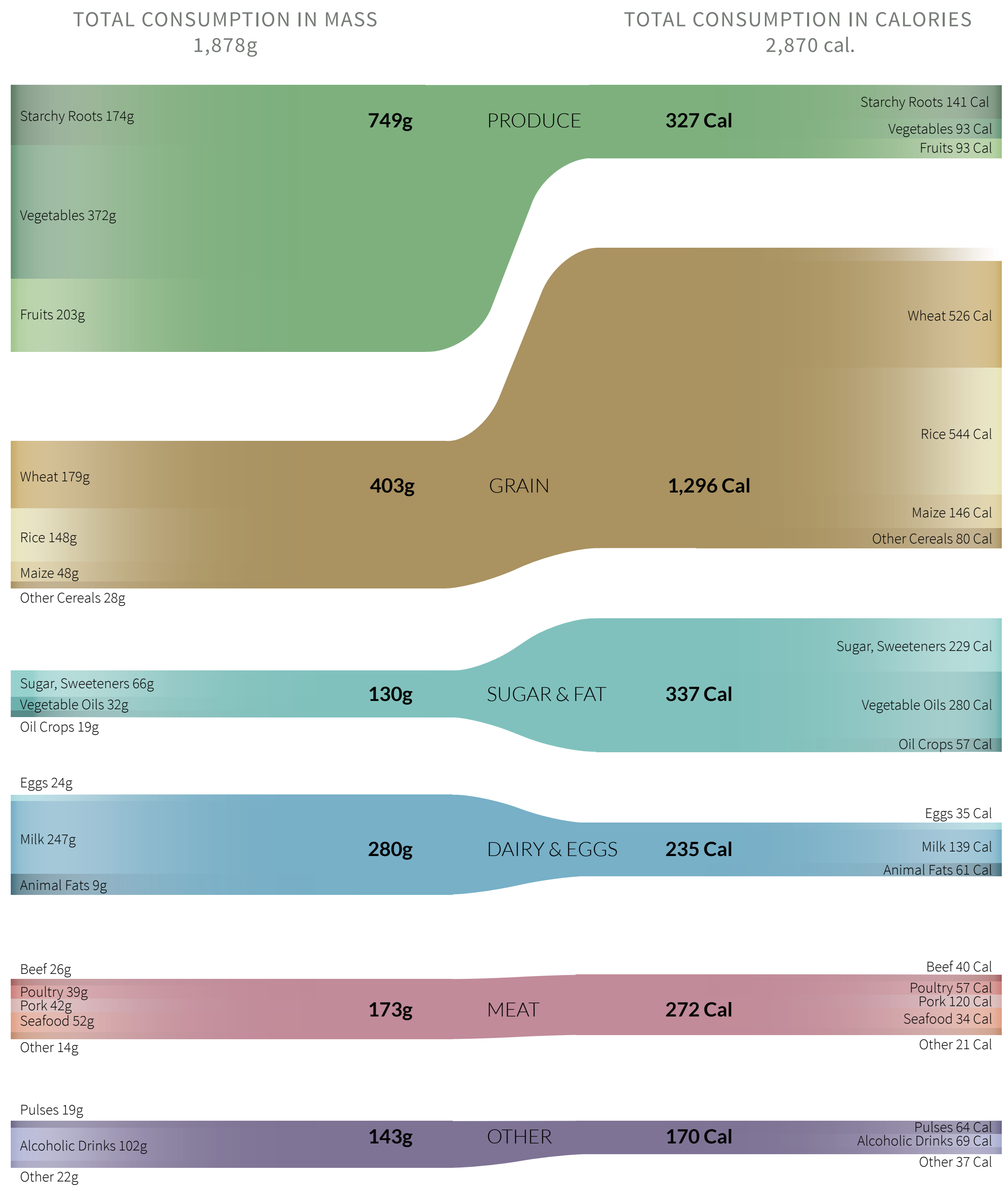
690 million people are hungry, 2 billion people have **micronutrient deficiencies** and there are **677.6 million adults with obesity**; each year **zoonoses** are responsible for **2.5 billion cases** of **human illness** and **2.7 million human deaths worldwide**; at least **700 000 people die due to drug-resistant diseases**; **44% of farmers** are **poisoned by pesticides**; and at least **170 000 agricultural workers** are killed.

A Changing World

Driving Trends

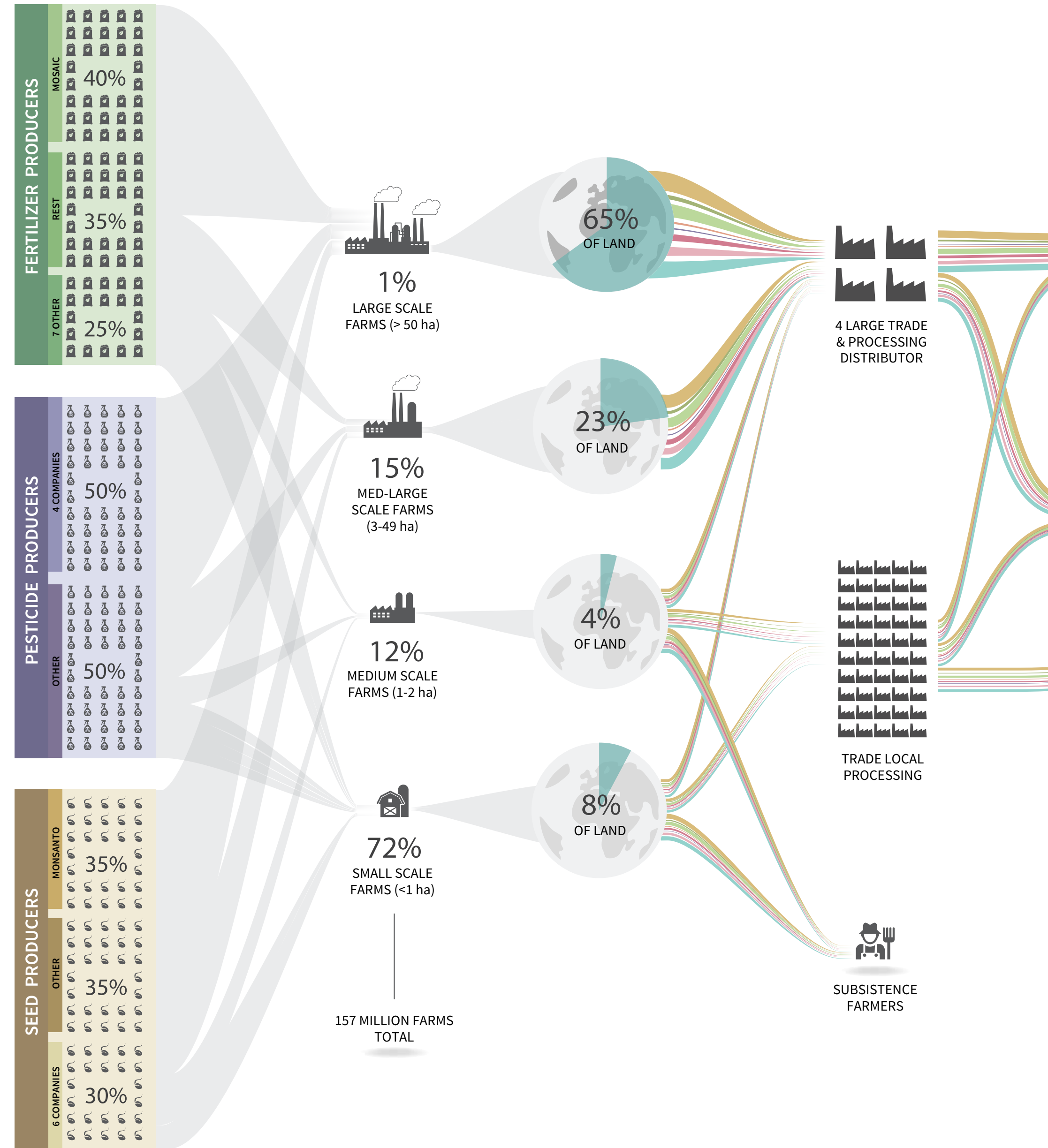


Global Food Consumption



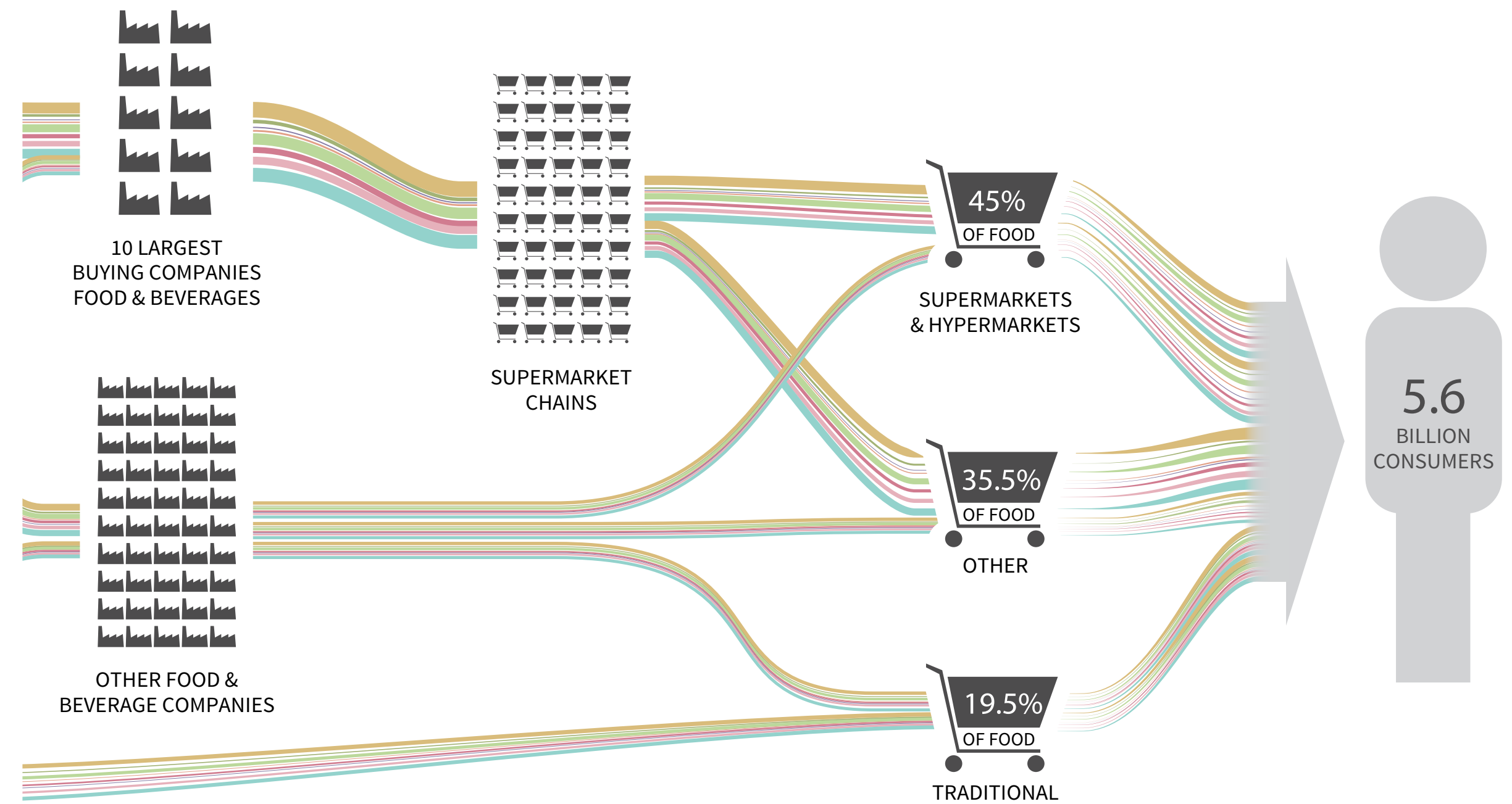
Global Food Consumption

Food Supply Chains



Global Food Consumption

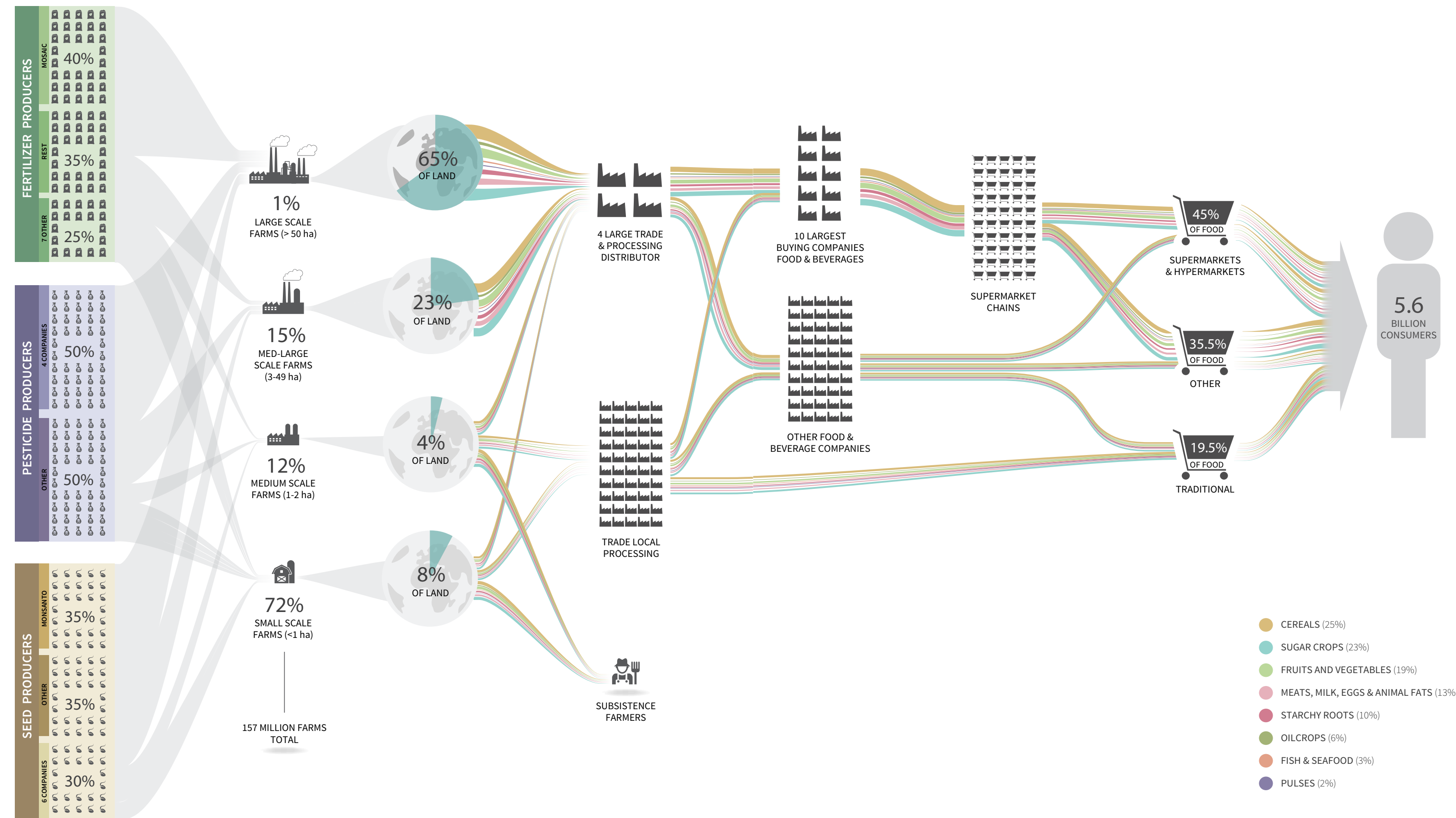
Food Supply Chains



- CEREALS (25%)
- SUGAR CROPS (23%)
- FRUITS AND VEGETABLES (19%)
- MEATS, MILK, EGGS & ANIMAL FATS (13%)
- STARCHY ROOTS (10%)
- OILCROPS (6%)
- FISH & SEAFOOD (3%)
- PULSES (2%)

Food Supply Chains

Global Food Consumption



Globalisation

Driving Trends



GLOBALISATION HAS CREATED SPACE FOR LARGE RETAILERS TO DOMINATE OVER MUCH OF THE DEVELOPED AND DEVELOPING WORLD. TODAY 51% OF GLOBAL FOOD SALES ARE PURCHASED THROUGH SUPERMARKETS AND HYPERMARKETS. FOOD SALES THROUGH THESE CHANNELS ARE GROWING AT AN ANNUAL RATE OF 2%.

Driving Trends

Globalisation

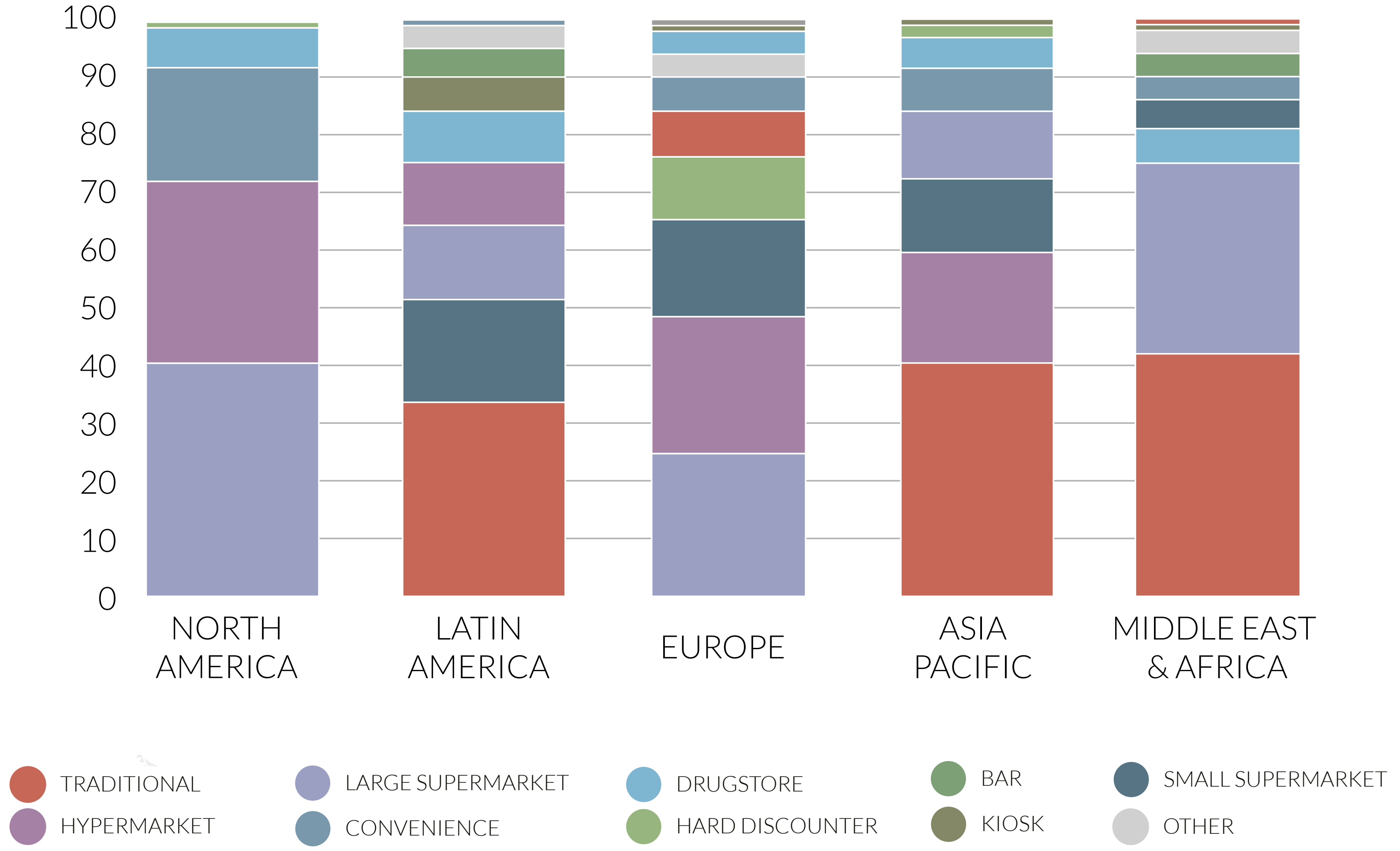
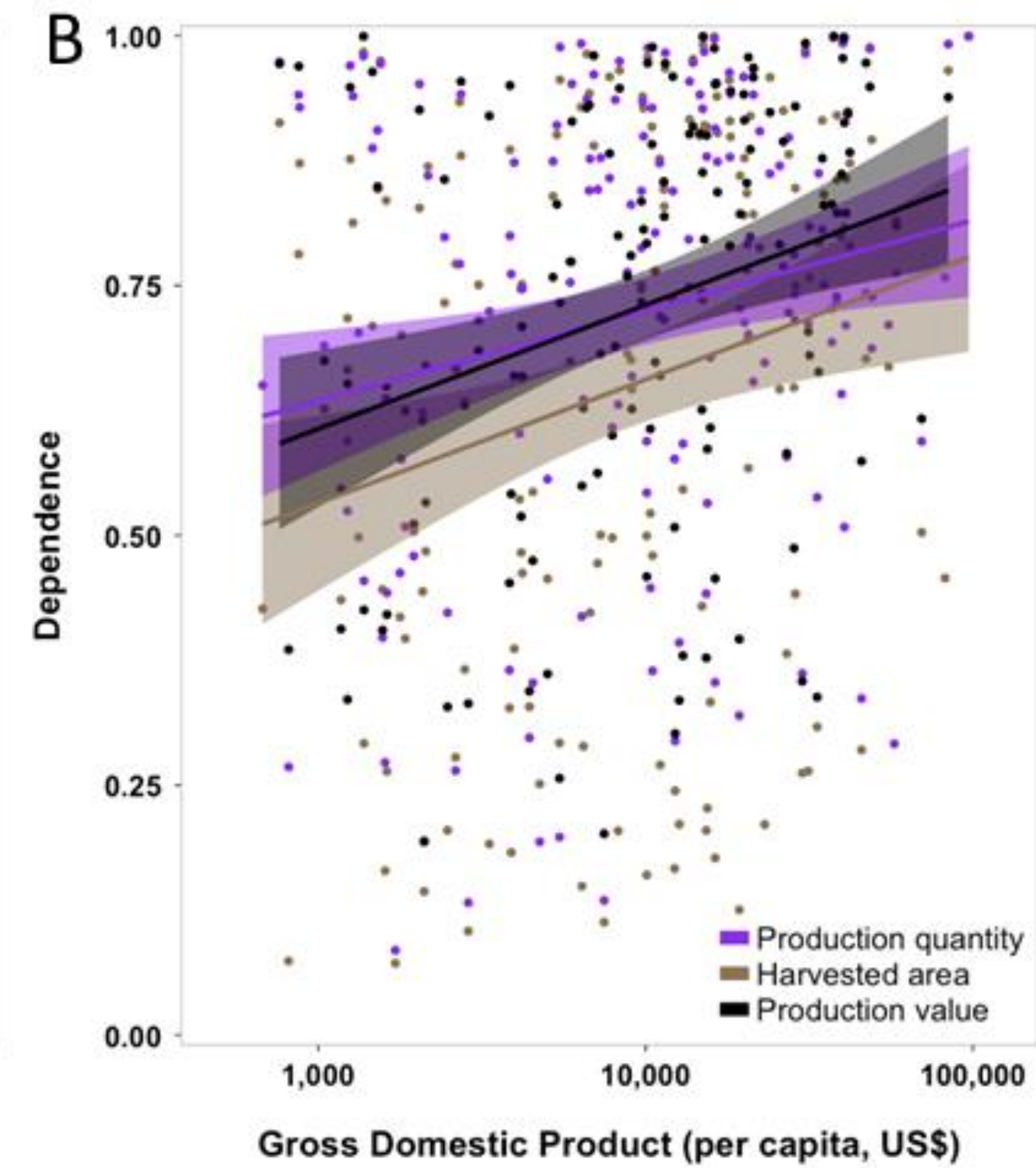
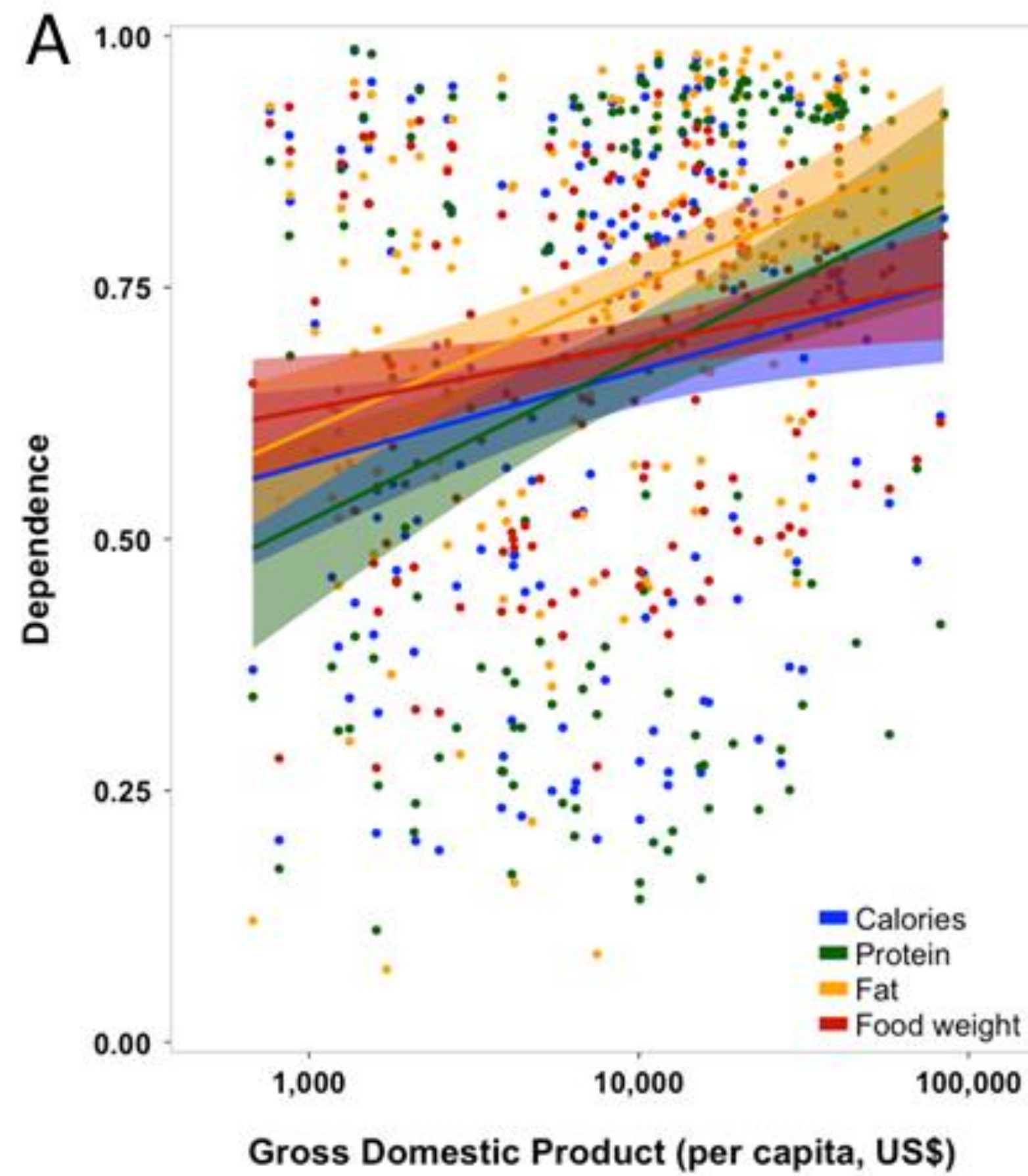


Figure 10: An overview of the different types of food retail channels in each region of the world. (Adapted directly from Nielsen "The Future of Grocery," 2015)

Gross Domestic Product

Driving Trends



Food Environment

Driving Trends

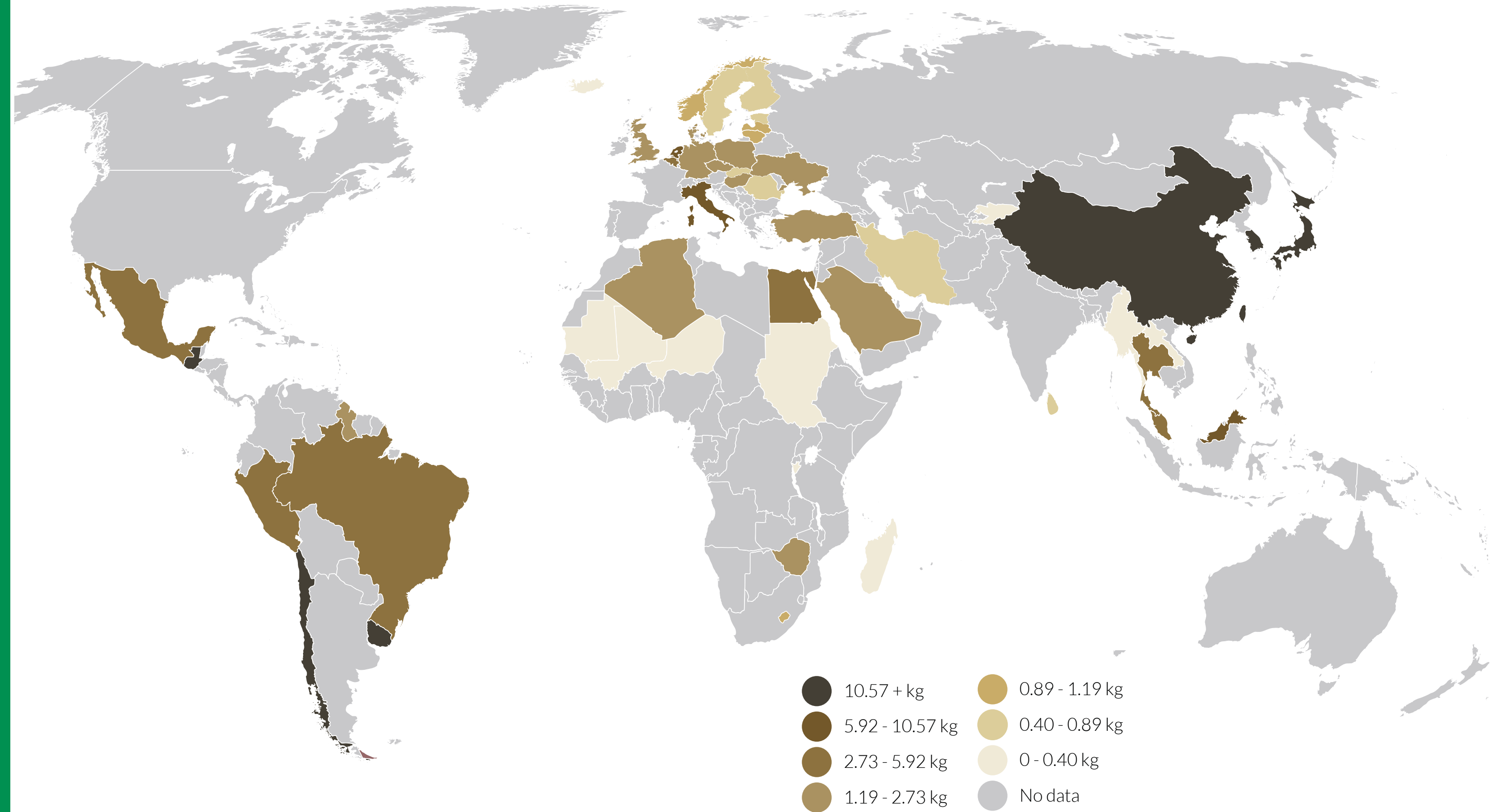


Figure 22: Pesticide use per area (kg pesticide use per hectare arable land). (FAO, 2015b)

Food Environment

PESTICIDE, WATER, AND FERTILIZER USE PER FOOD CATEGORY

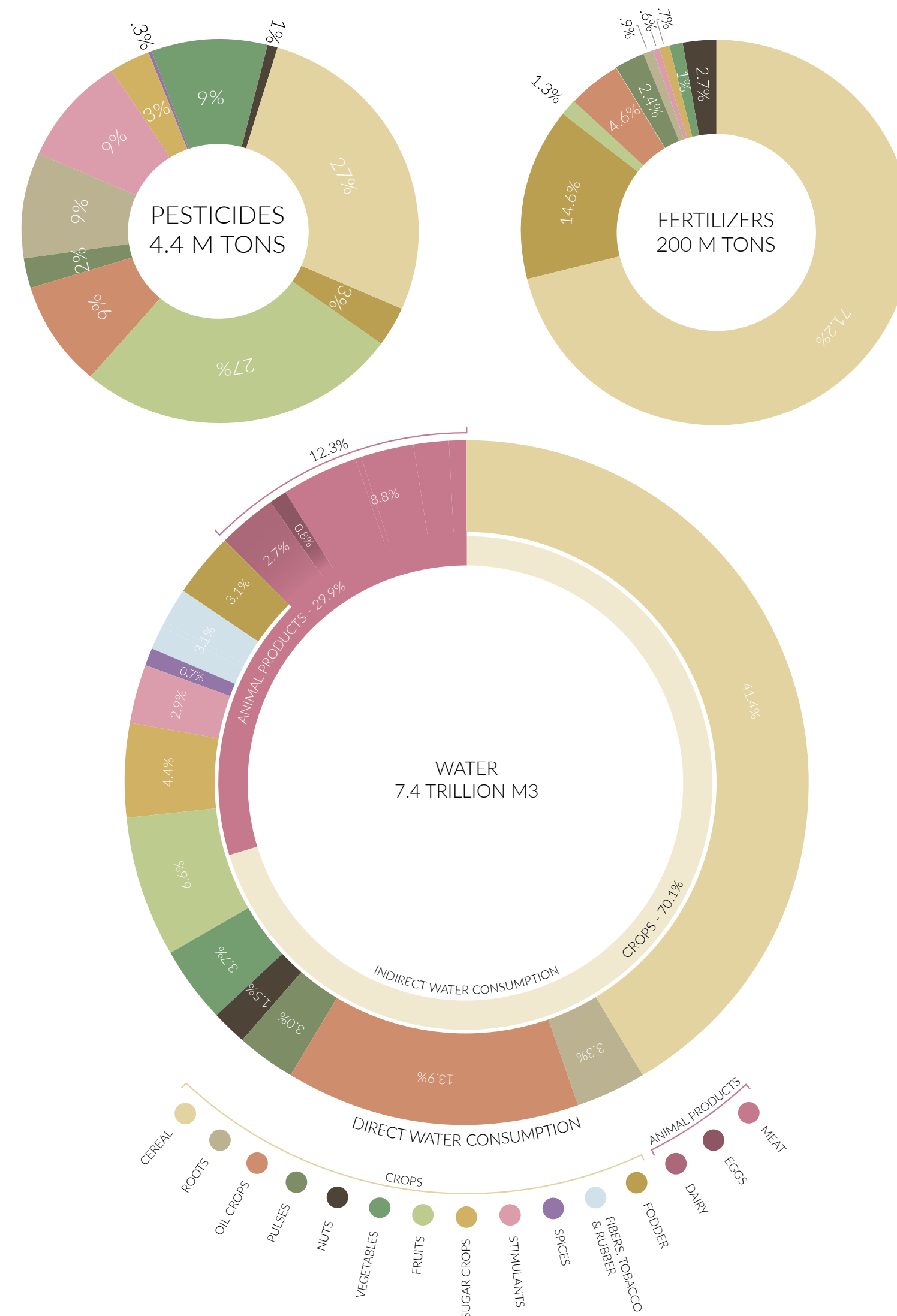


Figure 6: Pesticide, fertilizer, and water inputs per major food type. (FAO, 2015b; Mekonnen & Hoekstra, 2011)

Driving Trends

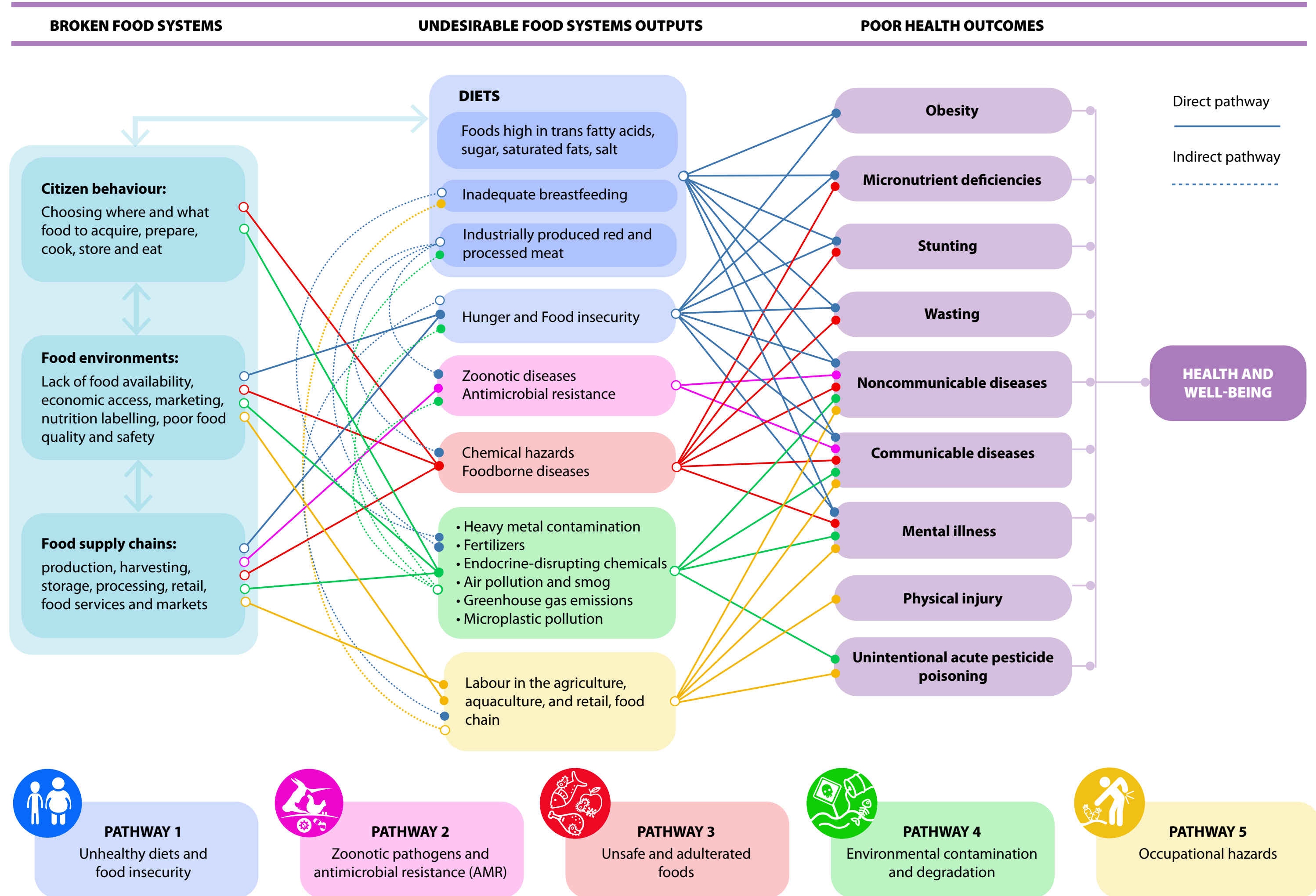
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Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

Broken Food Systems

Figure 1. The five interconnected and interrelated impact pathways through which food systems negatively affect human health



Food Insecurity

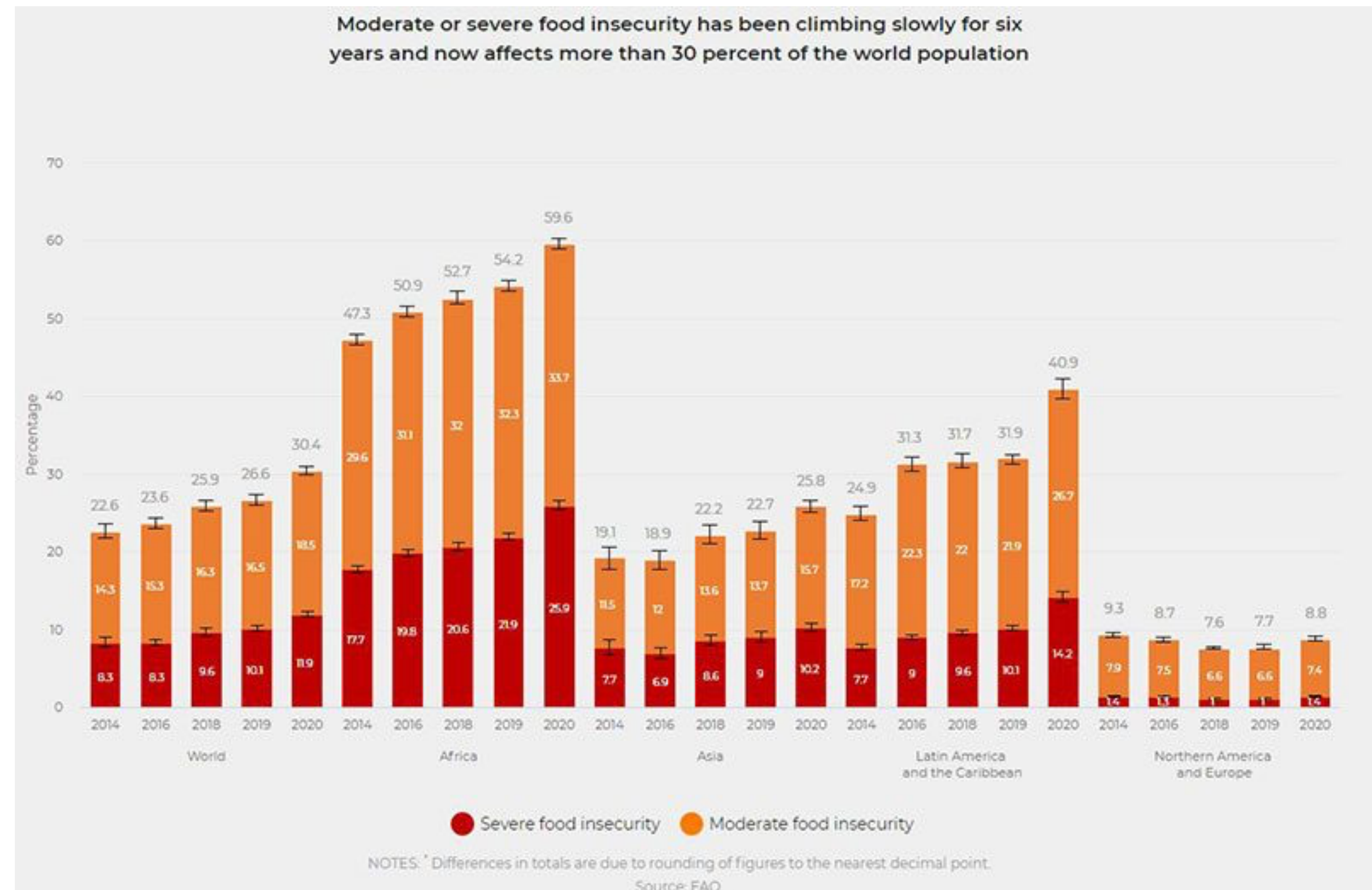


Unhealthy diets and food insecurity. This pathway comprises the aspects of food systems that lead to unhealthy diets or food insecurity and therefore contribute to malnutrition in all its forms. Malnutrition and hunger pose the highest risks to human health in terms of death and illness and include obesity, micronutrient deficiencies, stunting, wasting, communicable and noncommunicable diseases and mental illness.

Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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Food Insecurity

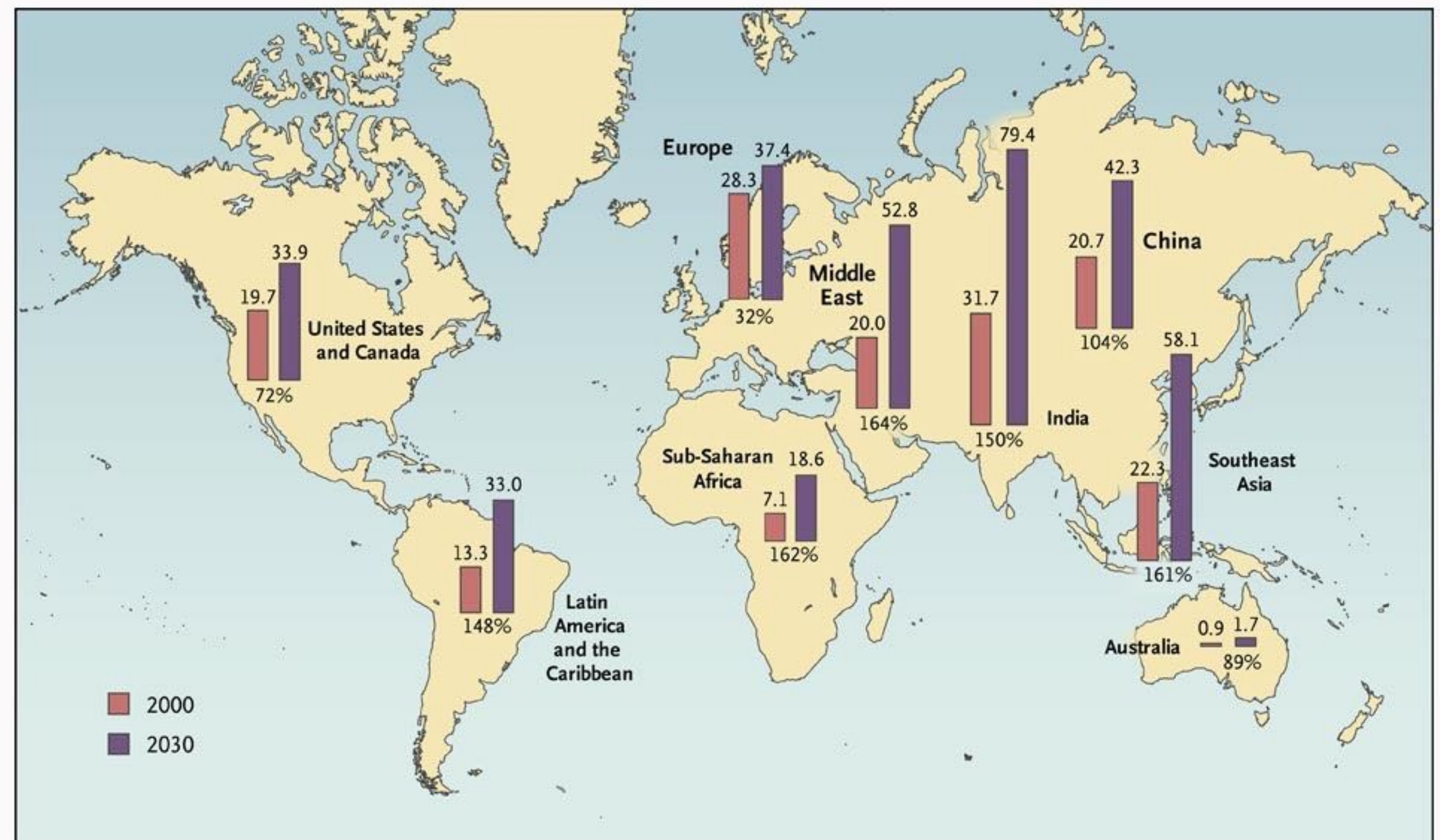


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millions of people with metabolic syndrome

Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

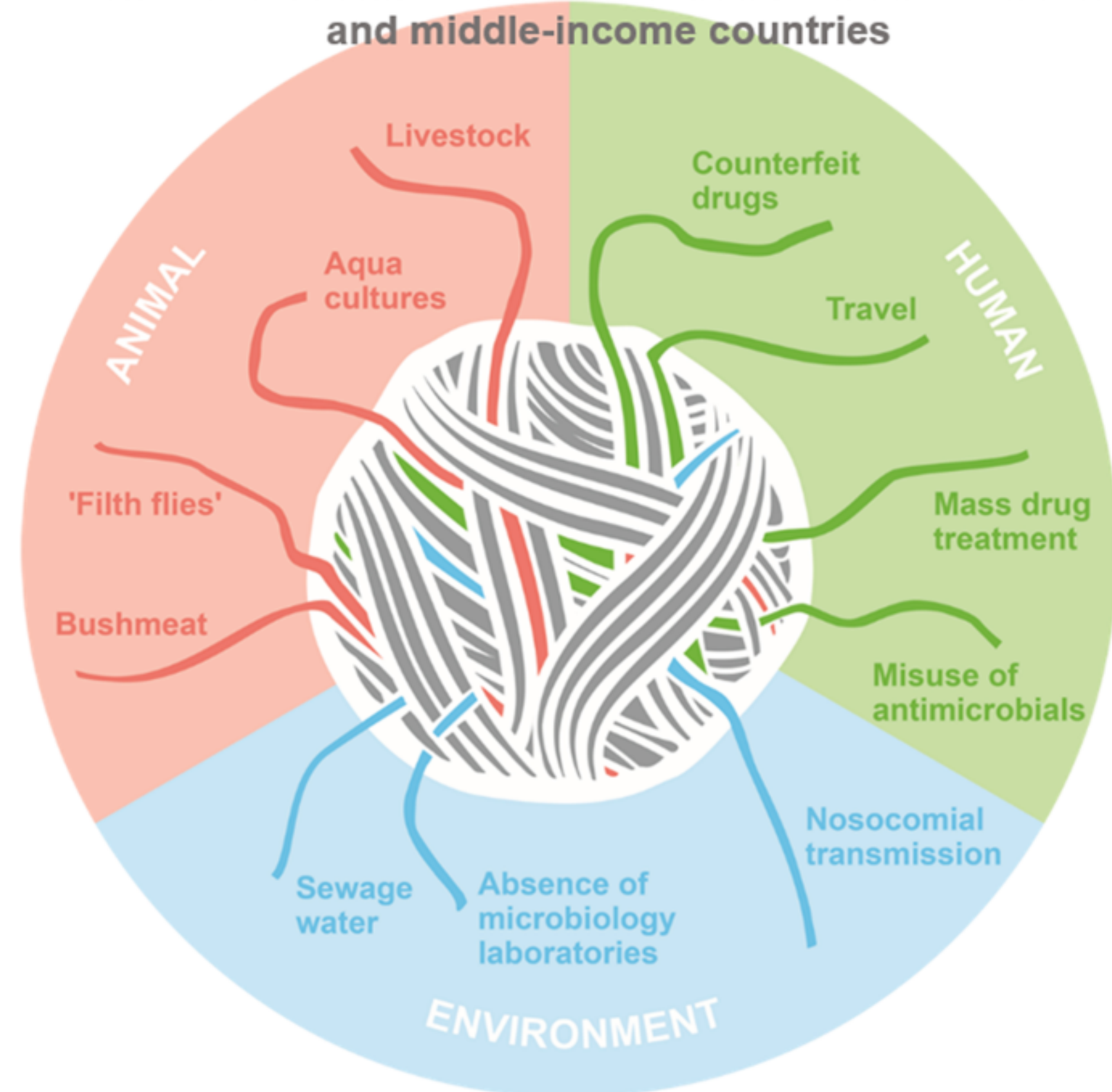
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Pathogens



Zoonotic pathogens and antimicrobial resistance. This pathway comprises the ways in which farmed, ranched and wild caught animals in food supply chains and the use of antibiotics result in zoonotic diseases and antimicrobial resistance, which further result in communicable and noncommunicable diseases in humans.

The 'Gordian knot of antimicrobial resistance' in low- and middle-income countries



Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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Unsafe Food



Unsafe and adulterated foods. In this pathway, food systems are the cause of various diseases and illnesses (e.g., micronutrient deficiency, stunting, wasting, communicable and noncommunicable diseases and mental illness) when foods and water contain infectious or toxic hazards, microbial pathogens, such as bacteria, viruses and parasites, or chemical residues, contaminants or biotoxins. These contaminants can occur in unsafe food supply chains or unhealthy environments or due to unsafe behaviour.



Food Processing



Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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1/5 OF ALL PRIMARY CROPS ARE PROCESSED BEFORE CONSUMPTION.

THE US FOOD PROCESSING INDUSTRY IS GROWING AT A RATE OF 5% ANNUALLY.

Food Processing



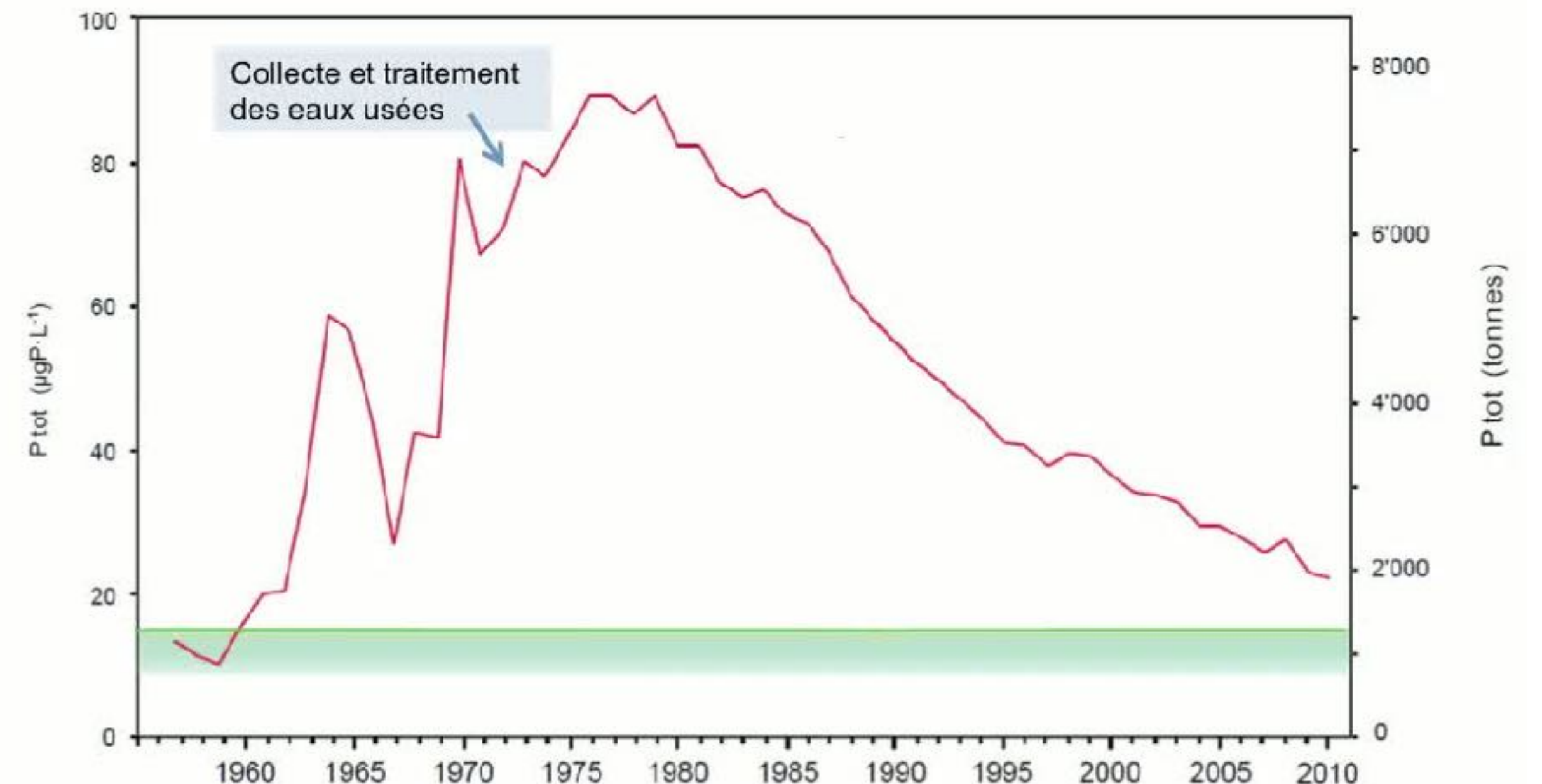
Environmental contamination and degradation. This pathway comprises contamination of the environment by use in food supply chains and food environments of fertilizers, manure, products containing heavy metals, endocrine-disrupting chemicals or hormone-growth promoters, which can cause various conditions, such as mental illness and other noncommunicable and communicable diseases. It includes the ways in which food production, food environments and citizen behaviour degrade the environment by emitting air pollution, greenhouse gases and microplastics, which affect our health and well-being.

Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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Evolution de la concentration en phosphore dans le lac Léman



Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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Environmental Contamination & Waste

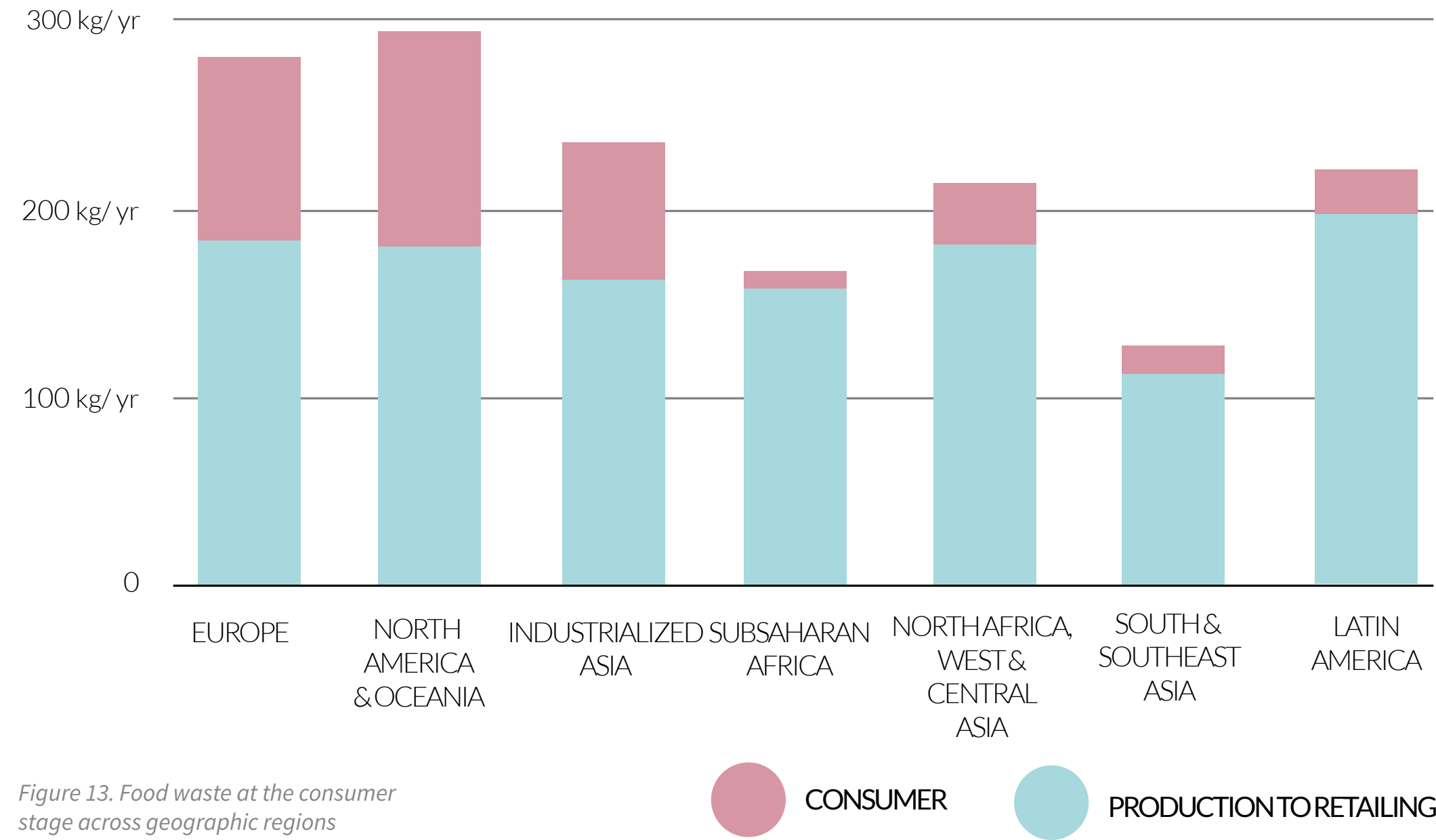


Figure 13. Food waste at the consumer stage across geographic regions (FAO, 2015b)

Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

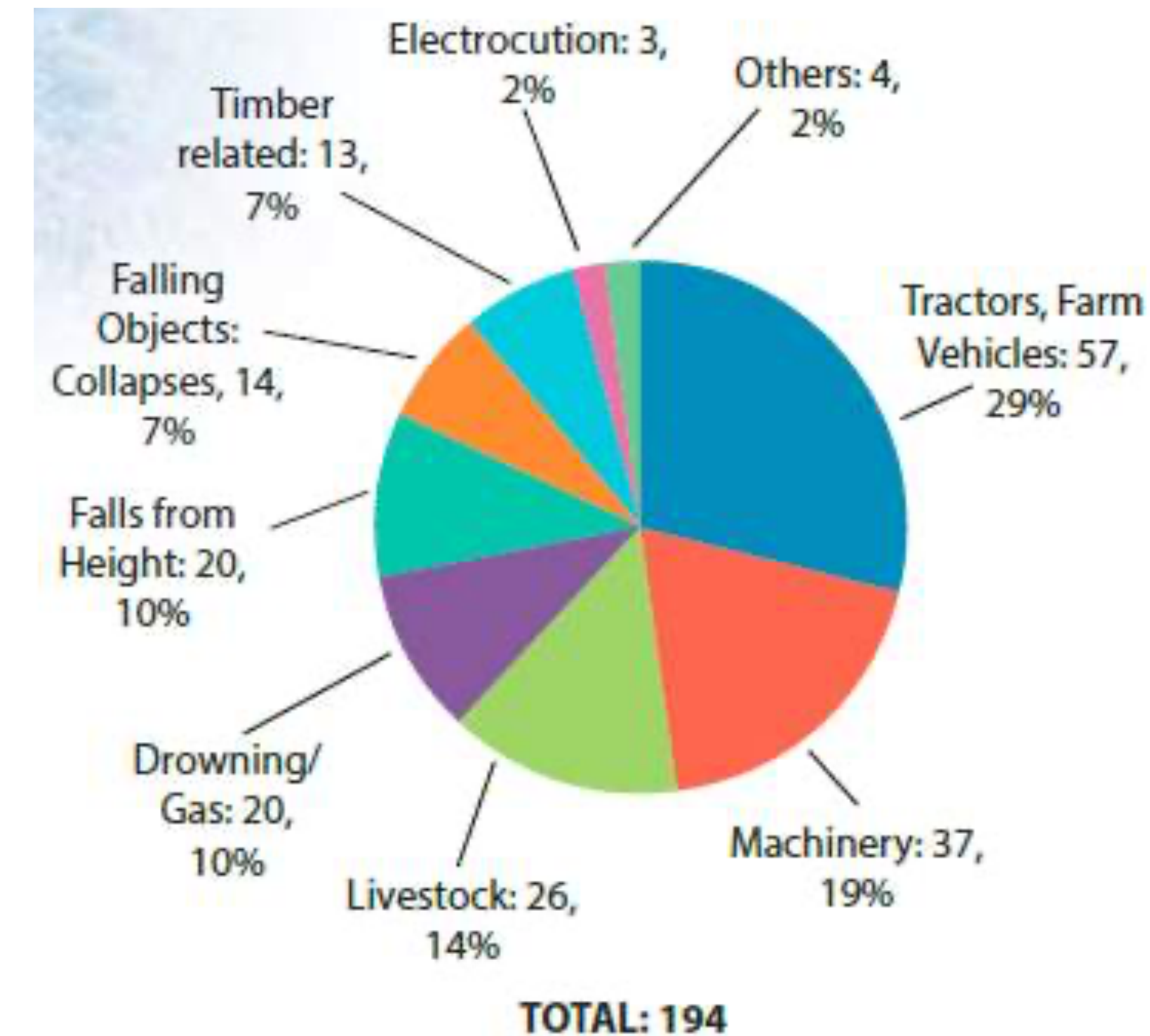
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Occupational Hazard



Occupational hazards. This pathway comprises the many physical and mental health effects on people working in the food system (e.g., farmers, fishermen, agricultural workers and people working in food retail, processing and other sectors of the food chain) due to the nature of their work or their working conditions. The effects include heat and cold stress, injuries, exposure to chemicals through the use of pesticides, fertilizers and insecticides, biological risks such as snakebites, infectious and parasitic diseases, zoonoses, ergonomic risks and psychosocial risks leading to stress and mental illness, including suicide.

AGRICULTURE IS ONE OF THE 3 MOST HAZARDOUS SECTORS TO WORK IN.



Food Systems & Human Health

The five interconnected and interrelated impact pathways through which food systems negatively affect human health

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Child Labour



Occupational hazards. This pathway comprises the many physical and mental health effects on people working in the food system (e.g., farmers, fishermen, agricultural workers and people working in food retail, processing and other sectors of the food chain) due to the nature of their work or their working conditions. The effects include heat and cold stress, injuries, exposure to chemicals through the use of pesticides, fertilizers and insecticides, biological risks such as snakebites, infectious and parasitic diseases, zoonoses, ergonomic risks and psychosocial risks leading to stress and mental illness, including suicide.

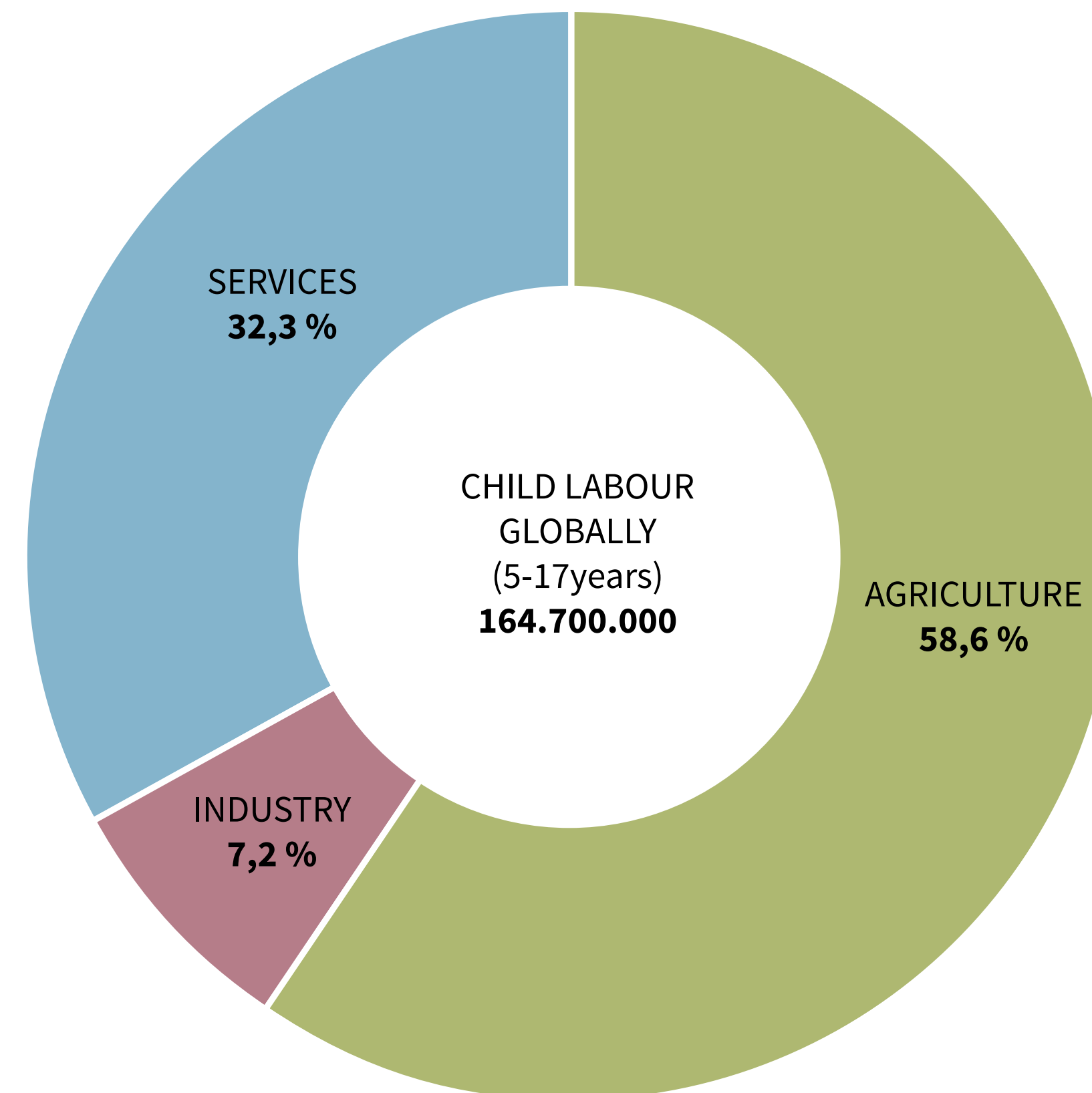


Figure 24: An overview of the main sectors in which child labour is occurring globally. (ILO, 2015)

Break

15 min

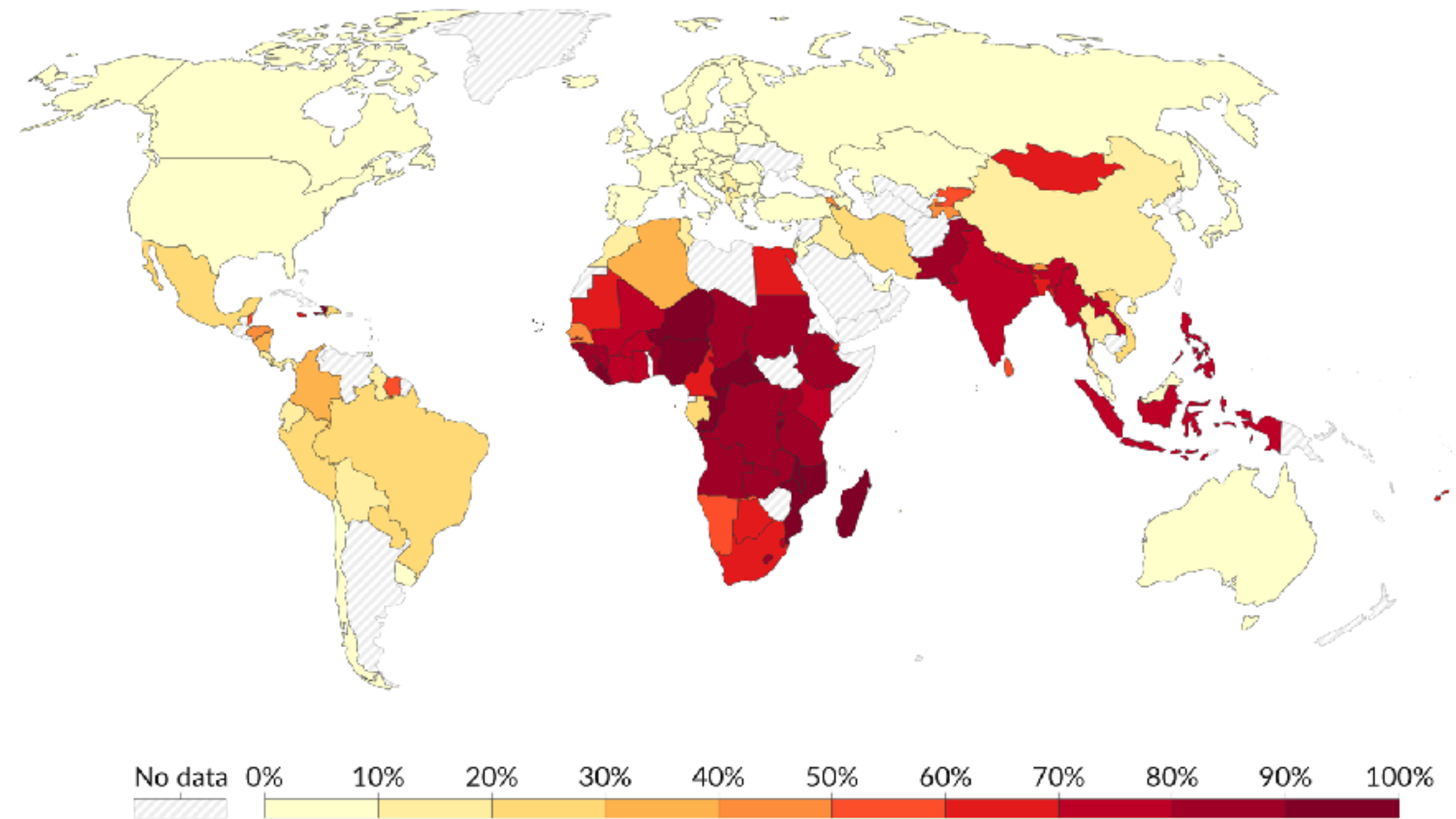
Break

Consequences of Broken Food Systems on human health

Share of population that cannot afford a healthy diet, 2021

Our World
in Data

A diet is deemed unaffordable if it costs more than 52% of a household's income. The cost of a healthy diet is the lowest-cost set of foods available that would meet requirements in dietary guidelines from governments and public health agencies.

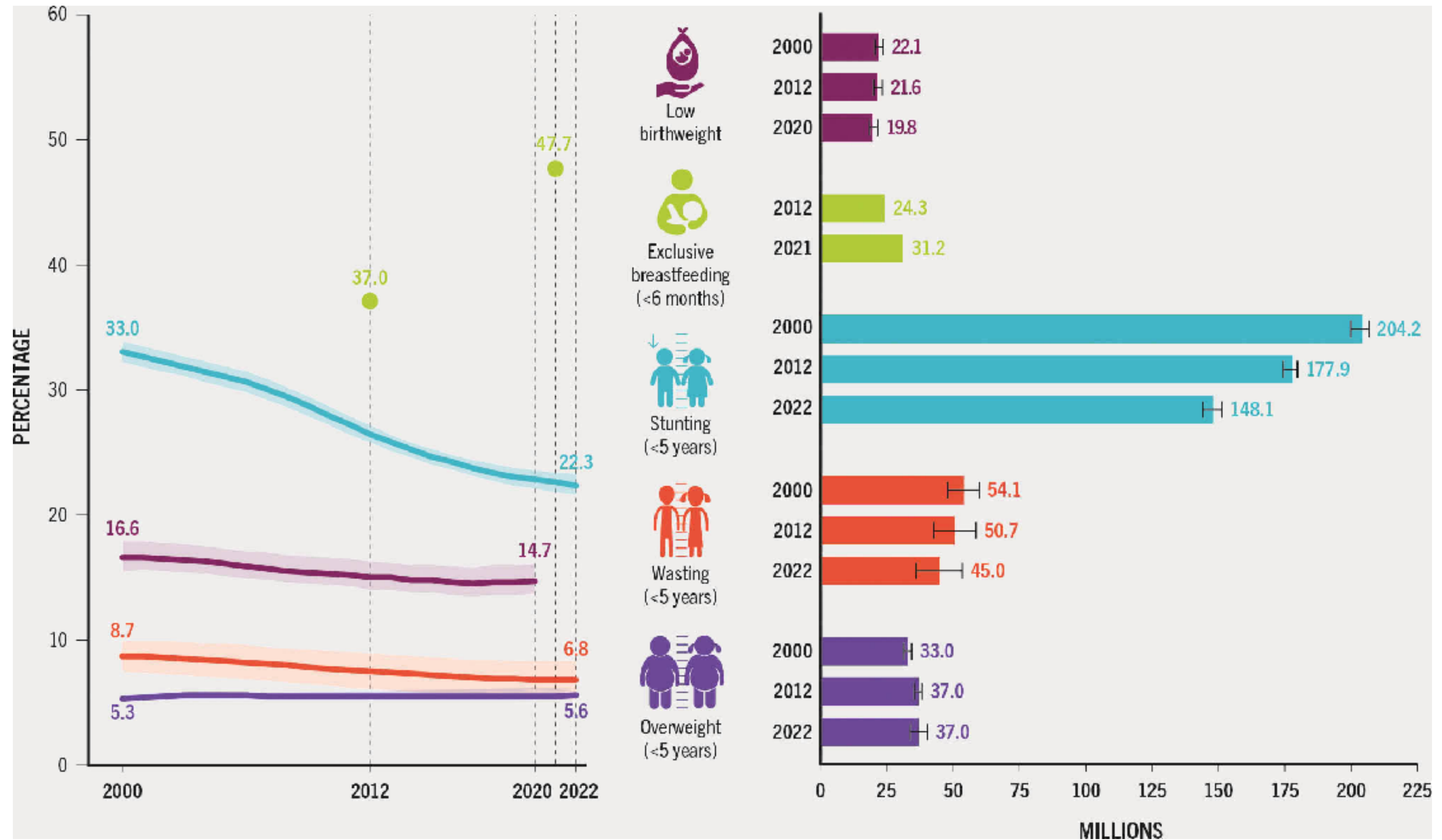


Data source: World Bank, adapted from Herforth et al. (2022)

OurWorldInData.org/food-prices | CC BY

Stunting, Wasting, Obesity

Poor Health Outcomes



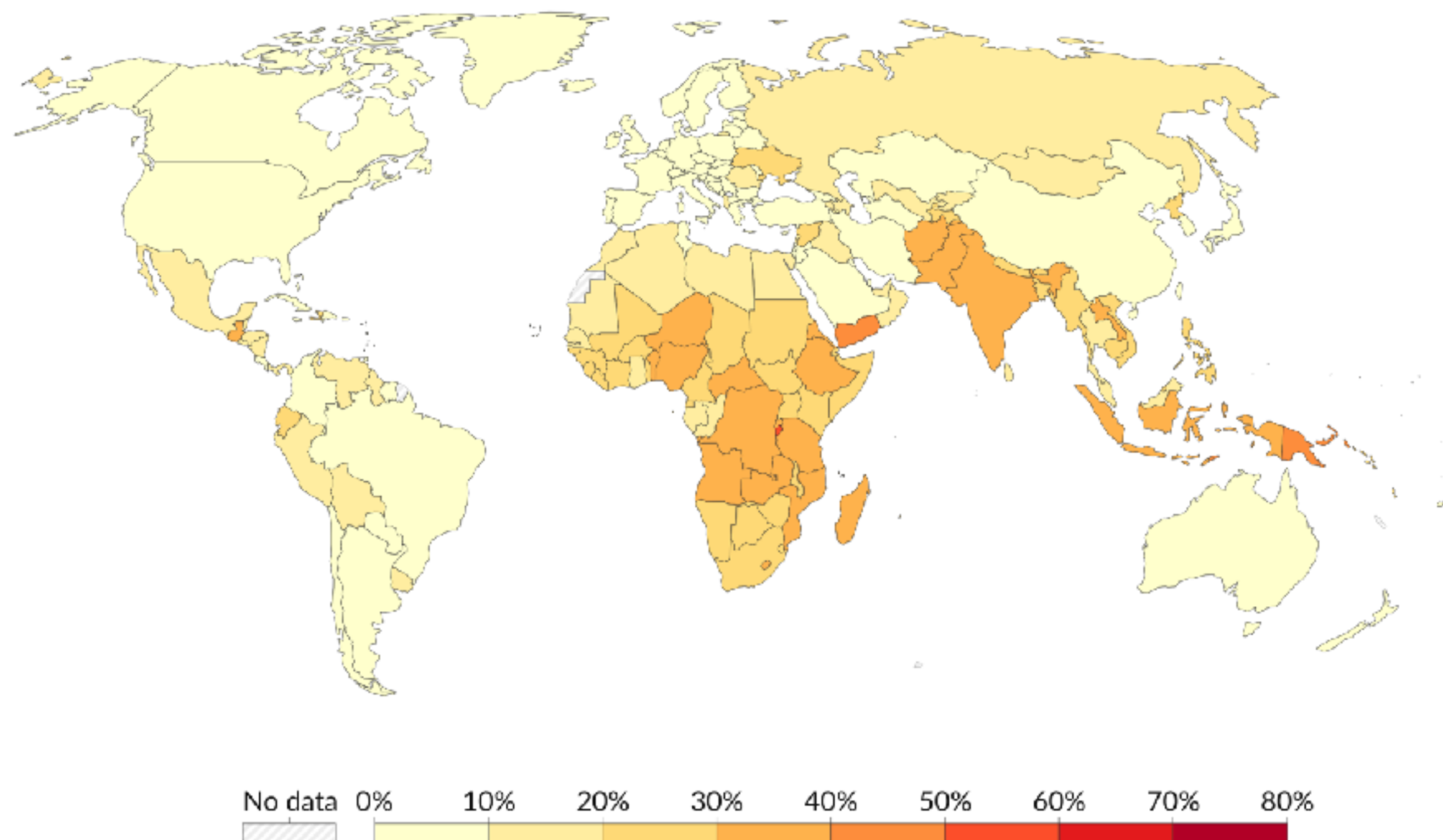
Poor Health Outcomes

Stunting

Malnutrition: Share of children who are stunted, 2021

Our World
in Data

The share of children younger than five years old that are defined as stunted. Stunting¹ is when a child is significantly shorter than the average for their age, as a consequence of poor nutrition and/or repeated infection.



Data source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/hunger-and-undernourishment | CC BY

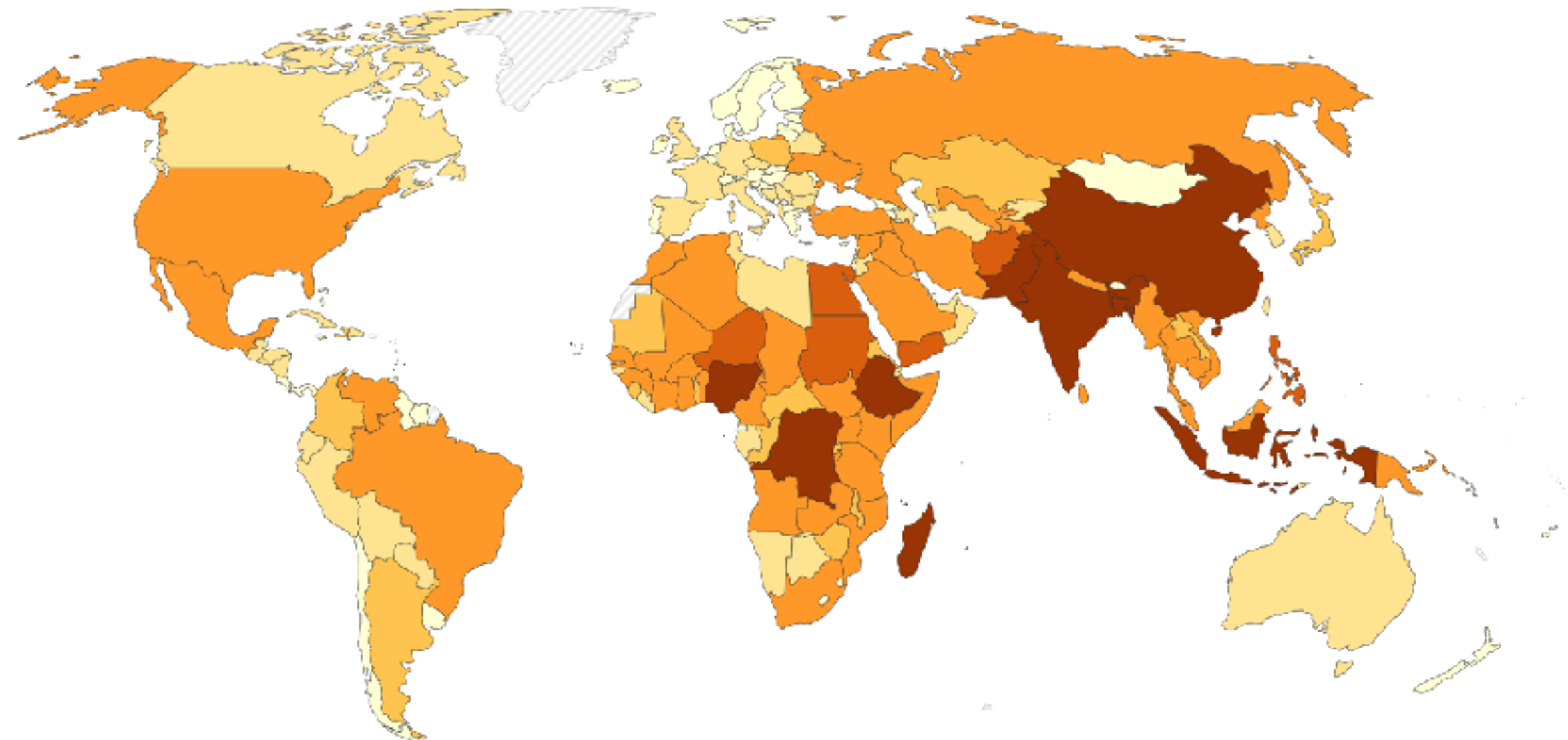
1. Childhood stunting: Stunting is one of the leading measures used to assess childhood malnutrition. It indicates that a child has failed to reach their growth potential due to disease, poor health, and malnutrition. A child is defined as 'stunted' if they are too short for their age. This indicates that their growth and development have been hindered. Stunting is measured based on a child's height relative to their age. Stunting is the share of children under five years old that fall two standard deviations below the expected height for their age. You can read more about this in our article.

Wasting

Malnutrition: Number of children who are wasted, 2016

The number of children younger than five who are 'wasted'. Wasting is when a child's weight is significantly lower than the average for their height, for example because of acute food shortage or disease.

Our World
in Data



No data 0 10,000 50,000 100,000 500,000 1 million

Data source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/hunger-and-undernourishment | CC BY

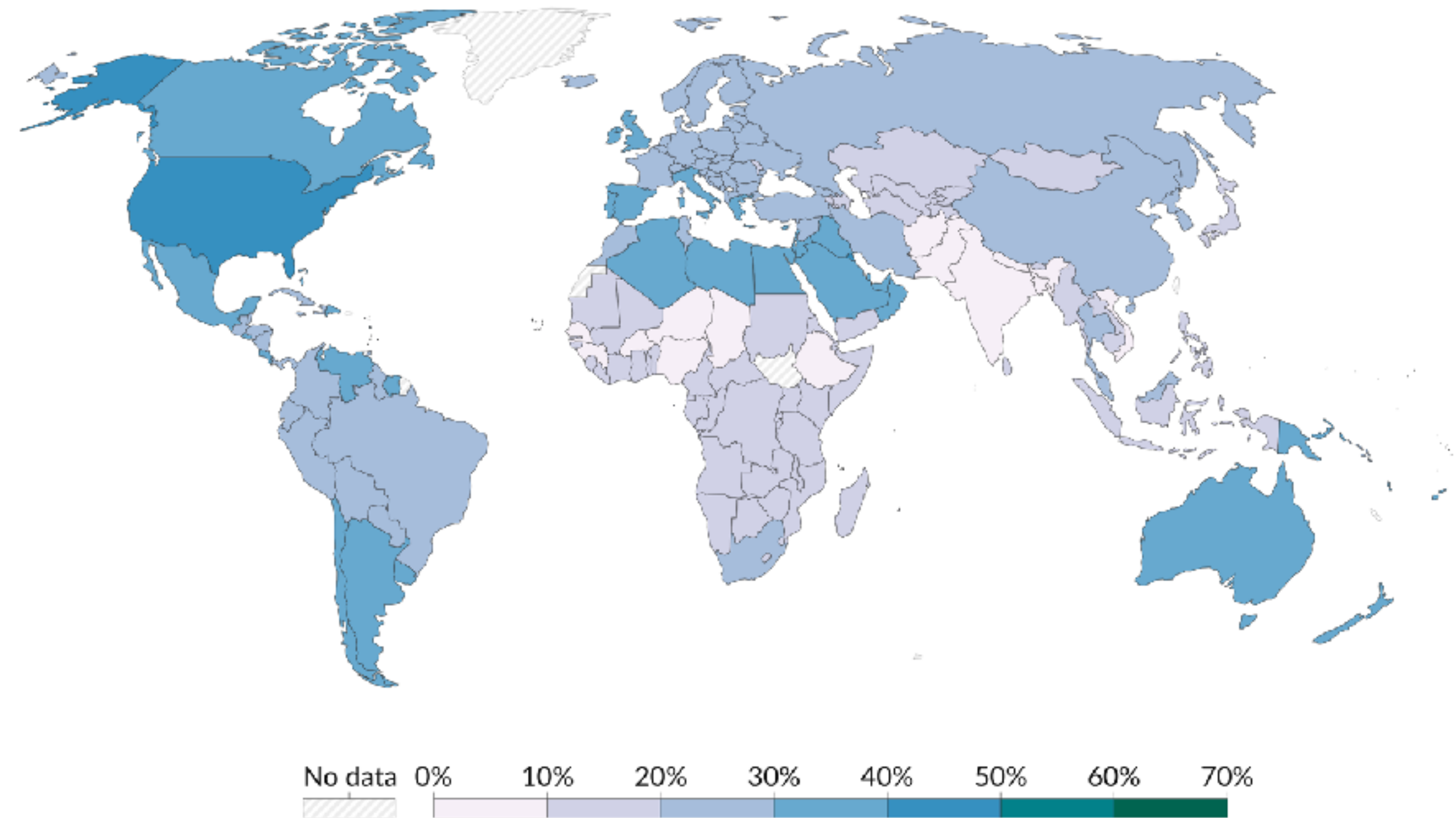
Poor Health
Outcomes

Overweight in the young

Share of children and adolescents who are overweight or obese, 2016

Our World
in Data

Share of children and adolescents aged 5 to 19 years old that are defined as either overweight or obese. This means their weight-for-height is more than one standard deviations from the median of the World Health Organization (WHO) Child Growth Standards.



Data source: WHO, Global Health Observatory (2022)

OurWorldInData.org/obesity | CC BY

Poor Health
Outcomes

Poor Health Outcomes

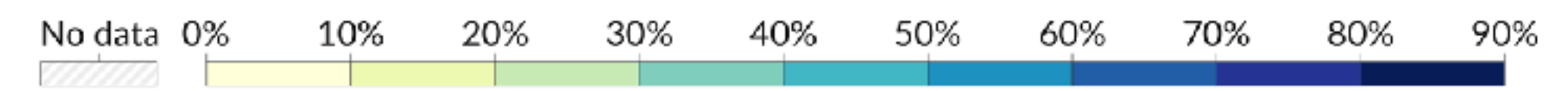
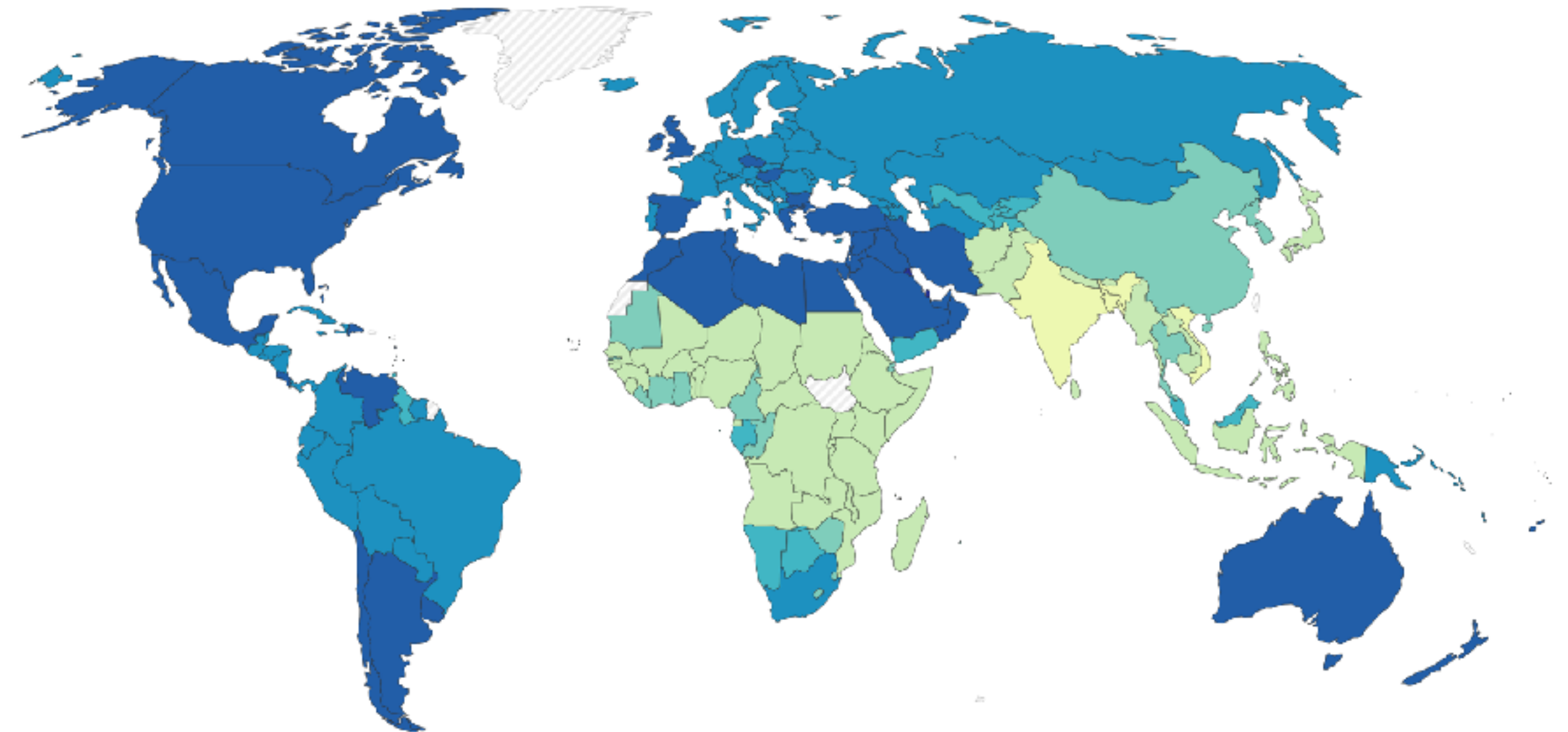
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Obesity

Share of adults who are overweight or obese, 2016



A person is defined as overweight if they have a body-mass index (BMI) equal to or greater than 25. BMI is a person's weight in kilograms divided by his height in metres squared.



Data source: WHO, Global Health Observatory

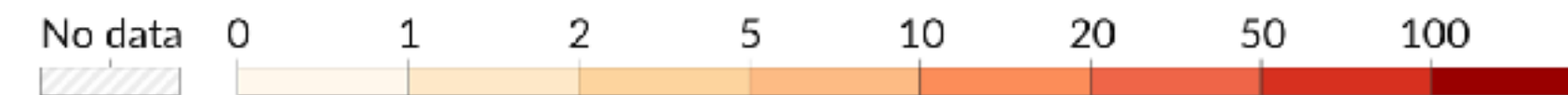
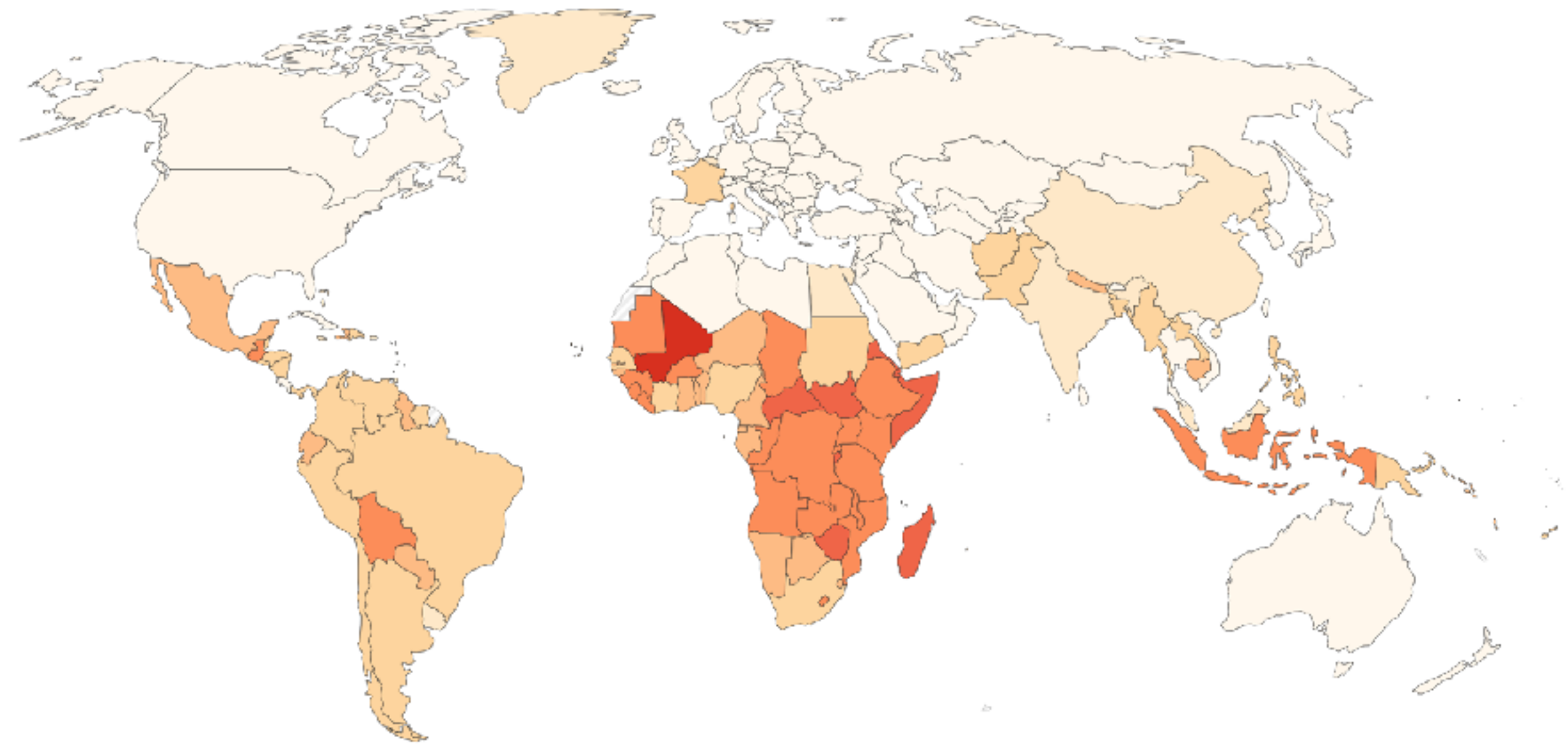
OurWorldInData.org/obesity | CC BY

Death by Malnutrition

Death rate from malnutrition, 2019

The estimated death rate from protein-energy malnutrition per 100,000 people.

Our World
in Data



Data source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/hunger-and-undernourishment | CC BY

Note: To allow comparisons between countries and over time this metric is age-standardized¹.

1. Age standardization: Age standardization is an adjustment that makes it possible to compare populations with different age structures, by standardizing them to a common reference population. [Read more: How does age standardization make health metrics comparable?](#)

Poor Health
Outcomes

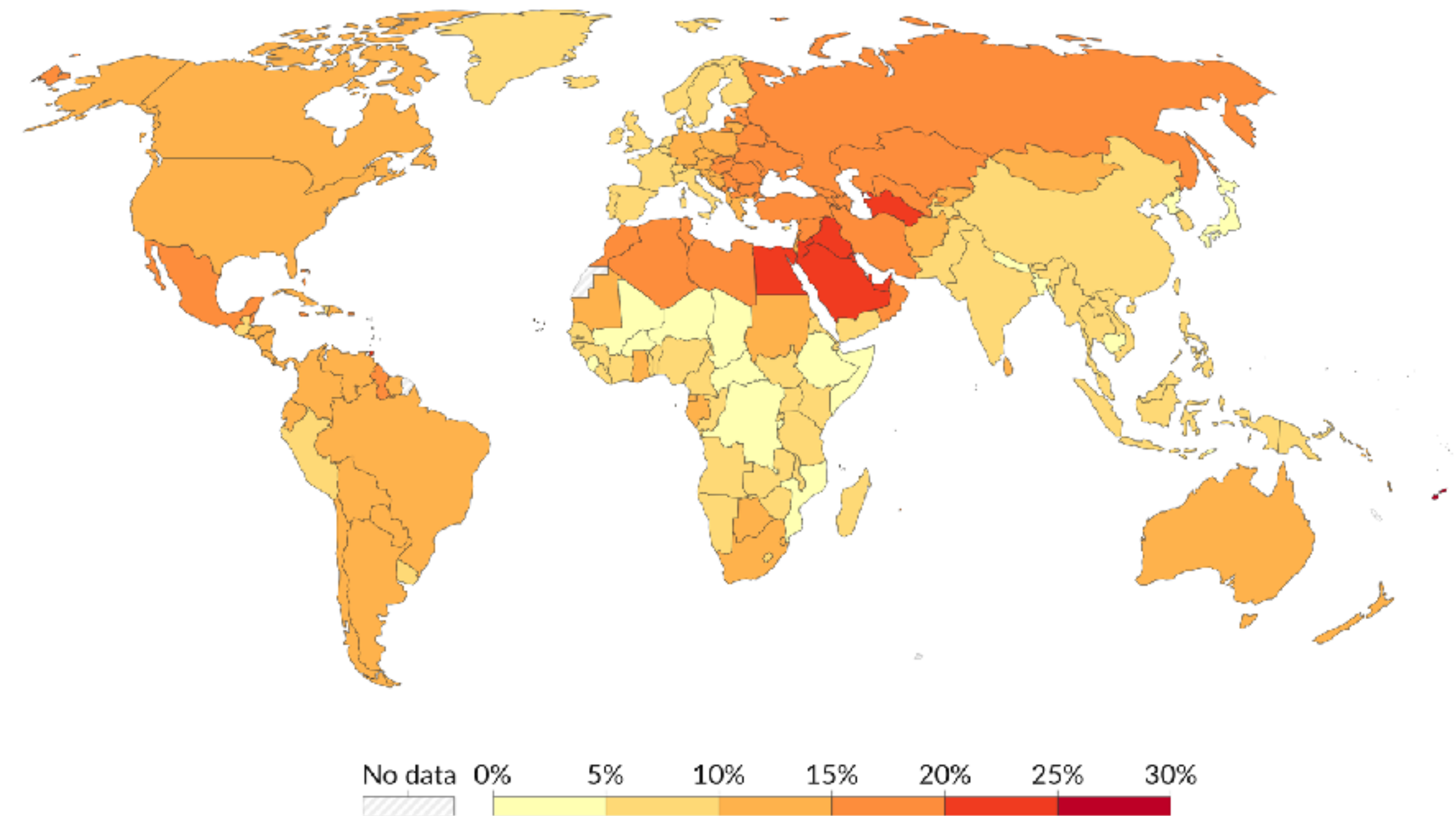
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Death by Obesity

Share of deaths attributed to obesity, 2019

Obesity is defined as having a body-mass index (BMI) equal to or greater than 30. BMI is a person's weight in kilograms divided by their height in meters squared. Shown is the share of total deaths, from any cause, with obesity as an attributed risk factor.

Our World
in Data



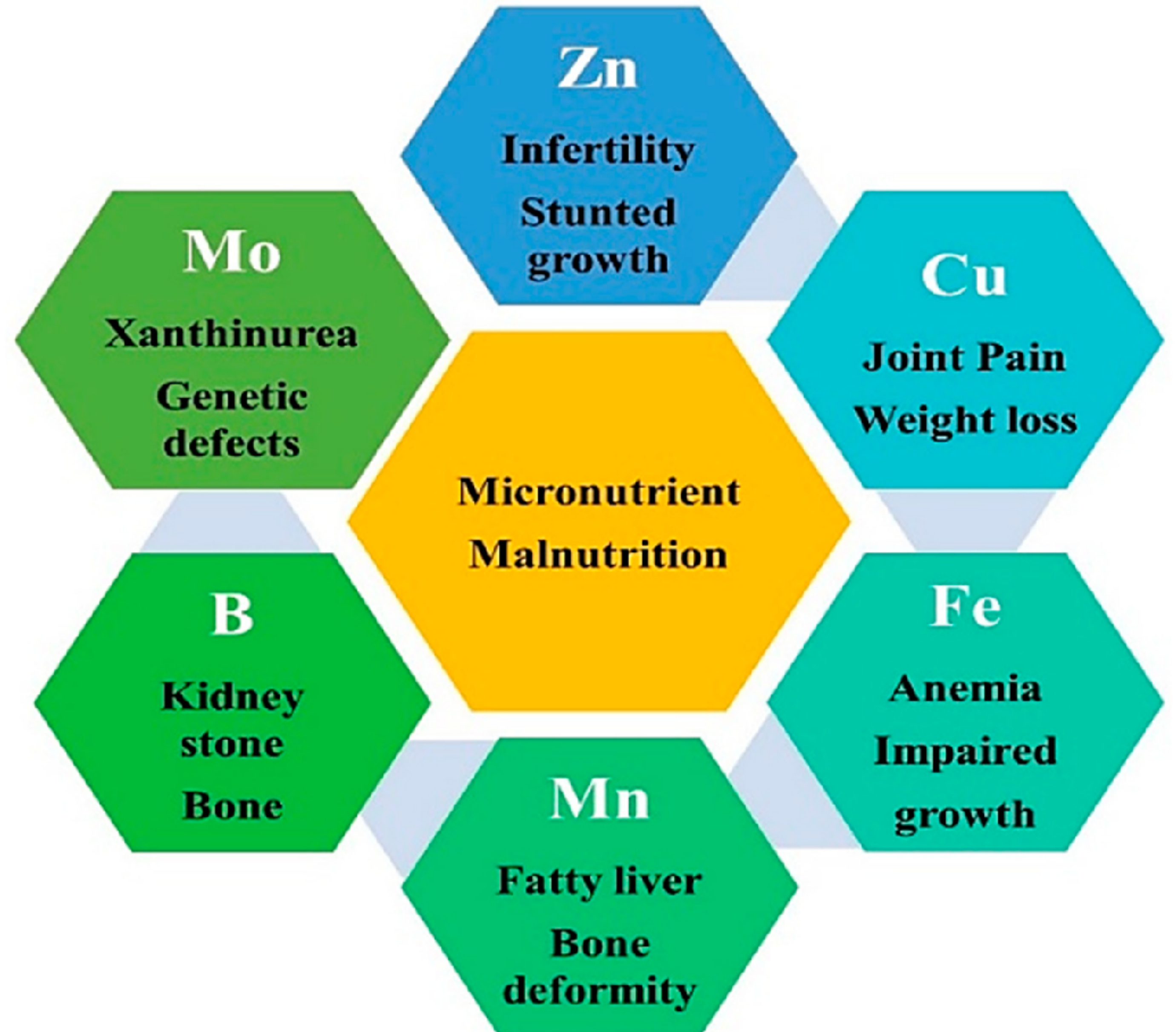
Data source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/obesity | CC BY

Poor Health
Outcomes

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Micronutrient Deficiency



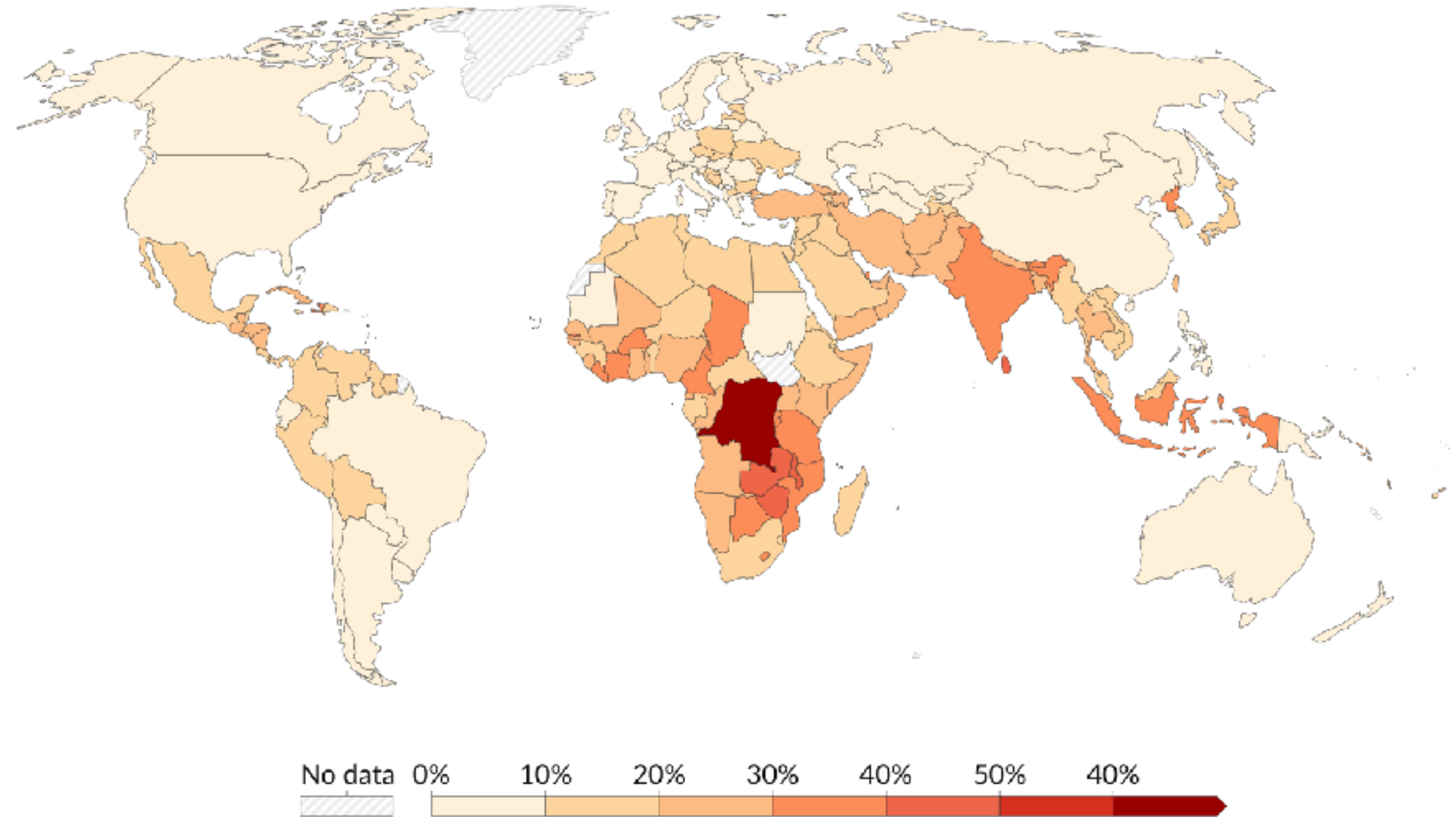
Poor Health
Outcomes

Micronutrient Deficiency

Global prevalence of zinc deficiency, 2005

The global prevalence of zinc deficiency, measured as the share of the total population with intakes below physiological requirements, 1990-2005.

Our World
in Data



Data source: Prevalence of zinc deficiency - Wessells et al. (2012)

Note: Wessells et al. (2012)

OurWorldInData.org/micronutrient-deficiency | CC BY

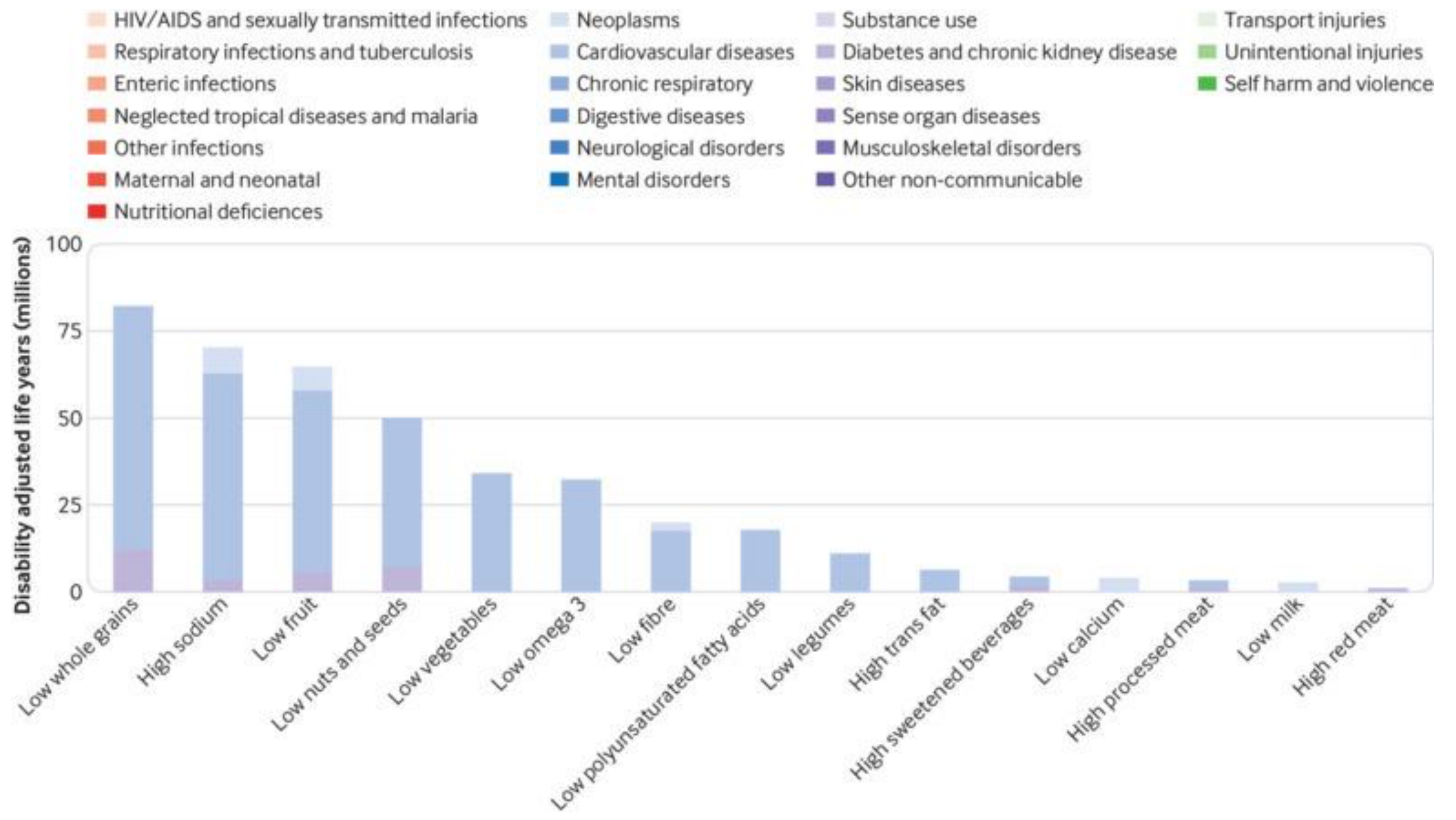
Poor Health
Outcomes

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Poor Health Outcomes

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Diseases



Poor Health Outcomes

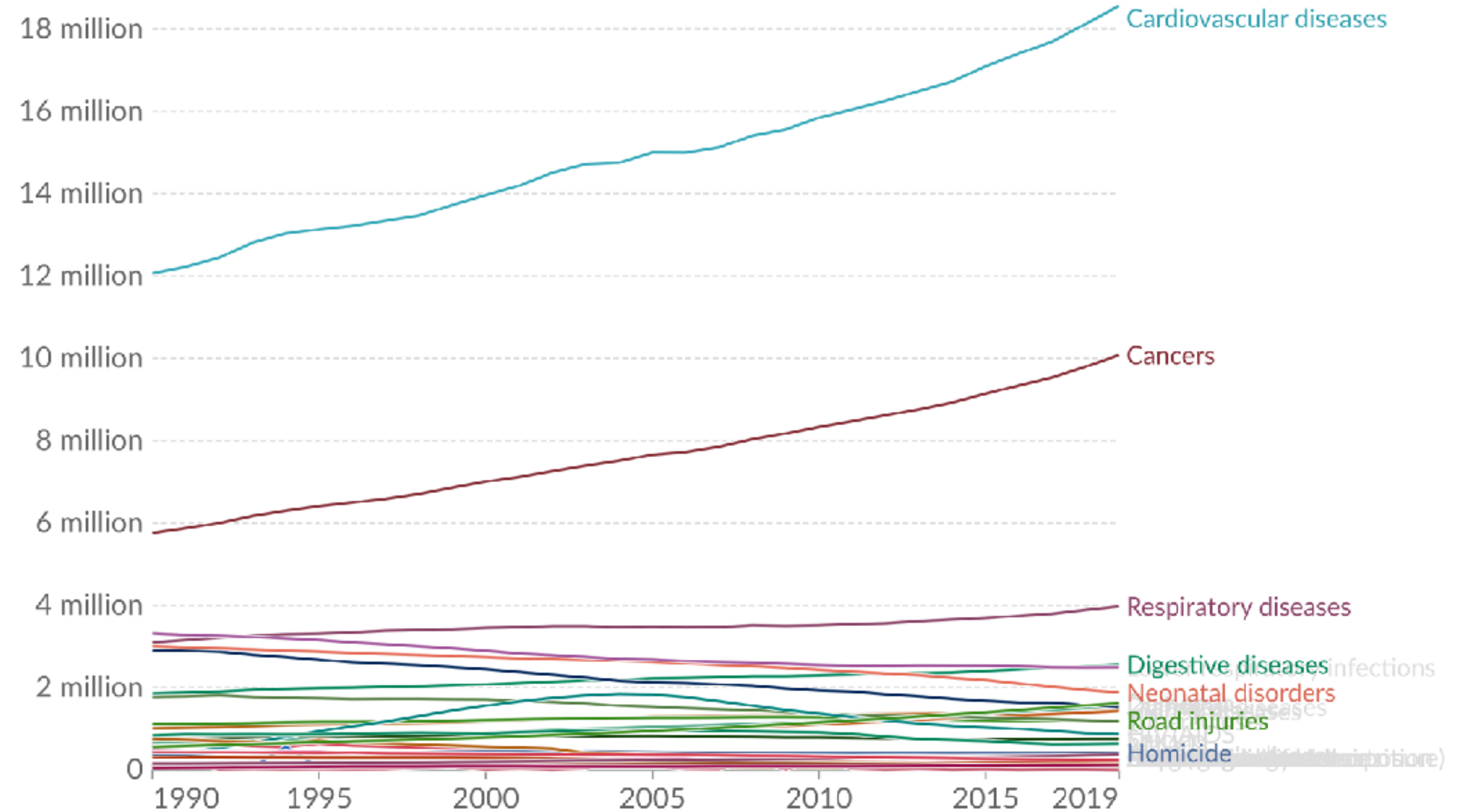
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Diseases

Causes of death, World, 1990 to 2019

Our World in Data

The estimated annual number of deaths from each cause. Estimates come with wide uncertainties, especially for countries with poor vital registration¹.



Data source: IHME, Global Burden of Disease (2019)

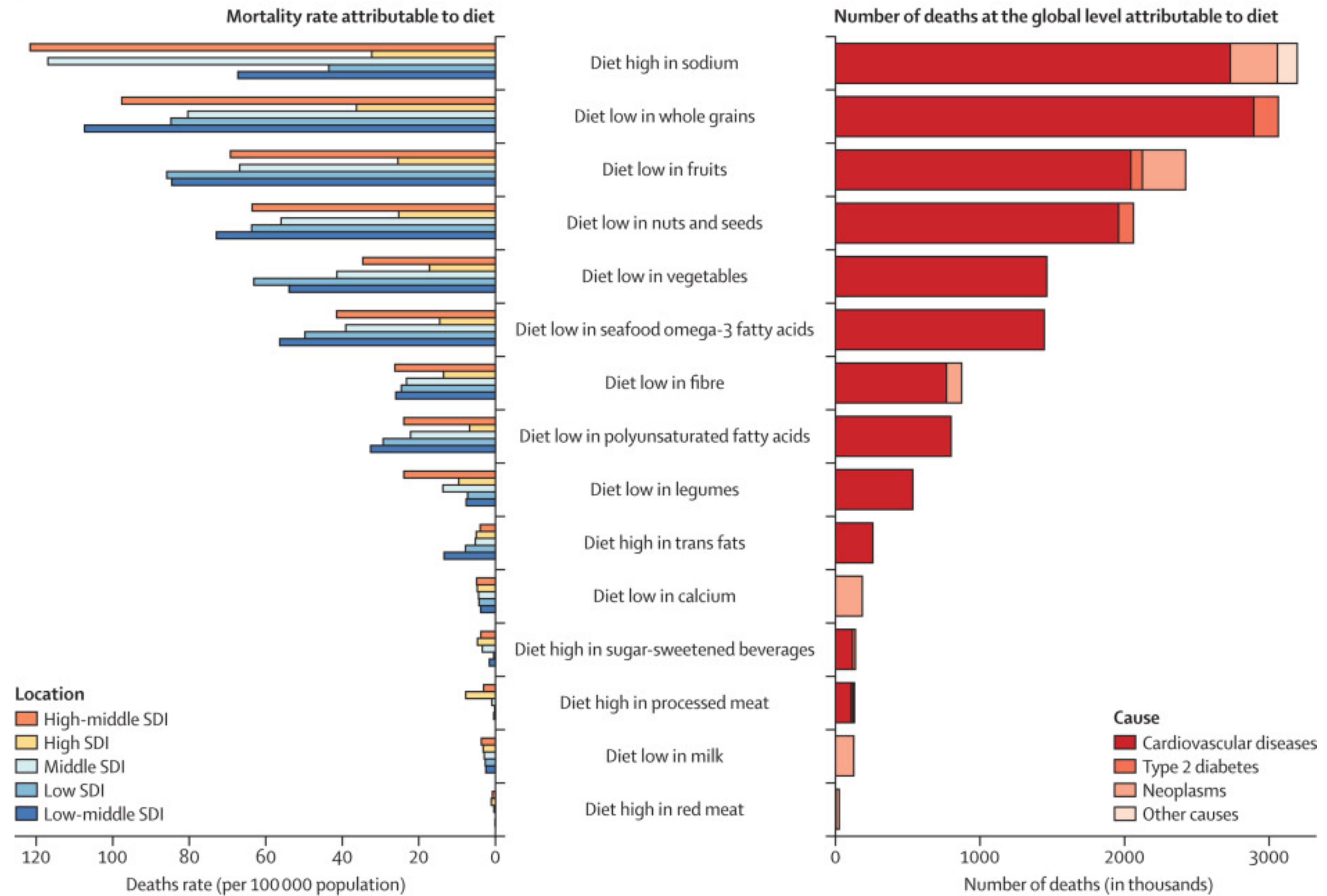
OurWorldInData.org/causes-of-death | CC BY

¹ **Civil and Vital Registration System:** A Civil and Vital Registration System (CVRS) is an administrative system in a country that manages information on births, marriages, deaths and divorces. It generates and stores 'vital records' and legal documents such as birth certificates and death certificates. You can read more about how deaths are registered around the world in our article: [How are causes of death registered around the world?](#)

Poor Health Outcomes

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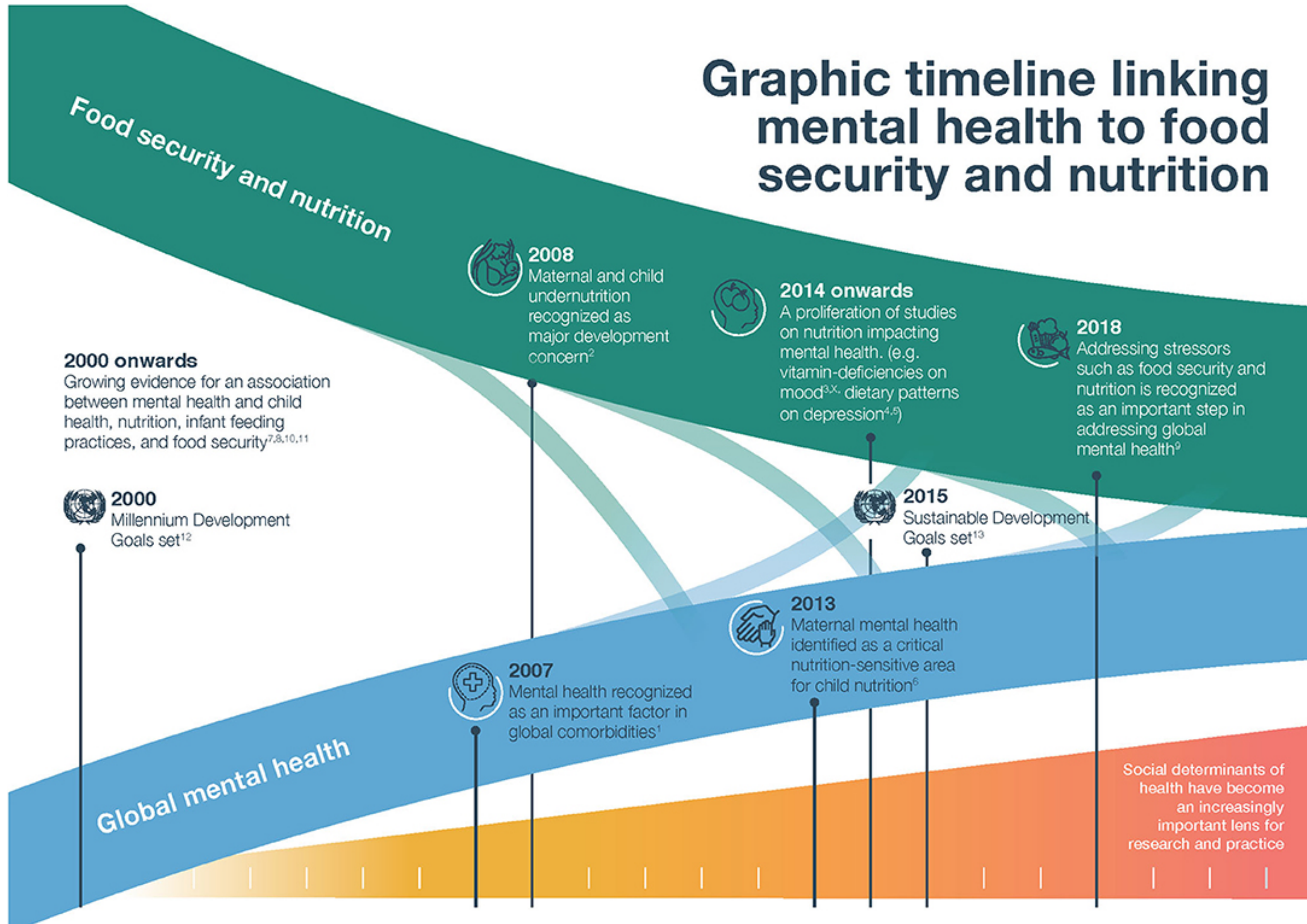
Diseases



SDI= socio-demographic index

Mental Illness

Graphic timeline linking mental health to food security and nutrition



Poor Health Outcomes

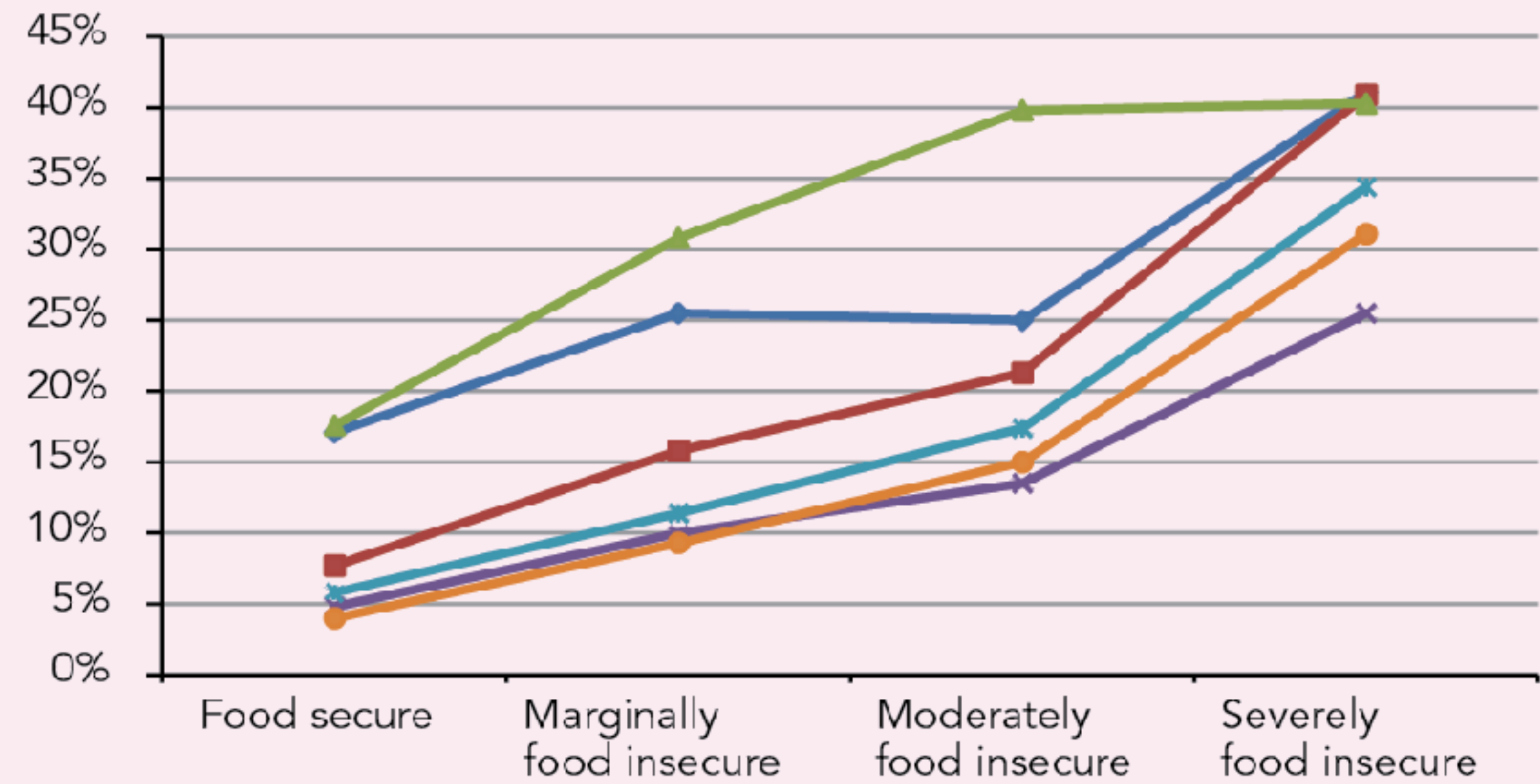
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Poor Health Outcomes

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Mental Illness

Adverse mental health outcomes reported by Canadian adults (18-64 years of age), by household food insecurity status²



- Depressive Thoughts in the Past Month
- Suicidal Thoughts in the Past Year
- Major Depressive Episode in the Past Year
- Physician Diagnosed Mood Disorder
- Physician Diagnosed Anxiety Disorder
- Self Reported Mental Health Status

Data Source: Statistics Canada, Canadian Community Health Survey (CCHS), 2005-2012

Adapted from: Tarasuk V, Cheng J, Gundersen C, de Oliveira C, Kurdyak P. The relation between food insecurity and mental health care service utilization in Ontario. Can J Psychiatry. 2018. DOI: 10.1177/0706743717752879

Poor Health Outcomes

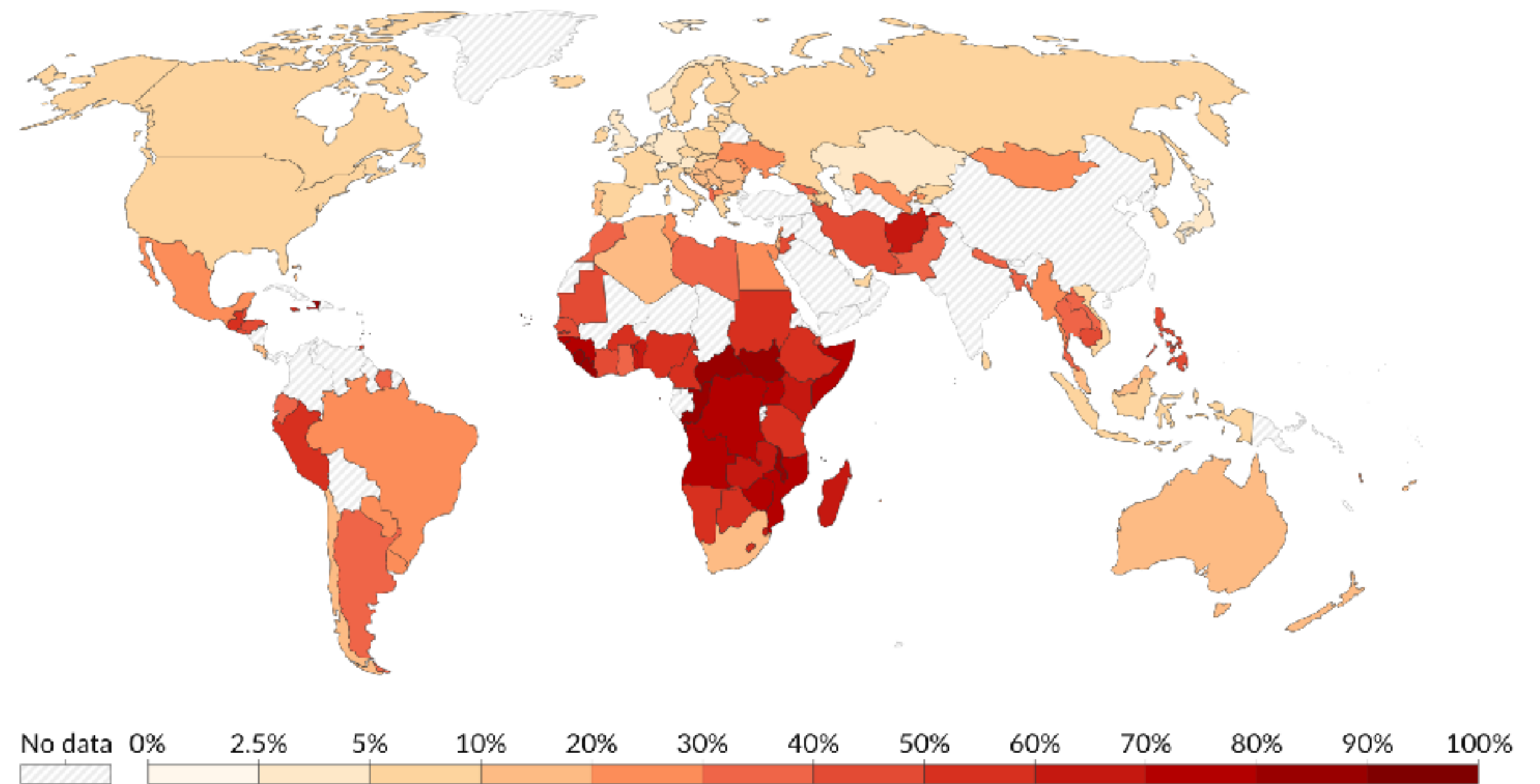
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Mental Illness

Share of population with moderate or severe food insecurity, 2020

Our World in Data

Food insecurity¹ is defined by the Food Insecurity Experience Scale (FIES). Moderate food insecurity is associated with the inability to regularly eat healthy, nutritious diets. Severe food insecurity is more related to insufficient quantity of food (energy).



Data source: Food and Agriculture Organization of the United Nations
OurWorldInData.org/hunger-and-undernourishment | CC BY

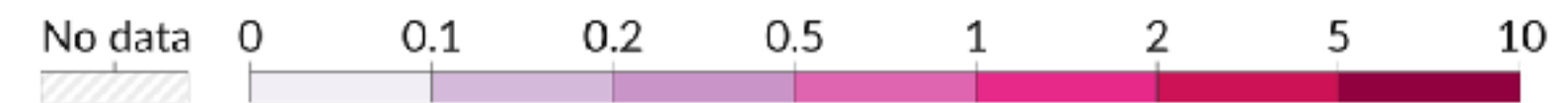
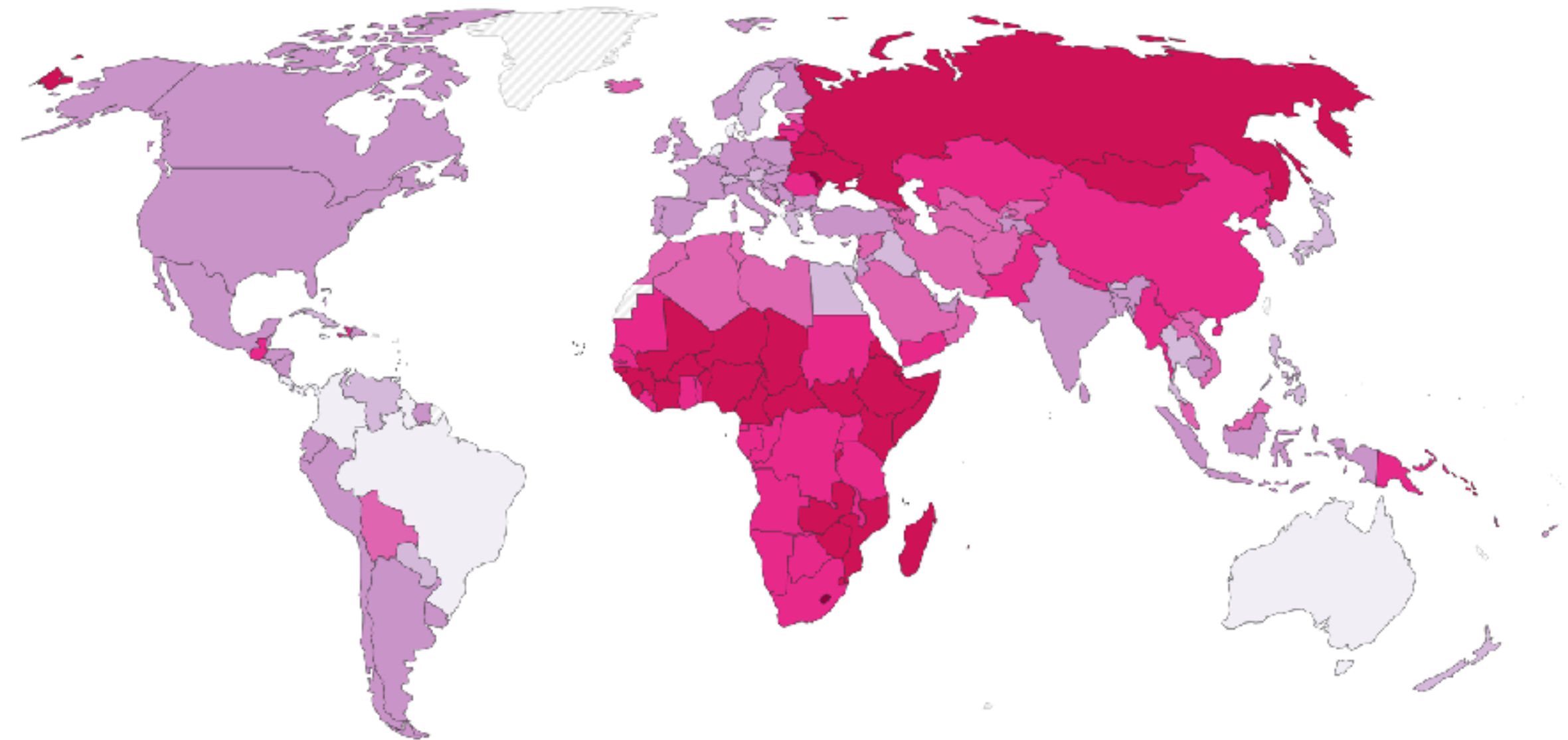
1. Food insecurity: Food insecurity is defined by the Food and Agriculture Organization (FAO) of the United Nations as the "situation when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life." It is measured using the Food Insecurity Experience Scale (FIES). This is based on household survey data about several conditions someone with food insecurity would typically experience. Moderate food insecurity is generally associated with the inability to regularly eat healthy, nutritious diets. Severe food insecurity is more strongly related to insufficient food (energy). You can read more about this in our article.

Poisoning

Death rate from unintentional poisoning, 2019

Death rate from unintentional poisoning, measured as the number of deaths per 100,000 people.

Our World
in Data



Data source: World Health Organization

OurWorldInData.org/causes-of-death | CC BY

Poor Health
Outcomes

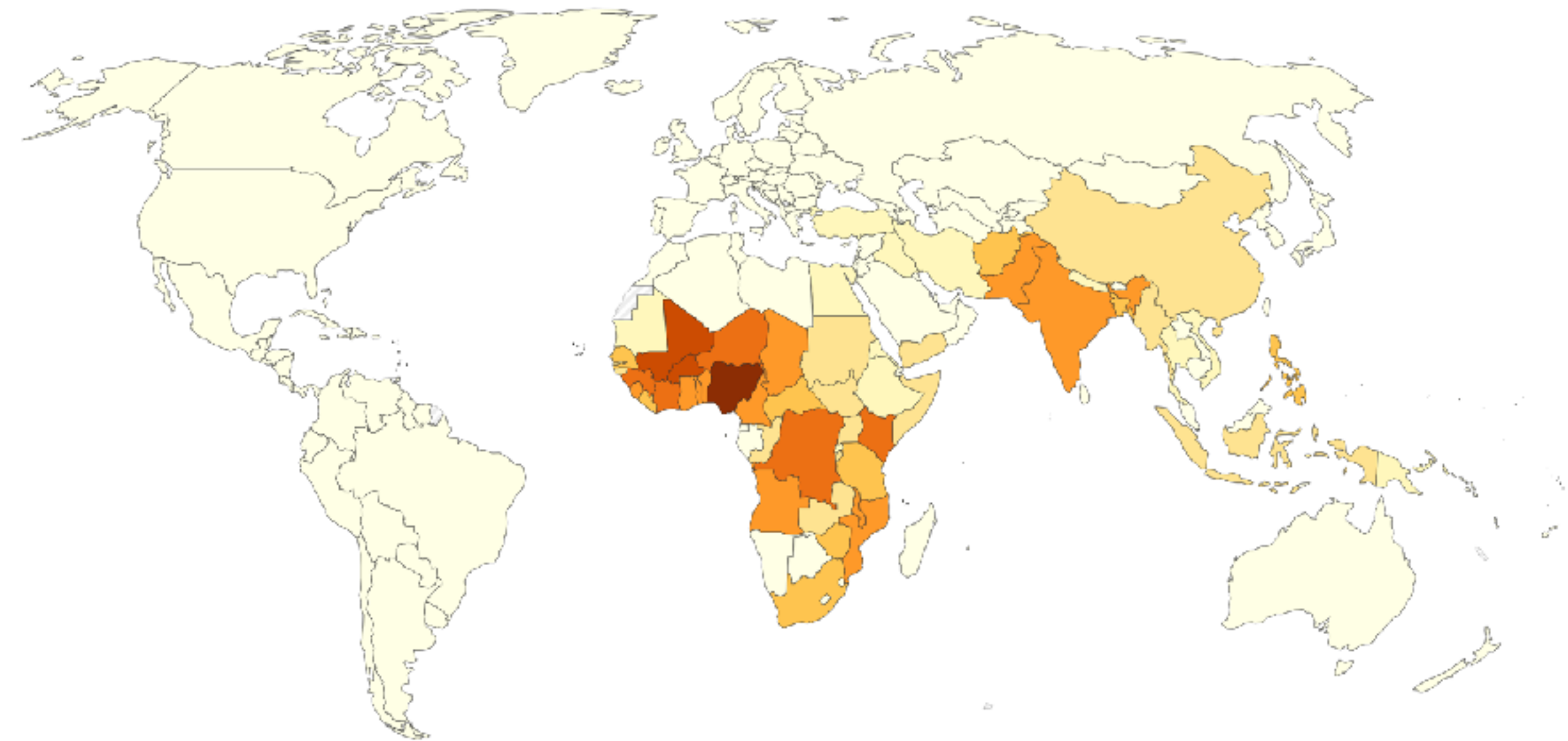
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Poisoning

Invasive non-typhoidal salmonella deaths in children under five, 2019

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Estimated annual number of deaths from invasive non-typhoidal salmonella¹ in children under five.



Data source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/child-mortality | CC BY

1. Invasive non-typhoidal salmonella: Non-typhoidal salmonellae are a group of bacteria that cause inflammation of the stomach and intestines. They can sometimes spread beyond the gut into the bloodstream, causing invasive non-typhoidal Salmonella (iNTS), especially in people who have weak immune systems, for example those with malnutrition or HIV/AIDS.

Poor Health
Outcomes

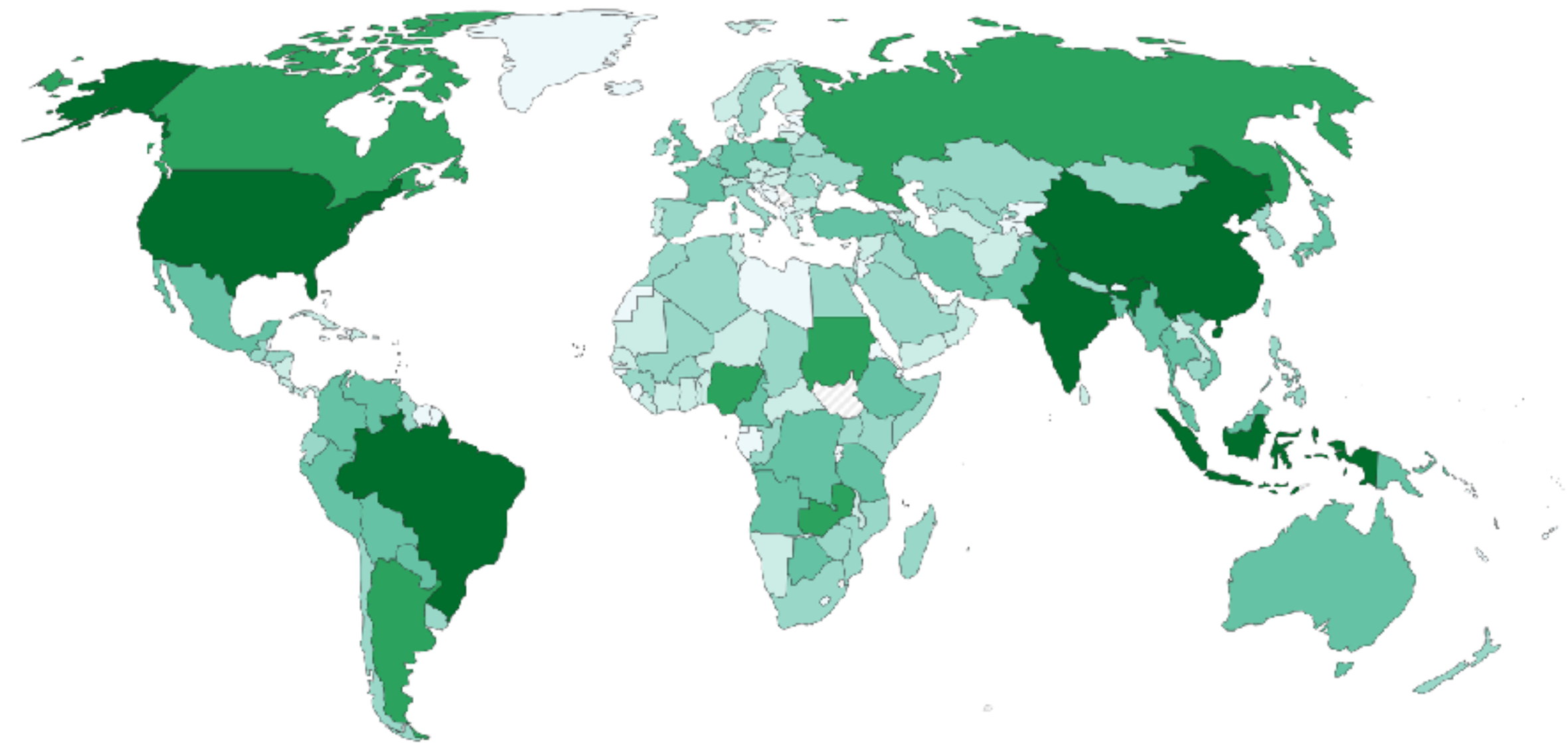
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Environment Contamination

Greenhouse gas emissions from food systems, 2015

Emissions are measured in carbon dioxide-equivalents¹.

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No data 0 t 10 million t 30 million t 100 million t 300 million t 1 billion t 3 billion t

Data source: Crippa et al. (2021).

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1. Carbon dioxide equivalents (CO₂eq): Carbon dioxide is the most important greenhouse gas, but not the only one. To capture all greenhouse gas emissions, researchers express them in "carbon dioxide equivalents" (CO₂eq). This takes all greenhouse gases into account, not just CO₂. To express all greenhouse gases in carbon dioxide equivalents (CO₂eq), each one is weighted by its global warming potential (GWP) value. GWP measures the amount of warming a gas creates compared to CO₂. CO₂ is given a GWP value of one. If a gas had a GWP of 10 then one kilogram of that gas would generate ten times the warming effect as one kilogram of CO₂. Carbon dioxide equivalents are calculated for each gas by multiplying the mass of emissions of a specific greenhouse gas by its GWP factor. This warming can be stated over different timescales. To calculate CO₂eq over 100 years, we'd multiply each gas by its GWP over a 100-year timescale (GWP100). Total greenhouse gas emissions – measured in CO₂eq – are then calculated by summing each gas' CO₂eq value.

Environment Contamination

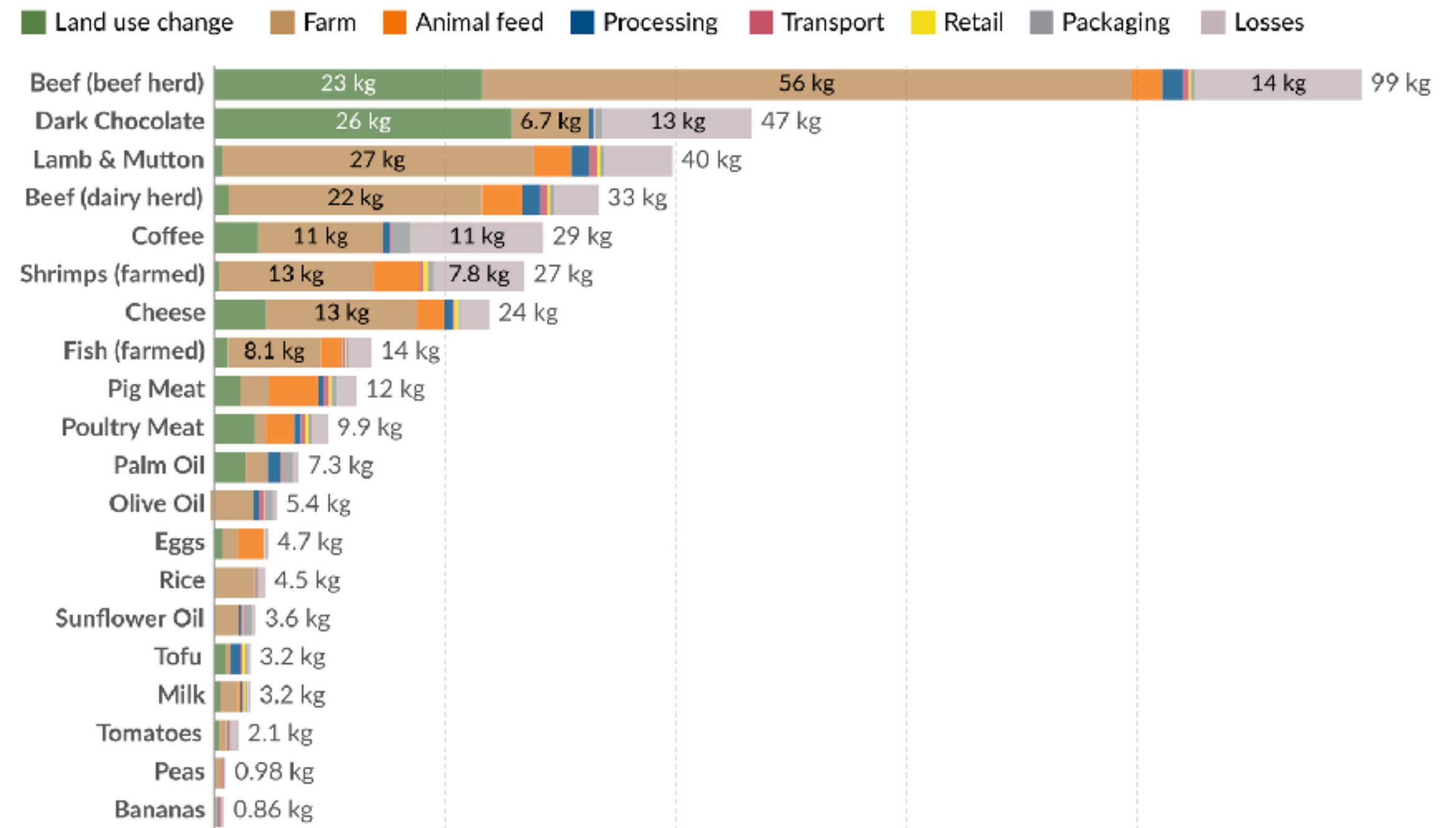
Poor Health Outcomes

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Food: greenhouse gas emissions across the supply chain

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Greenhouse gas emissions¹ are measured in carbon dioxide-equivalents (CO₂eq)² per kilogram of food.



Data source: Joseph Poore and Thomas Nemecek (2018).

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1. Greenhouse gas emissions: A greenhouse gas (GHG) is a gas that causes the atmosphere to warm by absorbing and emitting radiant energy. Greenhouse gases absorb radiation that is radiated by Earth, preventing this heat from escaping to space. Carbon dioxide (CO₂) is the most well-known greenhouse gas, but there are others including methane, nitrous oxide, and in fact, water vapor. Human-made emissions of greenhouse gases from fossil fuels, industry, and agriculture are the leading cause of global climate change. Greenhouse gas emissions measure the total amount of all greenhouse gases that are emitted. These are often quantified in carbon dioxide equivalents (CO₂eq) which take account of the amount of warming that each molecule of different gases creates.

2. Carbon dioxide equivalents (CO₂eq): Carbon dioxide is the most important greenhouse gas, but not the only one. To capture all greenhouse gas emissions, researchers express them in "carbon dioxide equivalents" (CO₂eq). This takes all greenhouse gases into account, not just CO₂. To express all greenhouse gases in carbon dioxide equivalents (CO₂eq), each one is weighted by its global warming potential (GWP) value. GWP measures the amount of warming a gas creates compared to CO₂. CO₂ is given a GWP value of one. If a gas had a GWP of 10 then one kilogram of that gas would generate ten times the warming effect as one kilogram of CO₂. Carbon dioxide equivalents are calculated for each gas by multiplying the mass of emissions of a specific greenhouse gas by its GWP factor. This warming can be stated over different timescales. To calculate CO₂eq over 100 years, we'd multiply each gas by its GWP over a 100-year timescale (GWP100). Total greenhouse gas emissions - measured in CO₂eq - are then calculated by summing each gas' CO₂eq value.

Environment Contamination

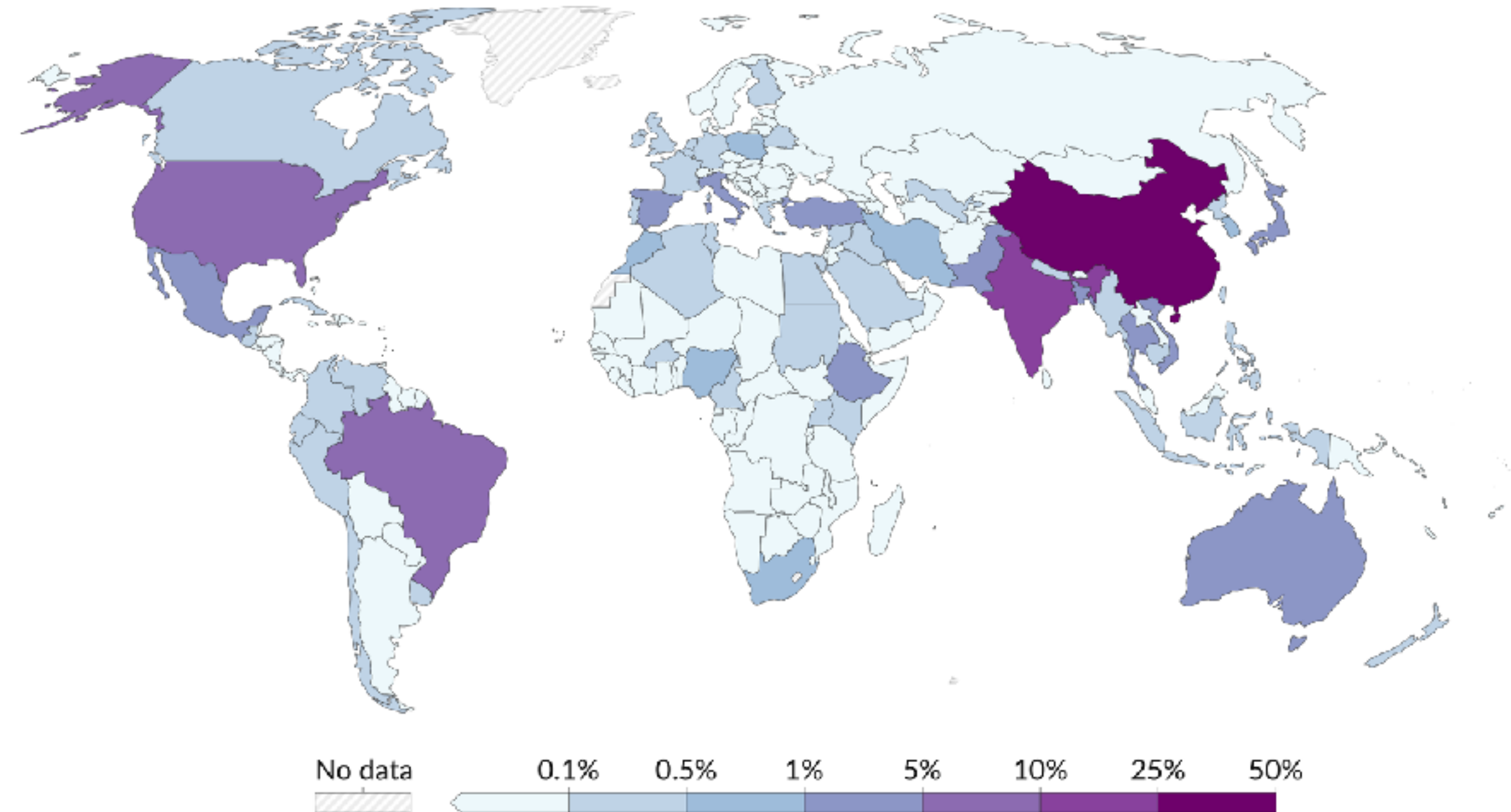
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Share of global excess phosphorous from croplands

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"Excess phosphorous" is the difference between nutrient inputs (from fertilizers and manure) and the amount harvested in crop material. This represents phosphorous that is lost to the environment and can create ecological imbalances on ecosystems and in water bodies.



Data source: West, Gerber, Engstrom, Mueller, Brauman, Carlson, Cassidy, Johnston, MacDonald, Ray & Siebert (2014). Leverage points for improving global food security and the environment. Science.

OurWorldInData.org/fertilizers | CC BY

Environment Contamination

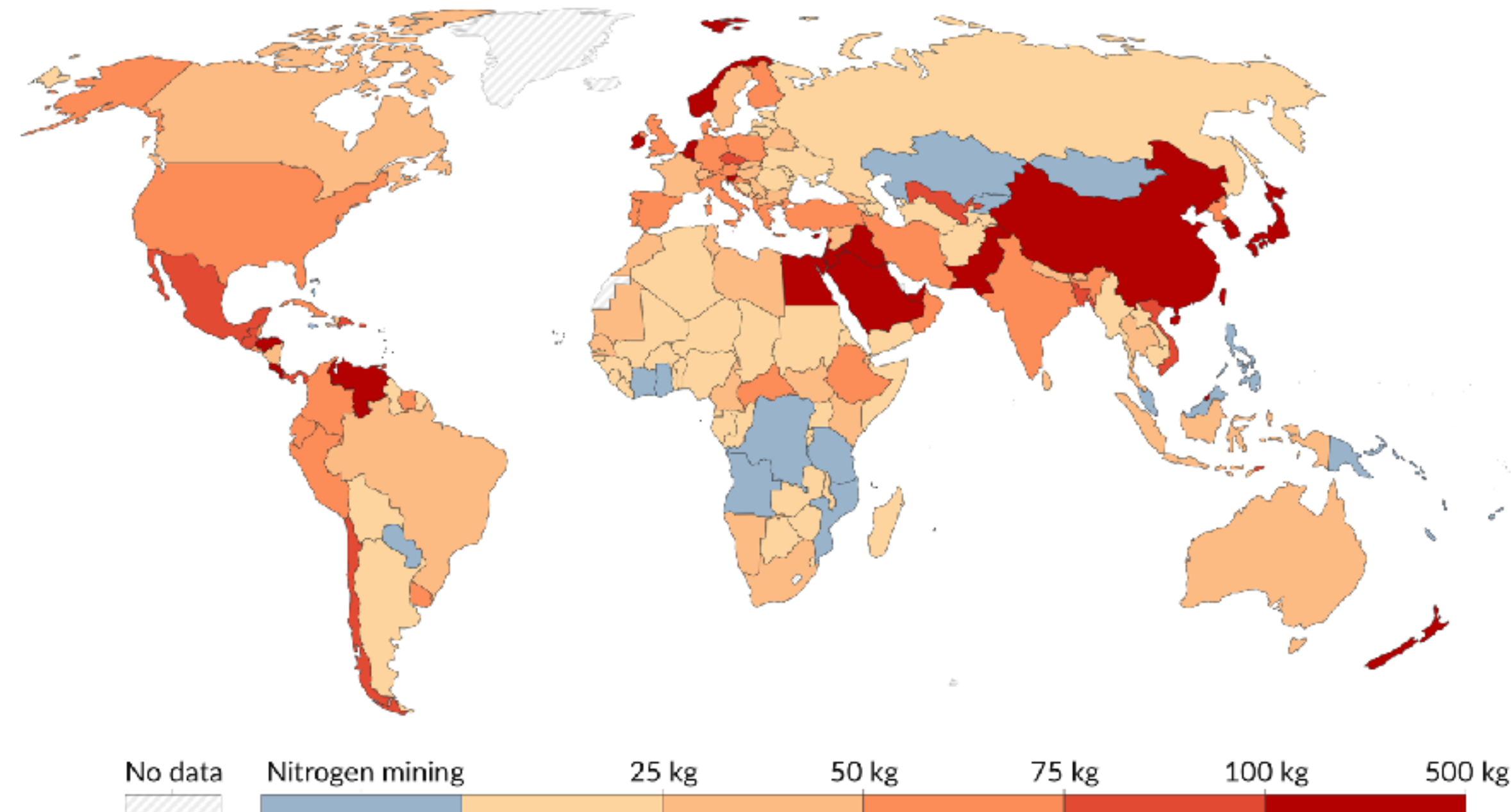
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Excess nitrogen per hectare of cropland

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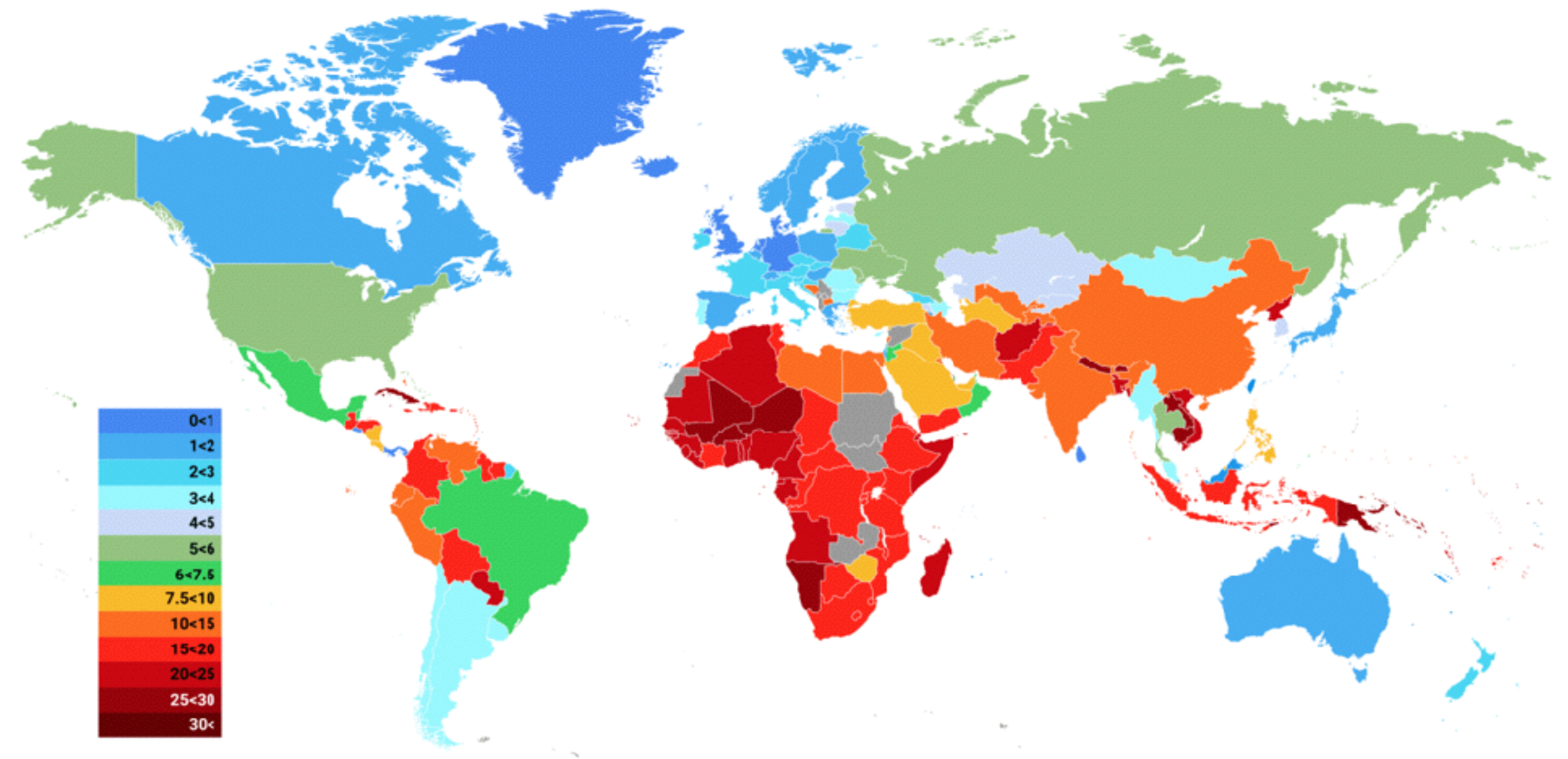
"Excess nitrogen" is the difference between nutrient inputs (from fertilizers, manure, and fixation from legumes) and the amount harvested in crop material. This represents nitrogen that is lost to the environment and can create ecological imbalances in ecosystems and water bodies.



Data source: West, Gerber, Engstrom, Mueller, Brauman, Carlson, Cassidy, Johnston, MacDonald, Ray & Siebert (2014). Leverage points for improving global food security and the environment. Science. OurWorldInData.org/fertilizers | CC BY

Physical Injury

How Do Workplace Fatality Rates per 100,000 Workers Change Across the Globe?

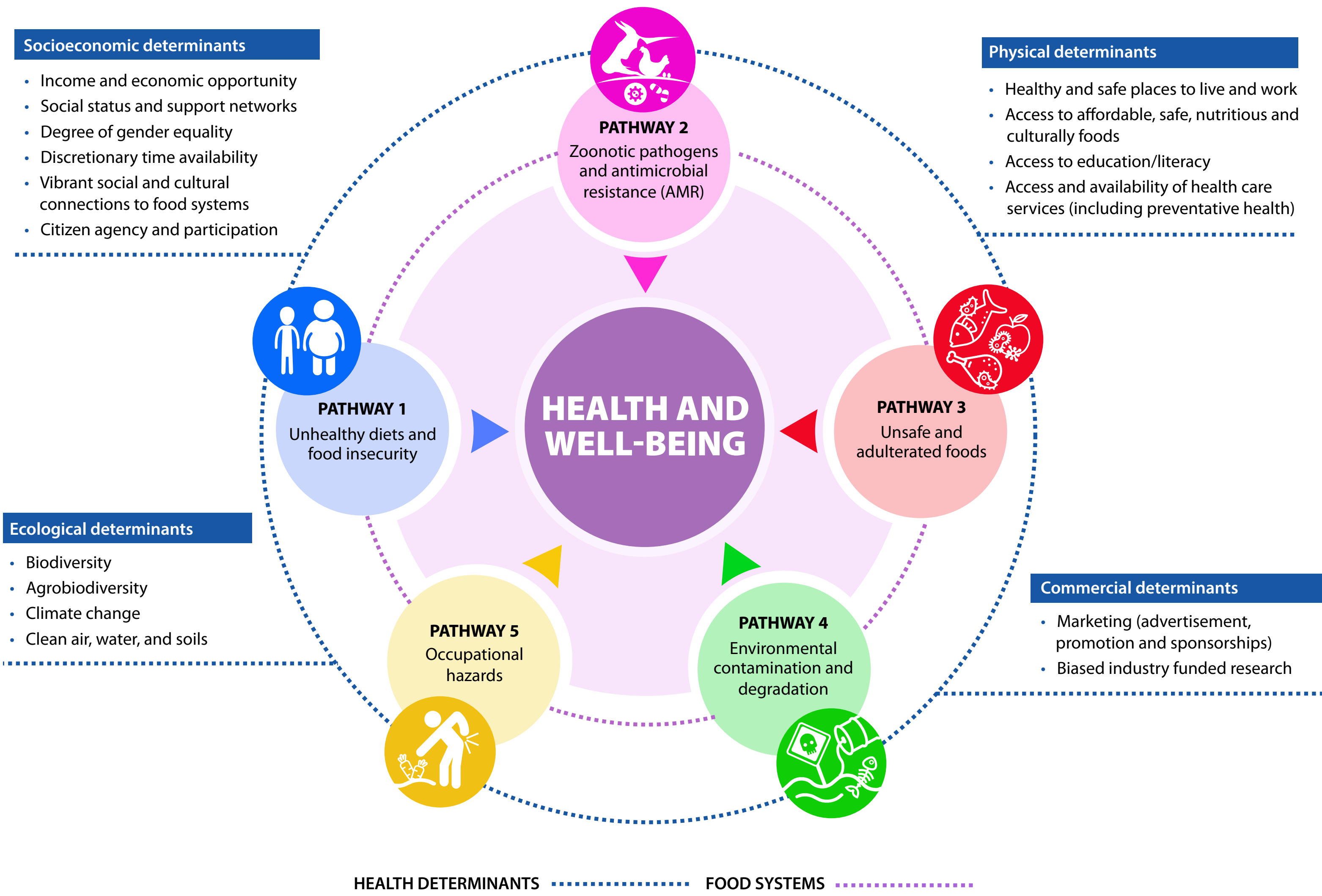


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Delivering Better Health

The four key determinants impacting human health through food systems



Nutritious Food for All

1. Reducing overall food demand
2. Progressively shifting to lower-impact, less-resource-intensive food sources
3. Ensuring that scarce resources (land, water) are allocated to food production as a priority over non-food uses
4. Improving economic access to food
5. Improving farmer productivity in the developing world

Challenges

Systemic challenges for the food system must be addressed simultaneously for the system to be considered sustainable.

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Planet Boundaries

1. Reducing impact of existing agricultural, fishing, and aquaculture practices (e.g, applying conservation measures, phasing out damaging fishing practices)
2. Placing limits on system expansion and intensification, particularly when addressing global yield gap (e.g., reducing arable land expansion, and if necessary directing it towards marginal lands, enforcing fisheries quotas more effectively)
3. Investing in the development of new sustainable agricultural and aquaculture techniques (e.g., organic cultivars, agroecological practices, alternative fish feeds, etc.)

Supporting Livelihoods

Challenges

Systemic challenges for the food system must be addressed simultaneously for the system to be considered sustainable.

78% OF POOR PEOPLE
LIVE IN
RURAL AREAS
AND WORK MAINLY IN AGRICULTURE.
THEY MUST BE LIFTED OUT OF POVERTY

Q&A

Discussion