

Global human population & food supply & demand

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1/23/2024

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1

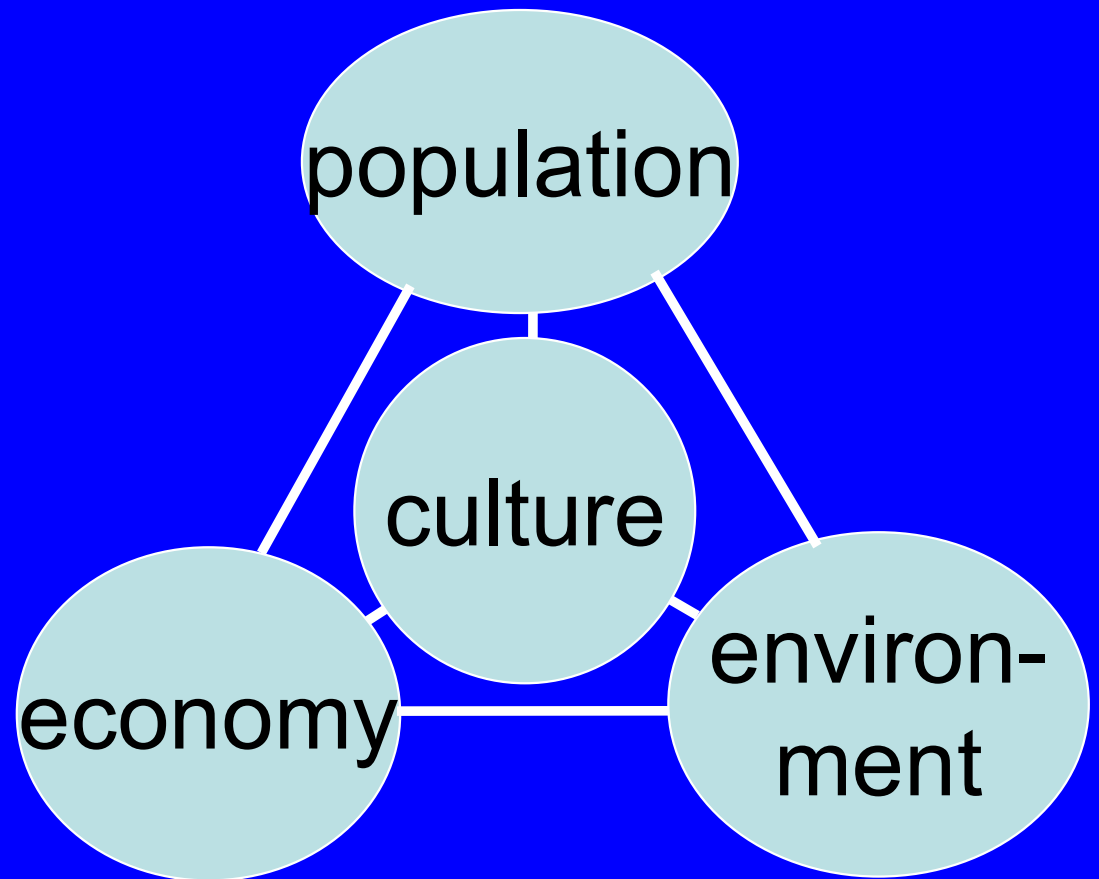
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Population
Economy
Environment
Culture
interact.



Global human population: summary

Past: ~1 billion → ~8 billion in ~200 years.

Growth was **not** exponential.

Present: Increasing ~74 million/year
(another USA population in <5 years). One
person in 10 is hungry. >1 child in 5 under
5 years old is stunted from chronic hunger.

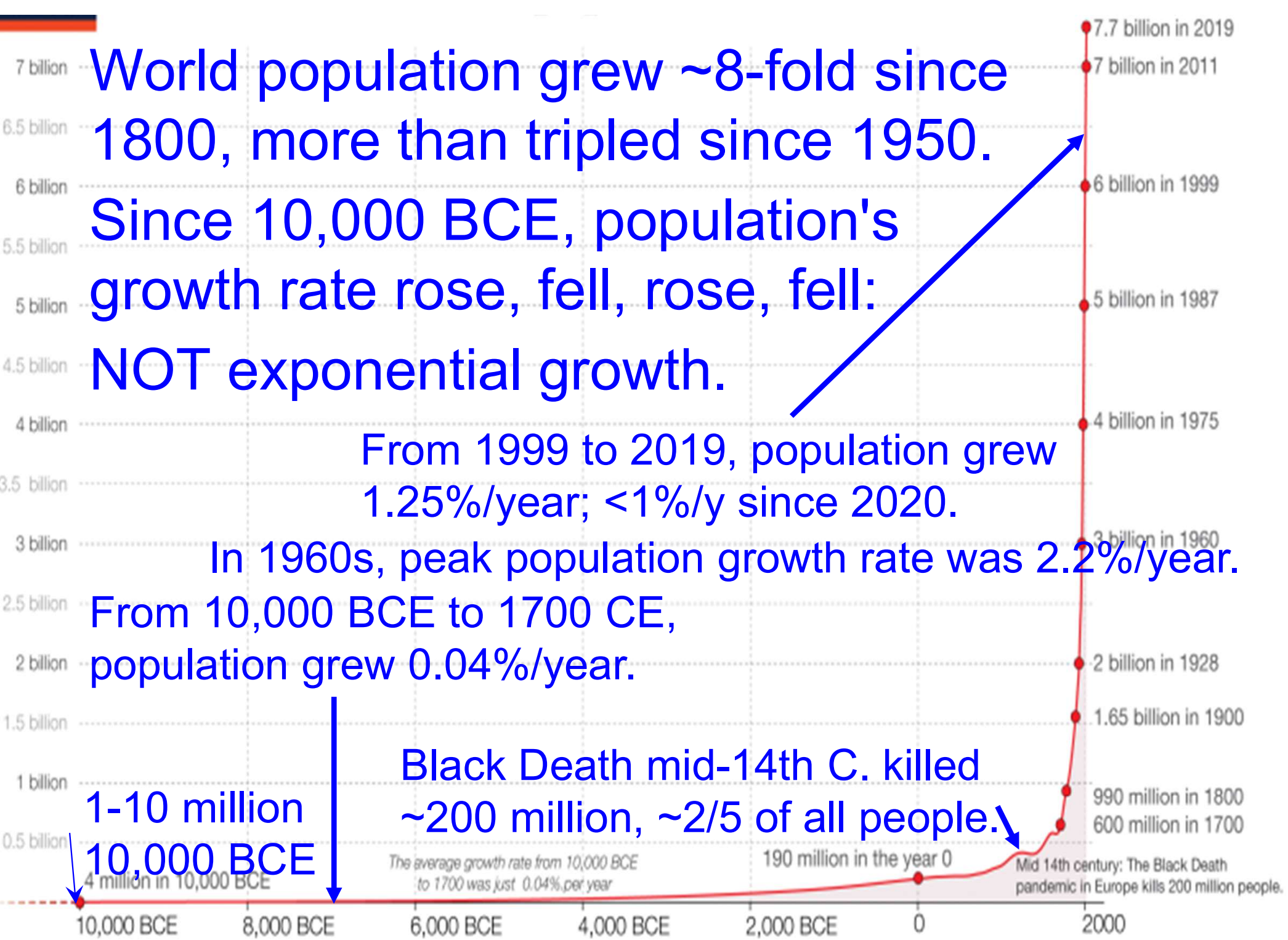
Future: If no nuclear war, plague, climate
catastrophe, comets, it will pass 9 billion
by 2037, 10 bln by 2058, & grow older,
more urban, more slowly, more Asian,
more African; and more migration.

Past

1/23/2024

2019-09-06
Cevennes, France





World population grew ~8-fold since 1800, more than tripled since 1950.

Since 10,000 BCE, population's growth rate rose, fell, rose, fell:

NOT exponential growth.

From 1999 to 2019, population grew 1.25%/year; <1%/y since 2020.

In 1960s, peak population growth rate was 2.2%/year.

From 10,000 BCE to 1700 CE, population grew 0.04%/year.

Black Death mid-14th C. killed ~200 million, ~2/5 of all people.

1-10 million
10,000 BCE

The average growth rate from 10,000 BCE to 1700 was just 0.04% per year

190 million in the year 0

Mid 14th century: The Black Death pandemic in Europe kills 200 million people.

4 changes in population growth

invention	dates	people	doubling time (years)	
			before	after
local agriculture	10,000-6,000	1-10	35,000-	1,400-
	BCE	million	350,000	3,000

independent inventions of agriculture in Middle East, Asia, Africa, Americas

global agriculture	1750	750 million	750-1,800	100-130
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exchanges of plants, animals, & people between Old World & New World

public health	1950	2.5 billion	87	36
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massive reductions in death rates of children in poor countries

fertility control	1970	3.7 billion	34	50
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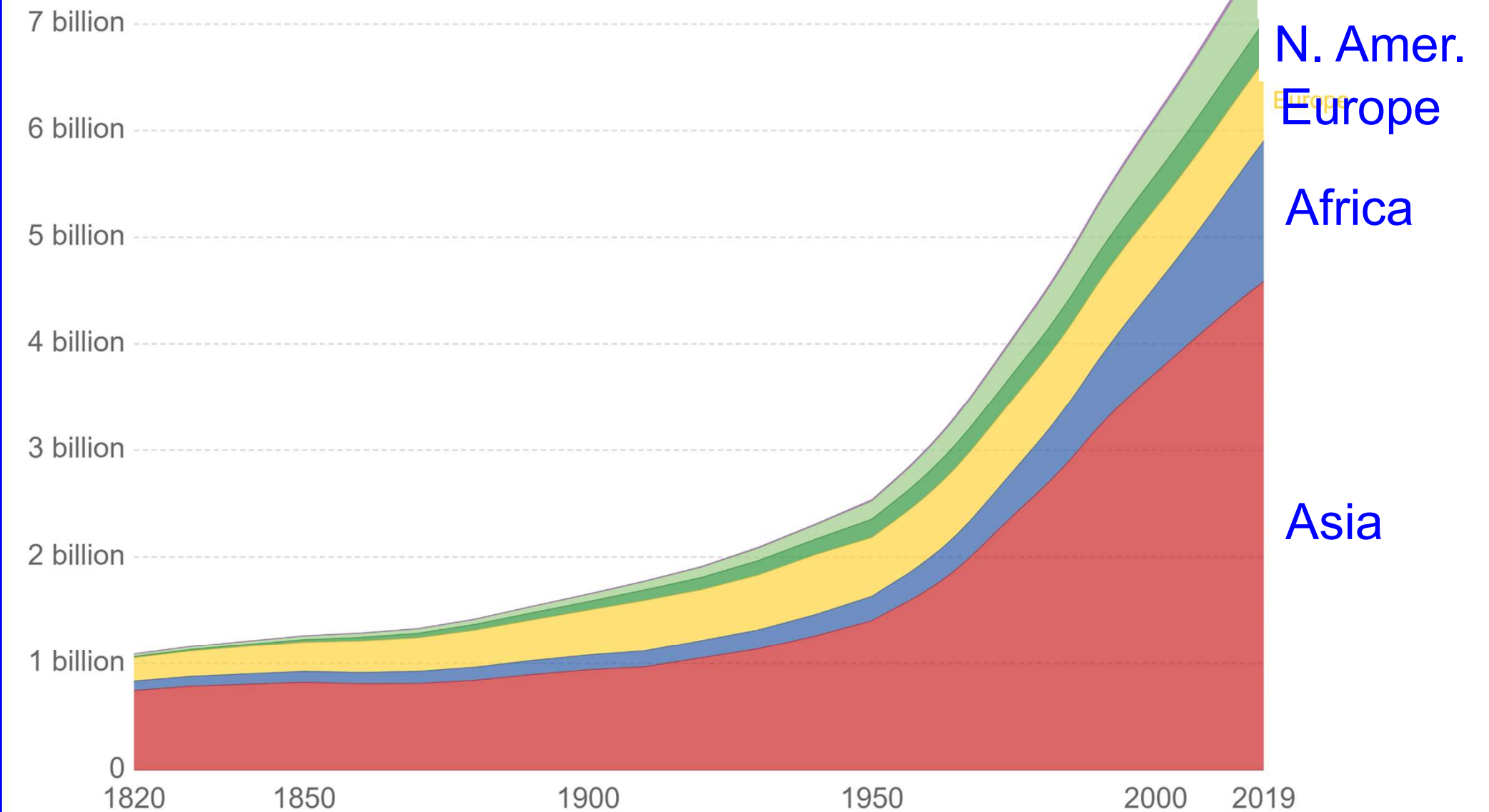
decline in fertility rates & Green Revolution

20th century was unique demographically.

1. Highest global population growth rate in history: only century in which global population doubled (grew 3.8 x)
2. Largest voluntary decline in fertility
3. Last century with more young people than old people
4. Last century with more rural people than urban people

World population by region 1820-2019

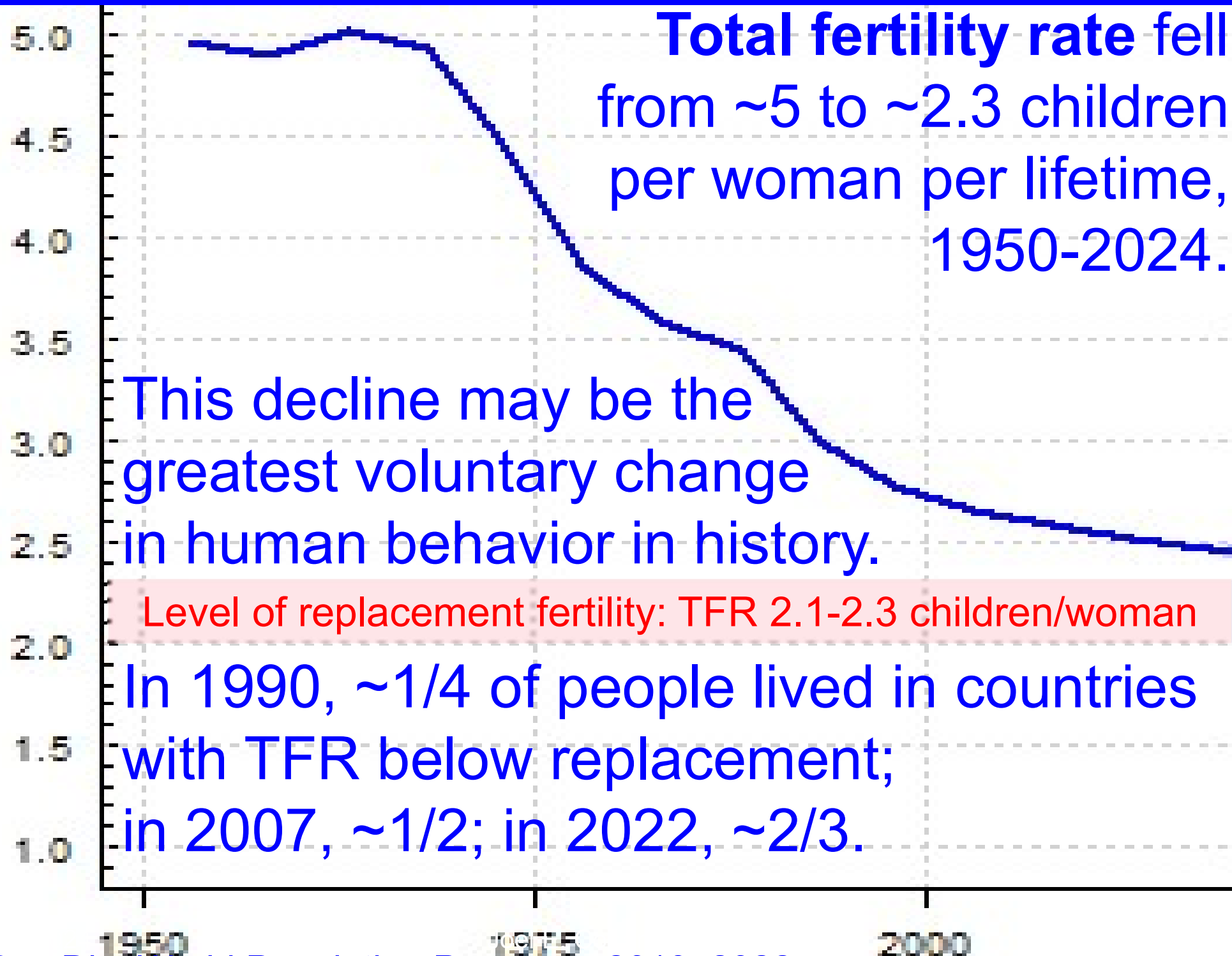
<https://ourworldindata.org/world-population-growth> (CC BY 4.0)



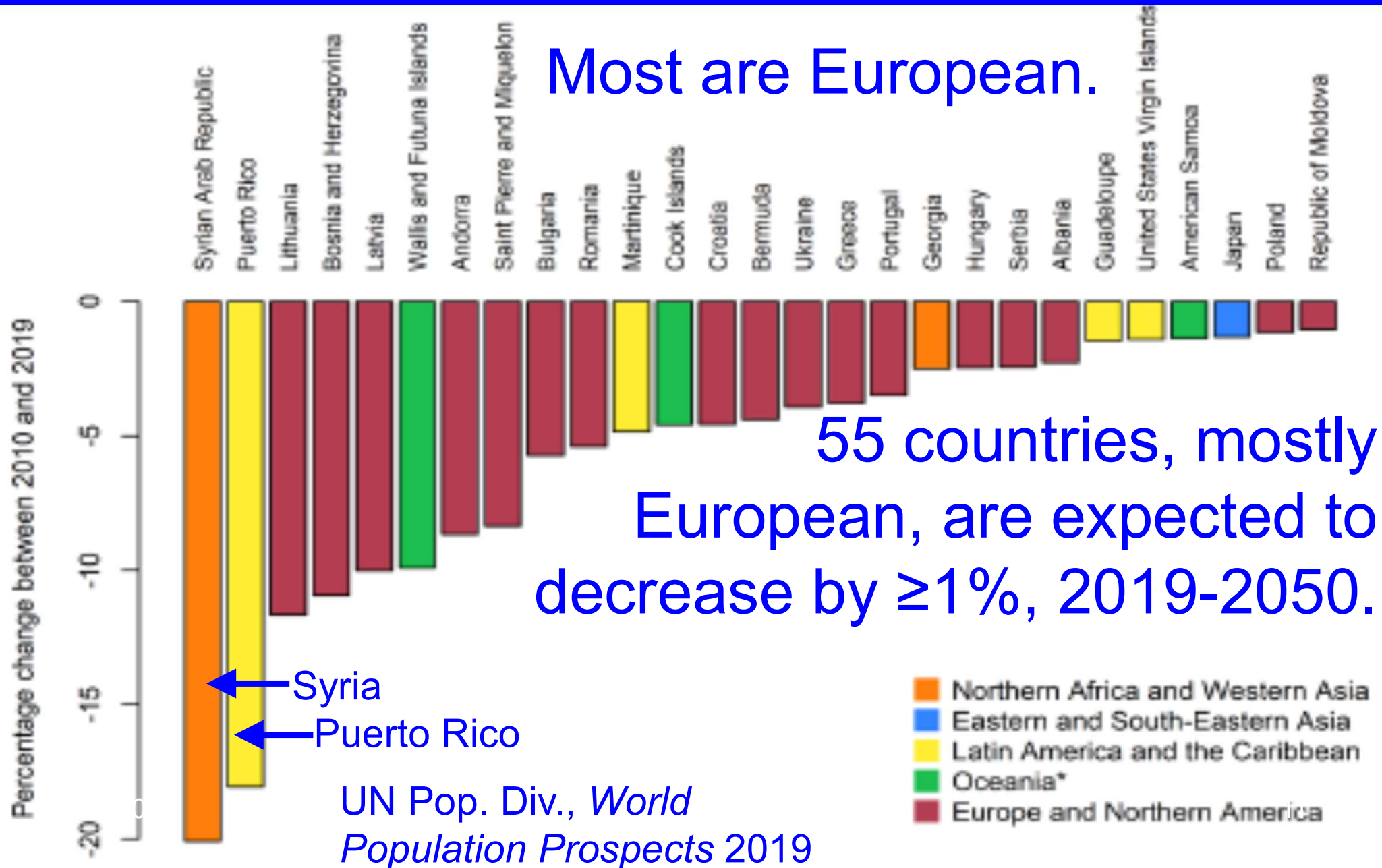
Source: HYDE (2016) & UN (2017)

OurWorldInData.org/world-population-growth/ • CC BY

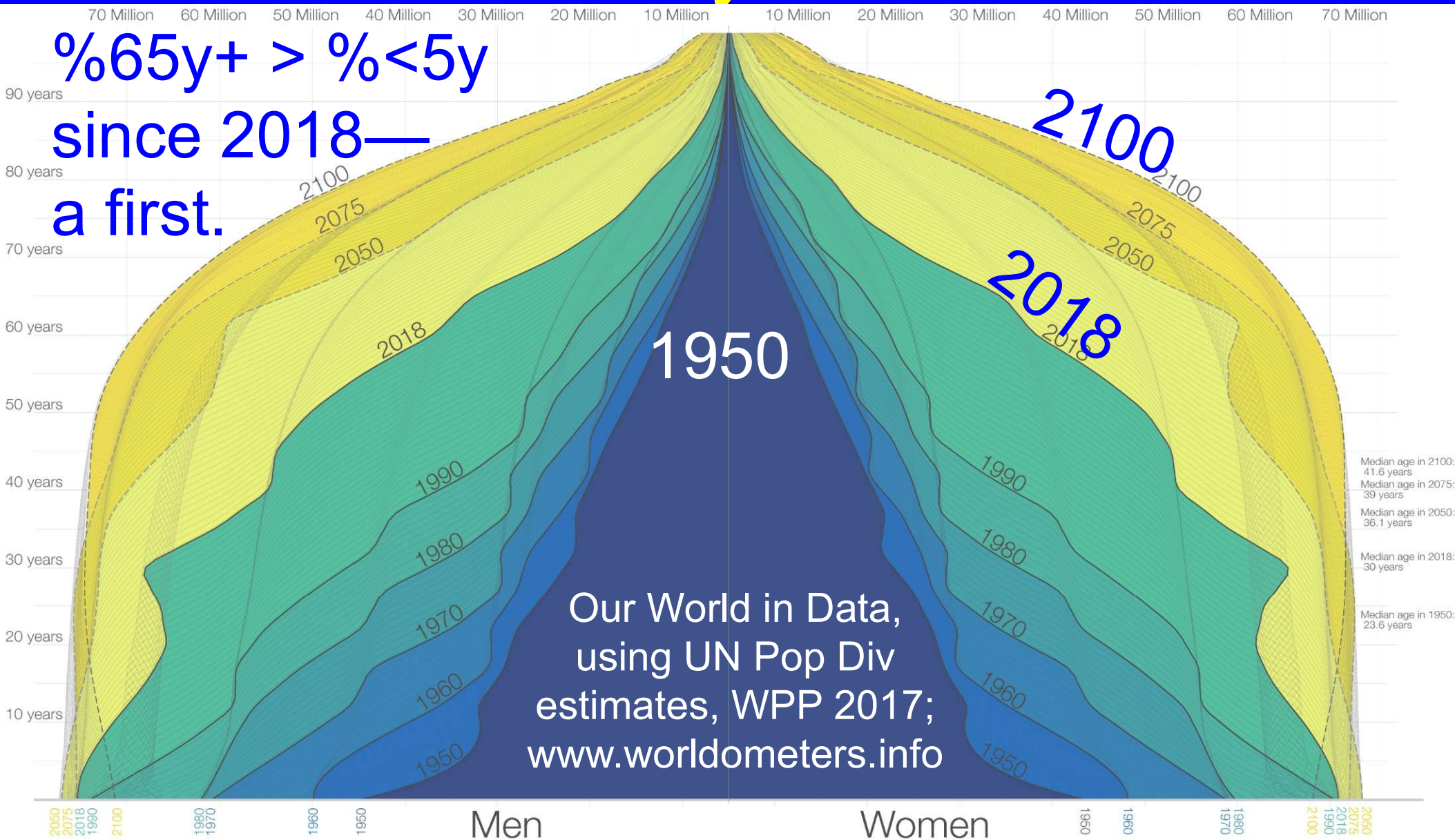
Live births per woman



Population size fell by at least 1% in 27 countries 2010-2019.

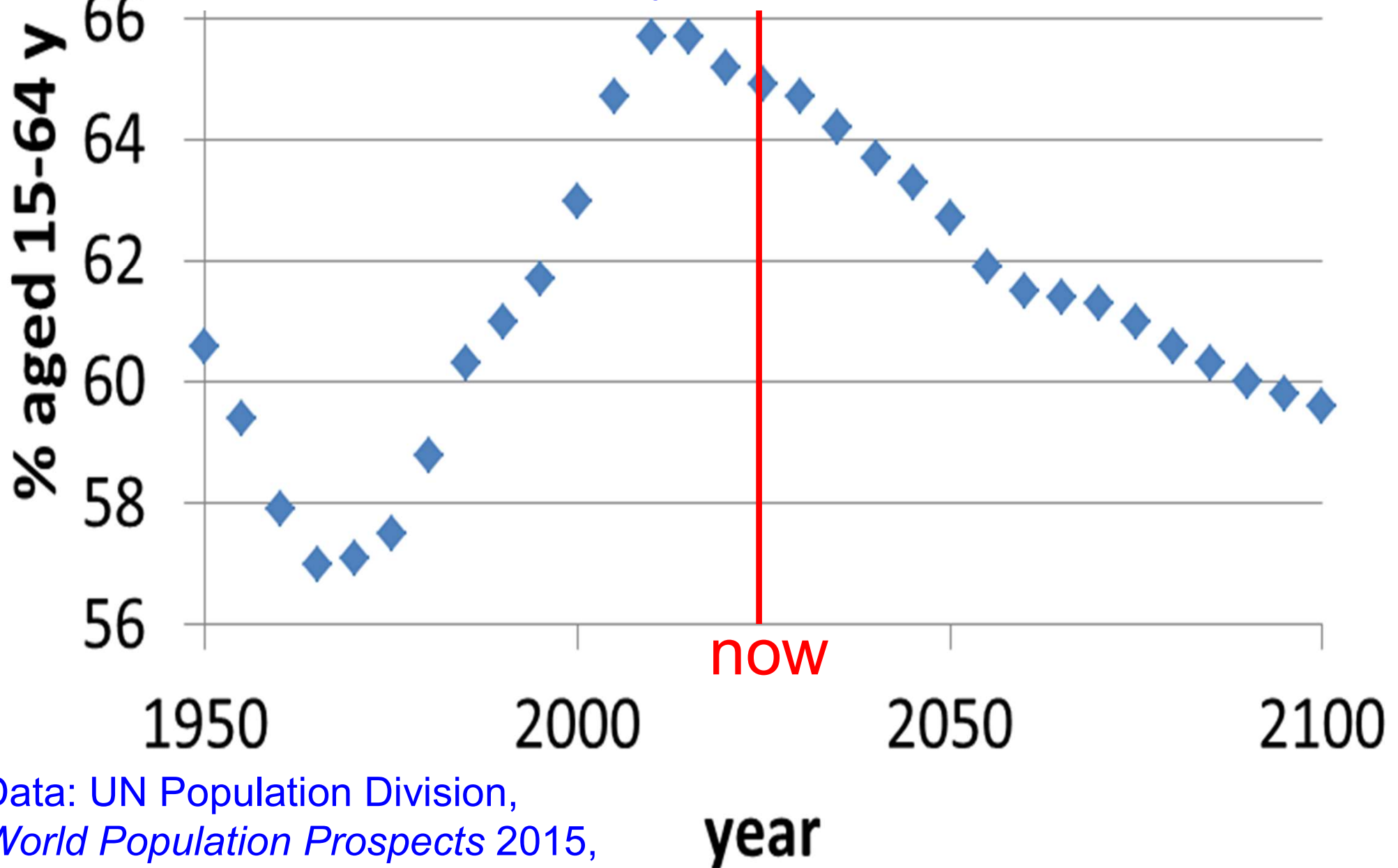


Median age rose from 21.5 years in 1970 to 30.7 years in 2024.



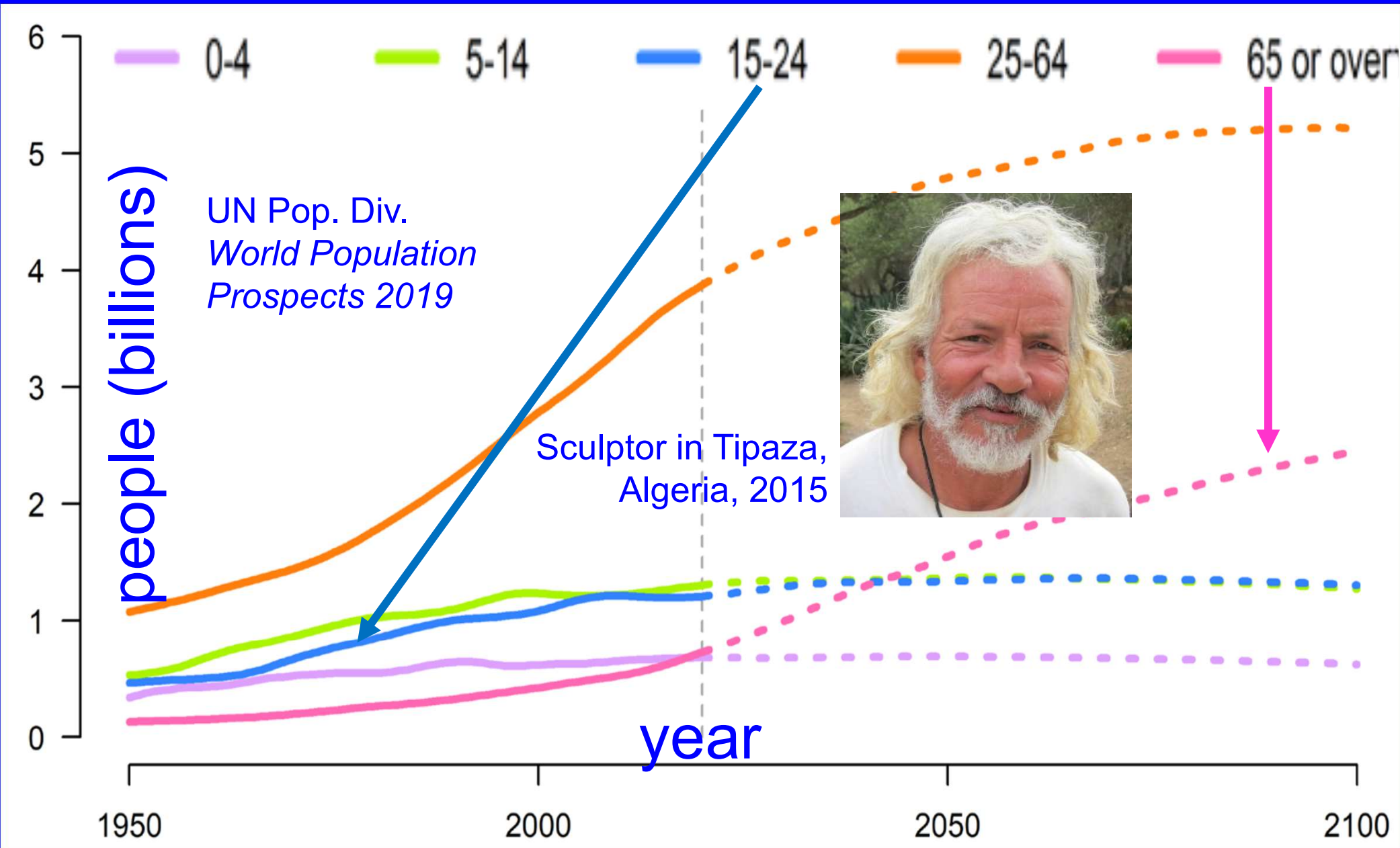
Data source: United Nations Population Division – World Population Prospects 2017; Medium Variant.
The data visualization is available at OurWorldinData.org, where you find more research on how the world is changing and why.
Licensed under CC-BY by the author Max Roser.

Fraction of people aged 15-64 years peaked, probably forever, at 66% in 2012.



Data: UN Population Division,
World Population Prospects 2015,
Medium variant; [updated data.worldbank.org/indicator/SP.POP.1564.TO.ZS](http://updated.data.worldbank.org/indicator/SP.POP.1564.TO.ZS)

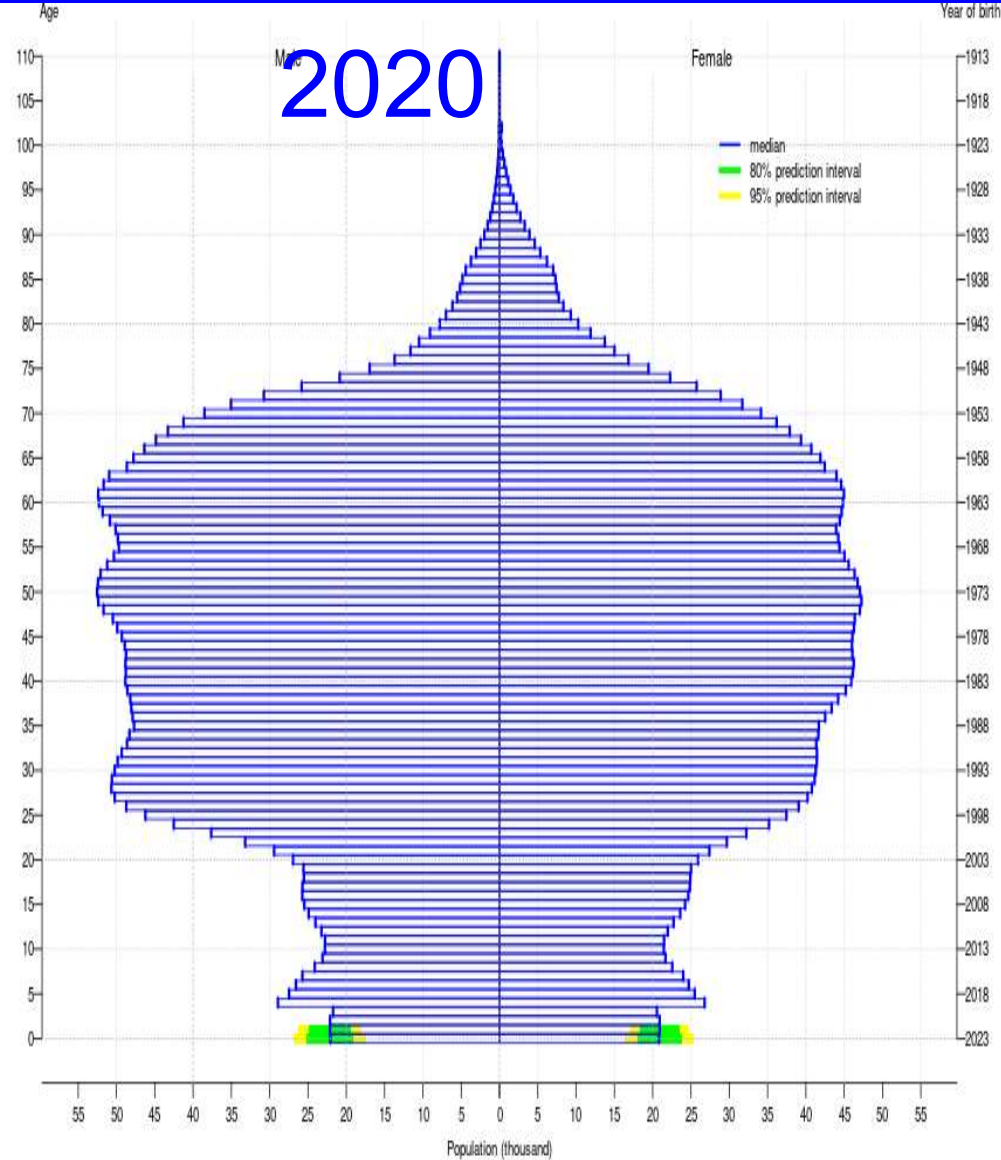
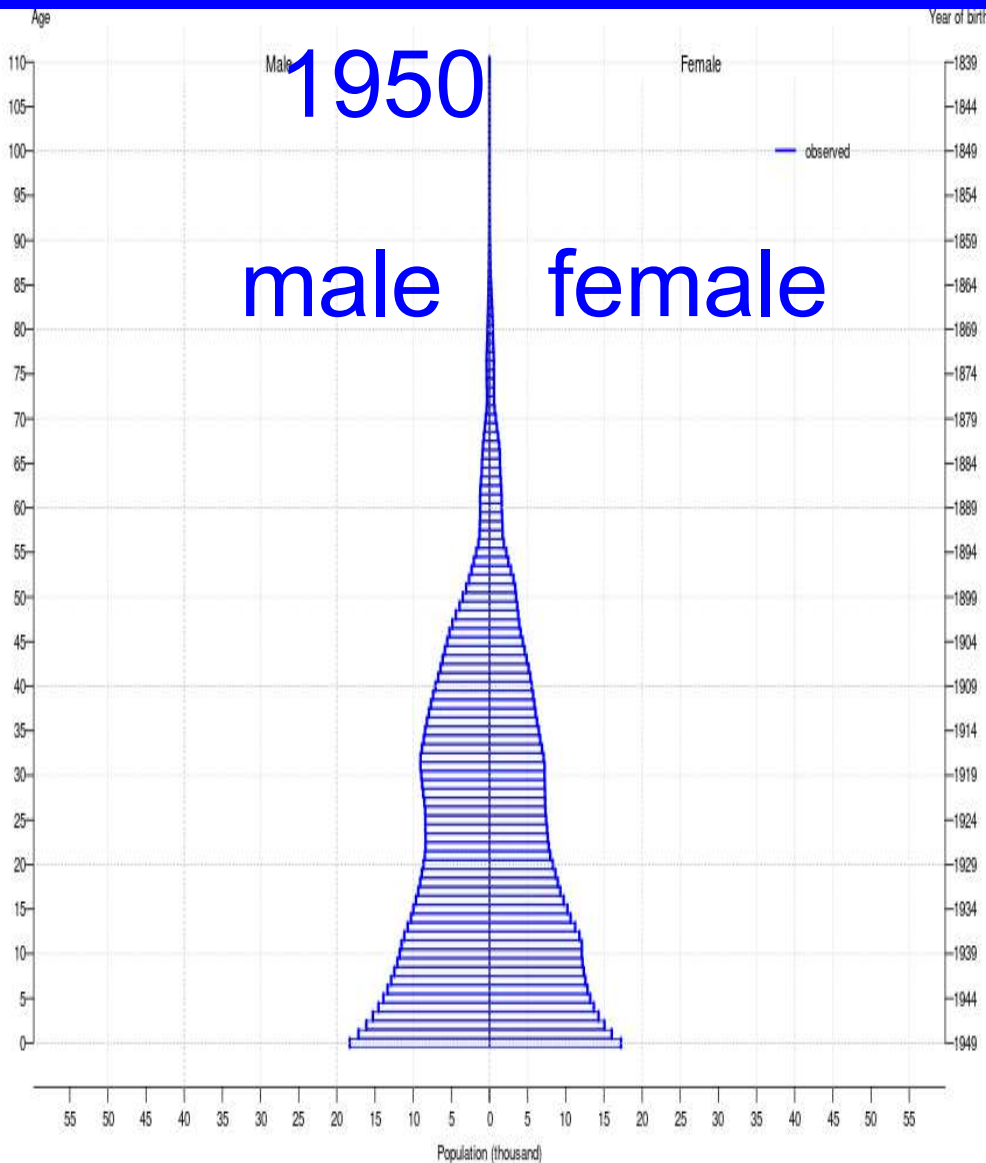
People 65+ are fastest growing age group.



Singapore: low fertility, long life

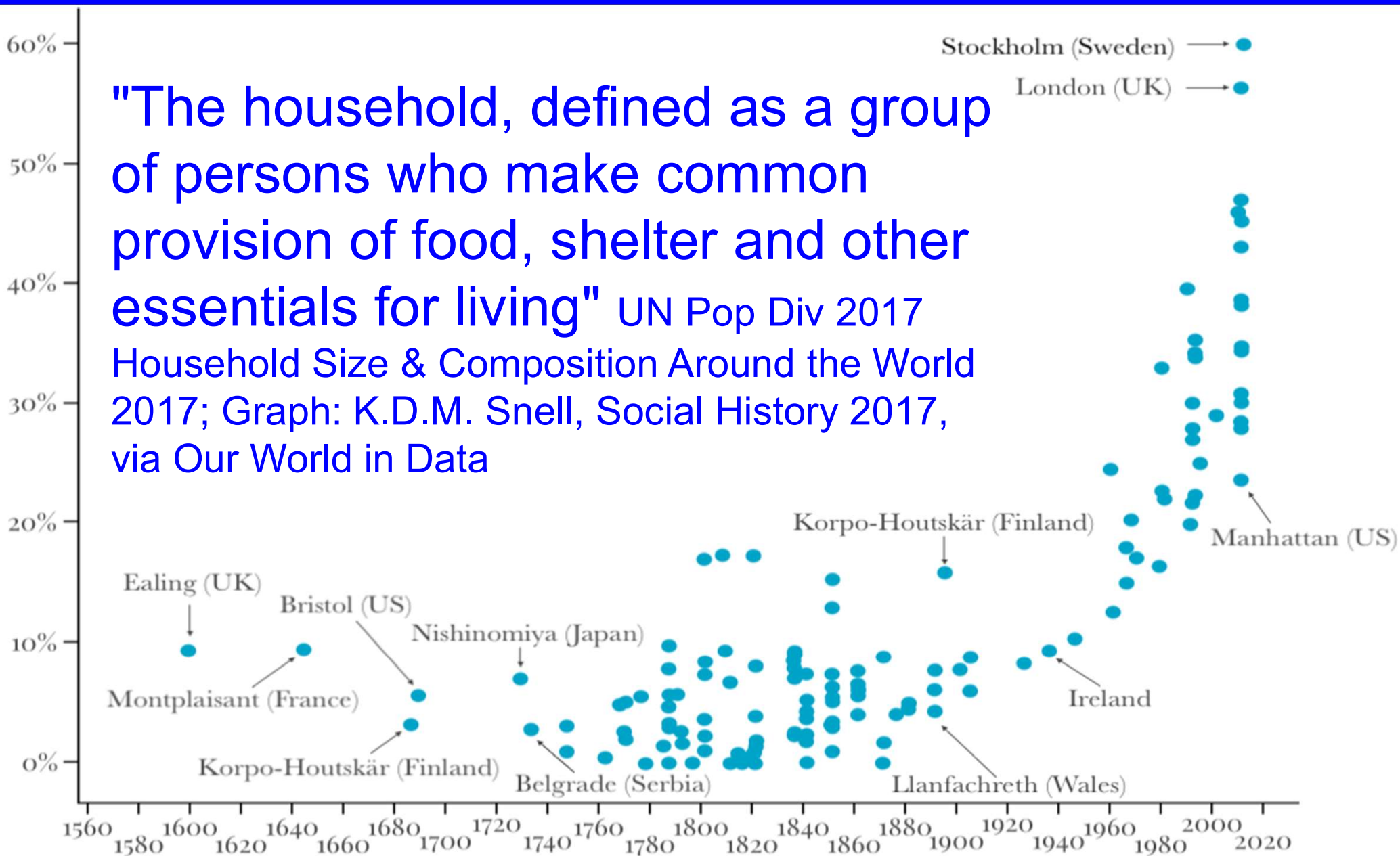
UN Population Division, *World Population Prospects 2022*

<http://population.un.org/wpp>



% 1-person households in villages & cities, 1600-2017

"The household, defined as a group of persons who make common provision of food, shelter and other essentials for living" UN Pop Div 2017 Household Size & Composition Around the World 2017; Graph: K.D.M. Snell, Social History 2017, via Our World in Data

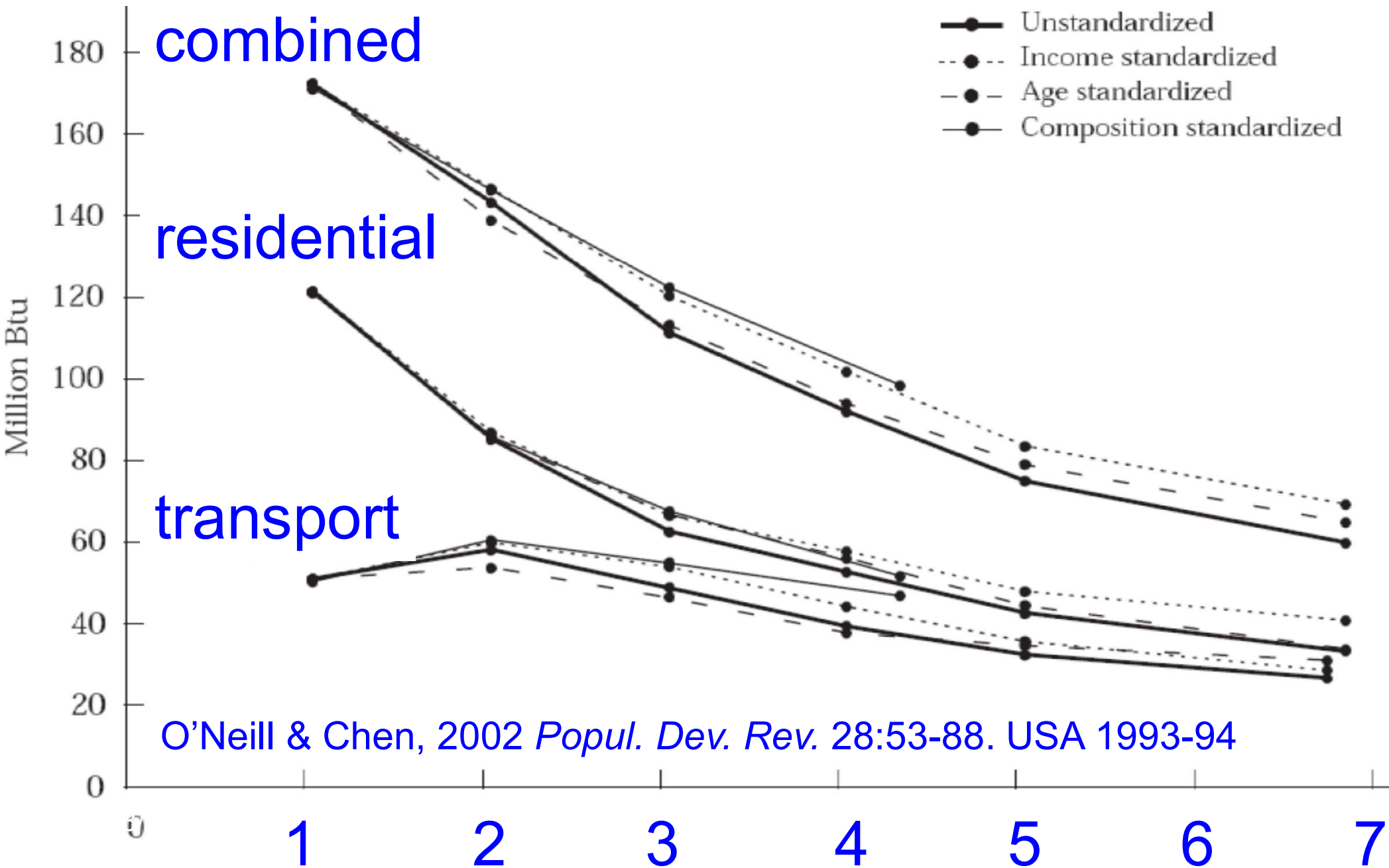


Number of households grew faster than number of people.

Average people per household 1970-2000 **fell** in less-developed countries, from 5.1 to 4.4, in more-developed countries, from 3.2 to 2.5.

Reasons: lower fertility, greater longevity, later marriage, more divorce, rising wealth, changing preferences

Energy use per person was greater in U. S. households with fewer people.

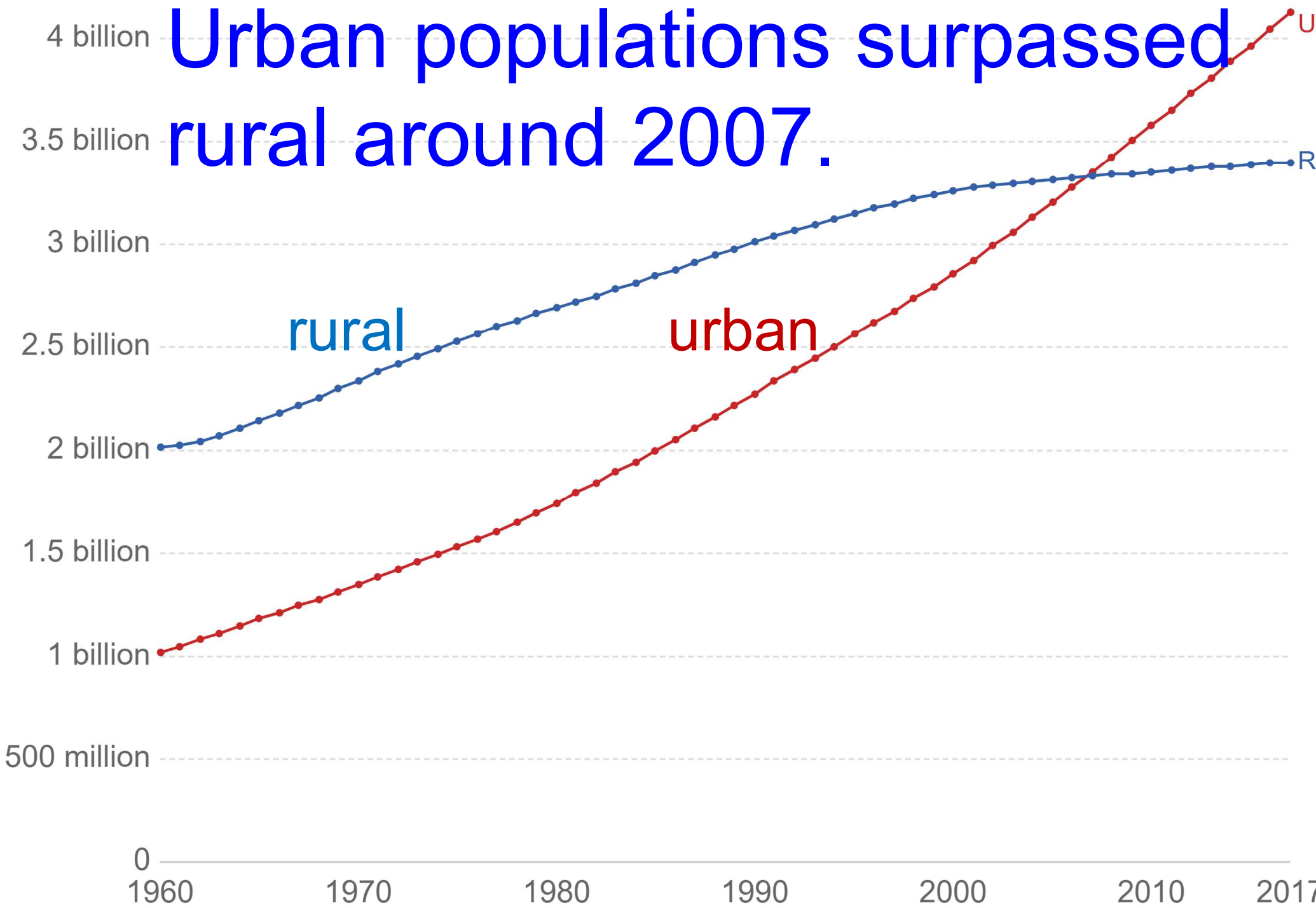


O'Neill & Chen, 2002 *Popul. Dev. Rev.* 28:53-88. USA 1993-94

Cities grew in 20th century.

	1900	1950	2000
Urban population (billions) % of total	0.21 13%	0.75 30%	2.87 47%
Number of cities with ≥ 10 million people	0	1	20
% of urban people living in cities with ≥ 10 million people	0	1.6	9.6

Urban populations surpassed rural around 2007.



Source: UN World Urbanization Prospects (2018)

OurWorldInData.org

Note: Urban populations are defined based on the definition of urban areas by national statistical offices.

Urban expansion competes with surrounding farms.



1/23/2024
Rice field, Fuji City, Japan 2006-01-22, Michiko Shimoda

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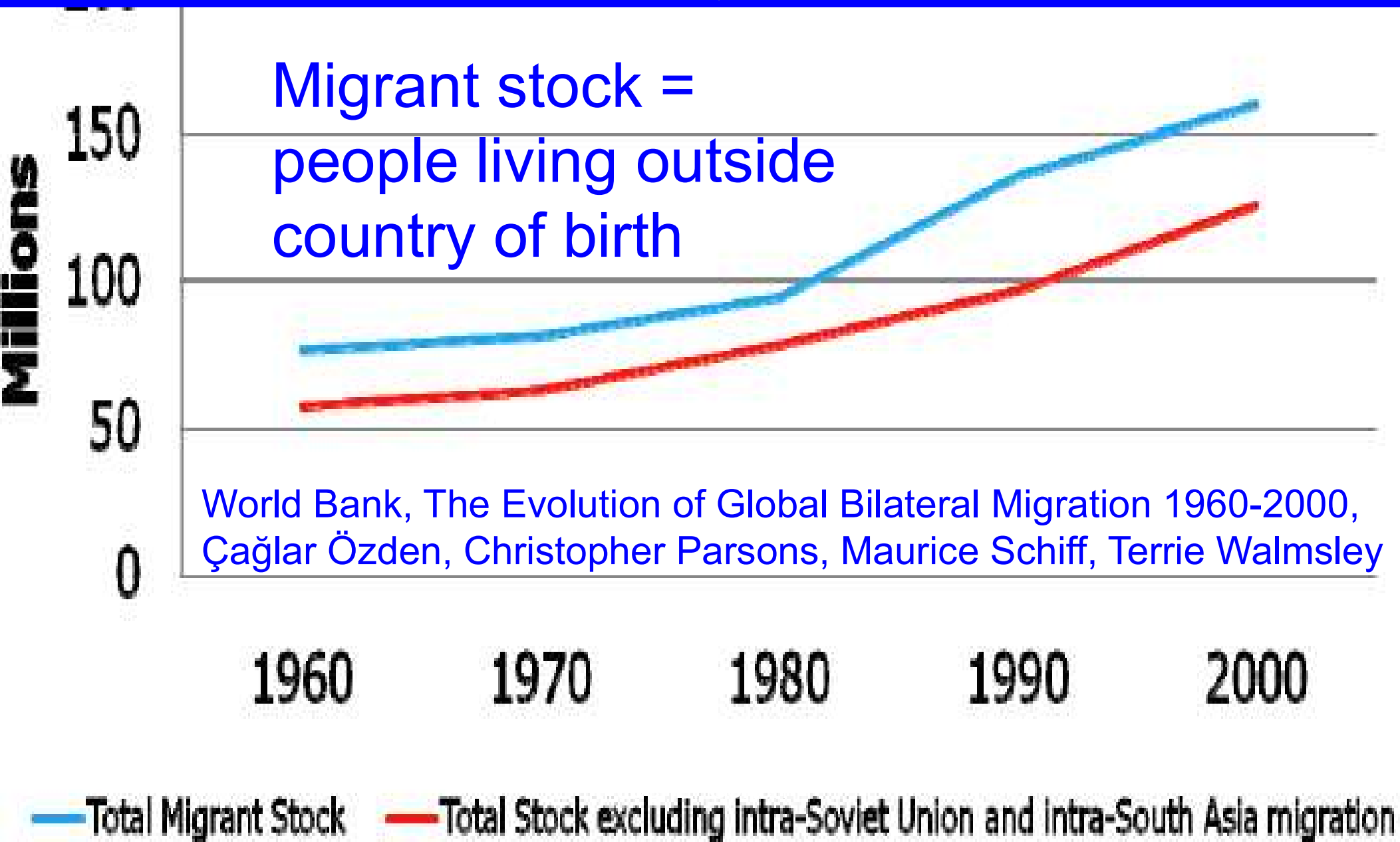
21

Urban growth could affect food supply.

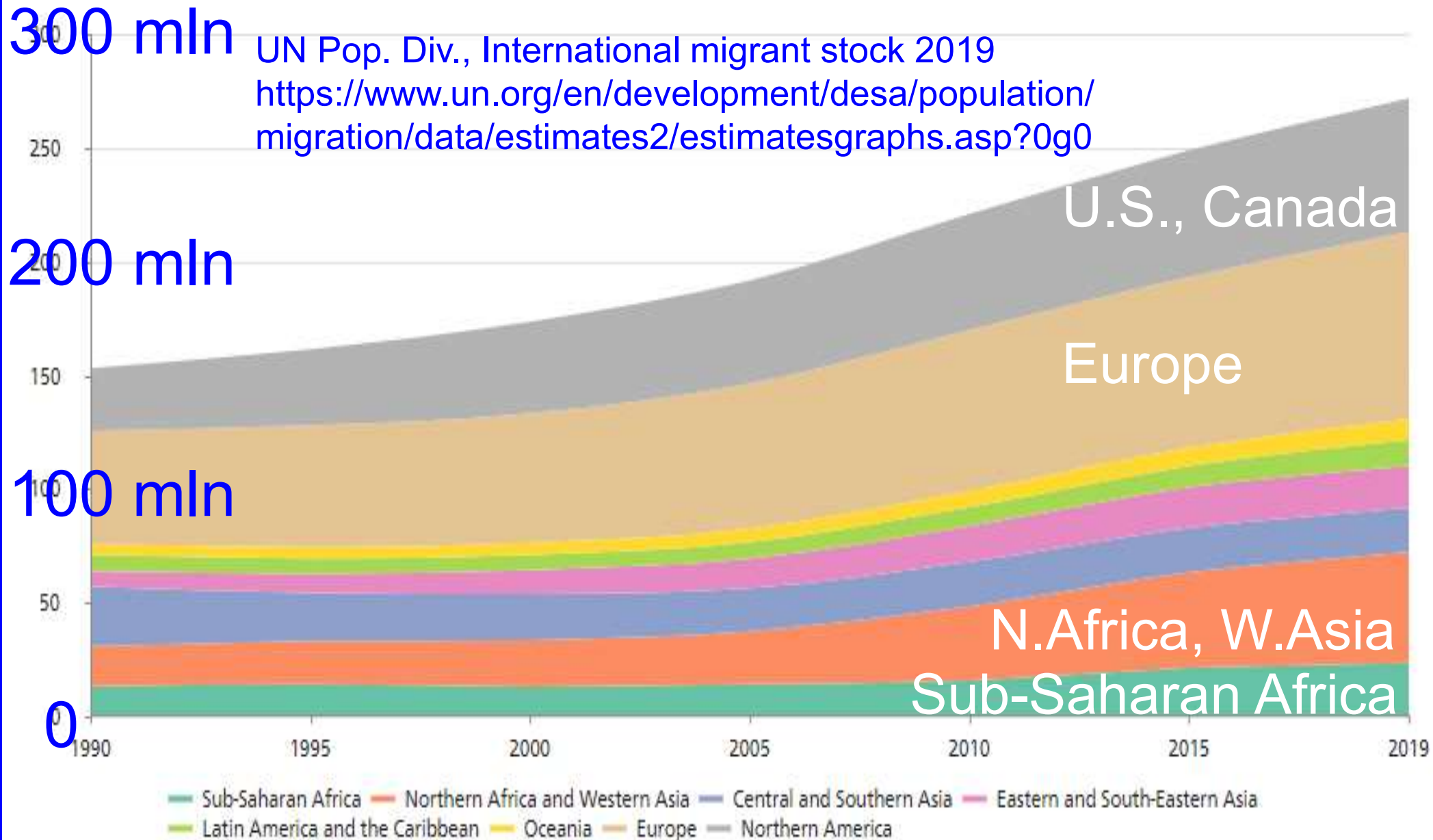
Many cities (~3% of land) are located on prime agricultural land (~10% of land).

If doubling of urban population leads to doubling of urban area, prime agricultural land could be removed from food production.

International migrant stock more than doubled, 1960-2000.



Most migrant stock lived in North America & Europe, 1990-2019.





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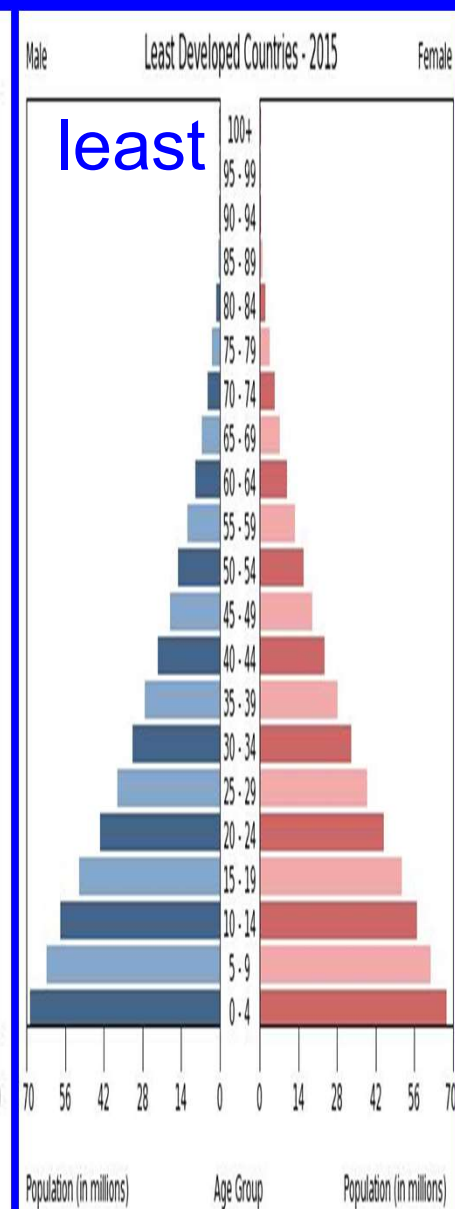
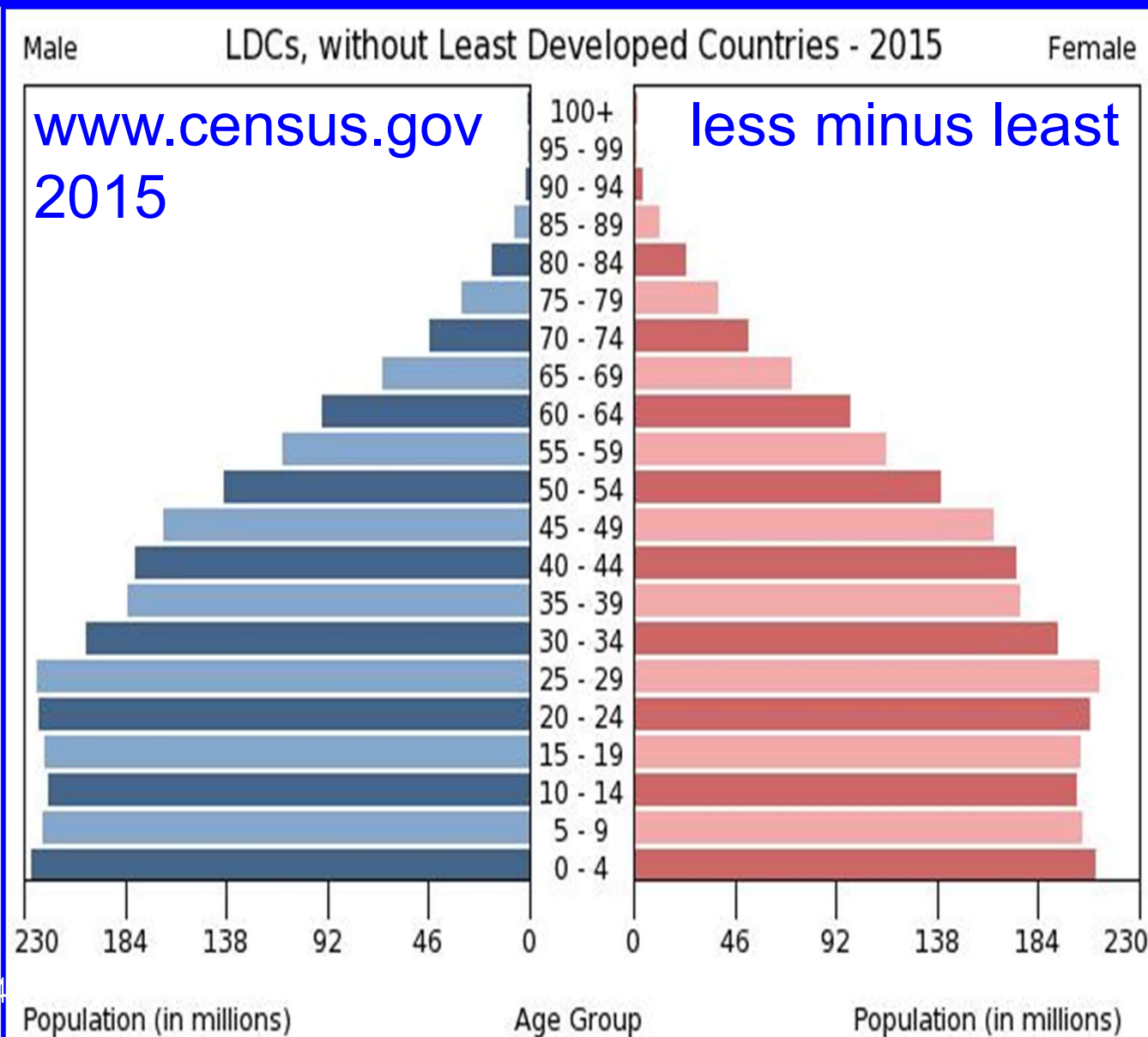
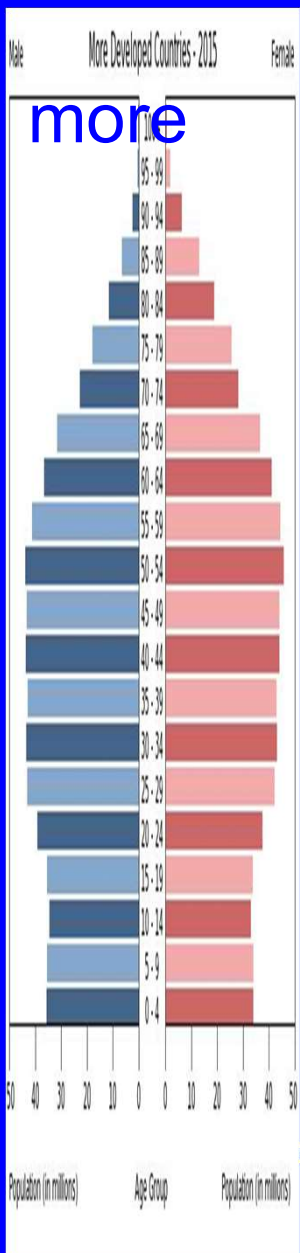
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Present

Berber girl, Atlas mountains₂₅
Morocco, 2009, JEC photo

Three worlds, one planet

Poor countries have younger populations.



Three worlds, one planet

PRB World Population Data Sheet 2023	High Income	Middle Income	Low Income
Population (billions, mid-2023)	1.25	6.00	0.72
Infant Mortality Rate (deaths/1000 born)	4	27	45
Total Fertility Rate (children/woman)	1.5	2.1	4.6
% Urban Population	82	55	35
Population per km ² of Arable Land	8452	1073	774
GNI / person, USD PPP	\$60,988	\$14,261	\$2,202

1/23/2024

$$60988/2202 = 27.7$$

27

Davies, Lluberas,
Shorrocks, Credit
Suisse Global
Wealth Report &
Databook 2022

1.1% of adults have 45.8% of wealth.

> USD 1 million

59.4 million (1.1%)

USD 208.3 trillion (45.8%)

USD 3.5 million/adult

USD 100,000 to 1 million

642 m (12.0%)

USD 178.9 trillion (39.4%)

USD 10,000 to 100,000

1,844 m (34.4%)

USD 61.9 trillion (13.6%)

< USD 10,000

2,818 m (52.5%)

USD 5.3 trillion (1.2%)

Wealth range

USD 1881 / adult

Total wealth (% of world)

52.5% of adults have 1.2% of wealth.

Number of adults (percent of world adults)

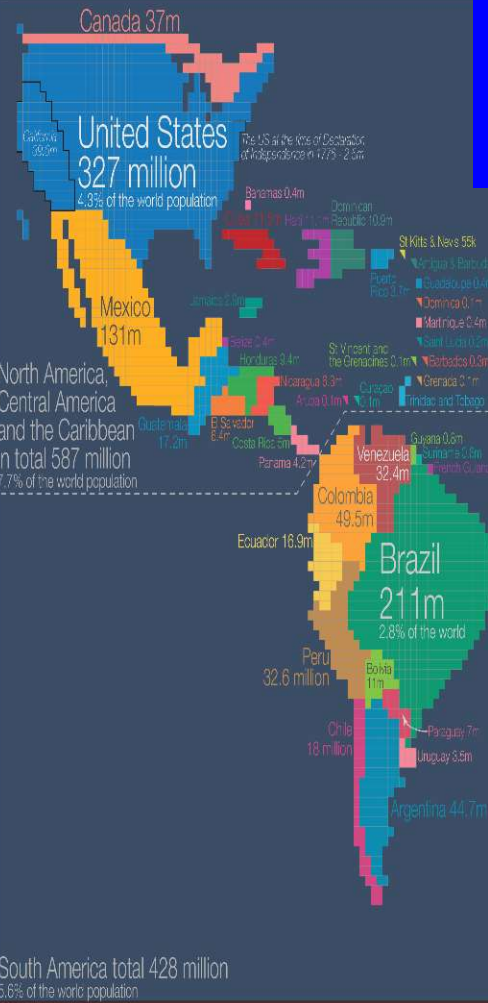
World has ~8 billion people.

Our World in Data

N&S Amer
~13%

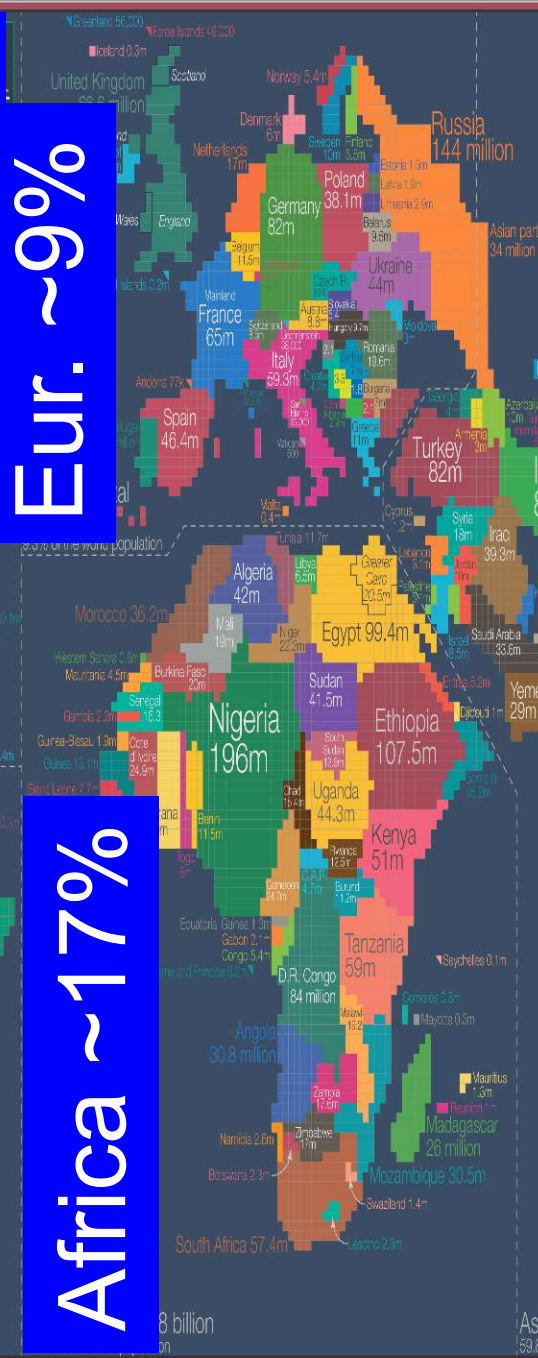
world's largest problems and how to make progress against them.

Population data from the United Nations Population Division
Version 8 (October 2018) Licensed under CC BY 4.0

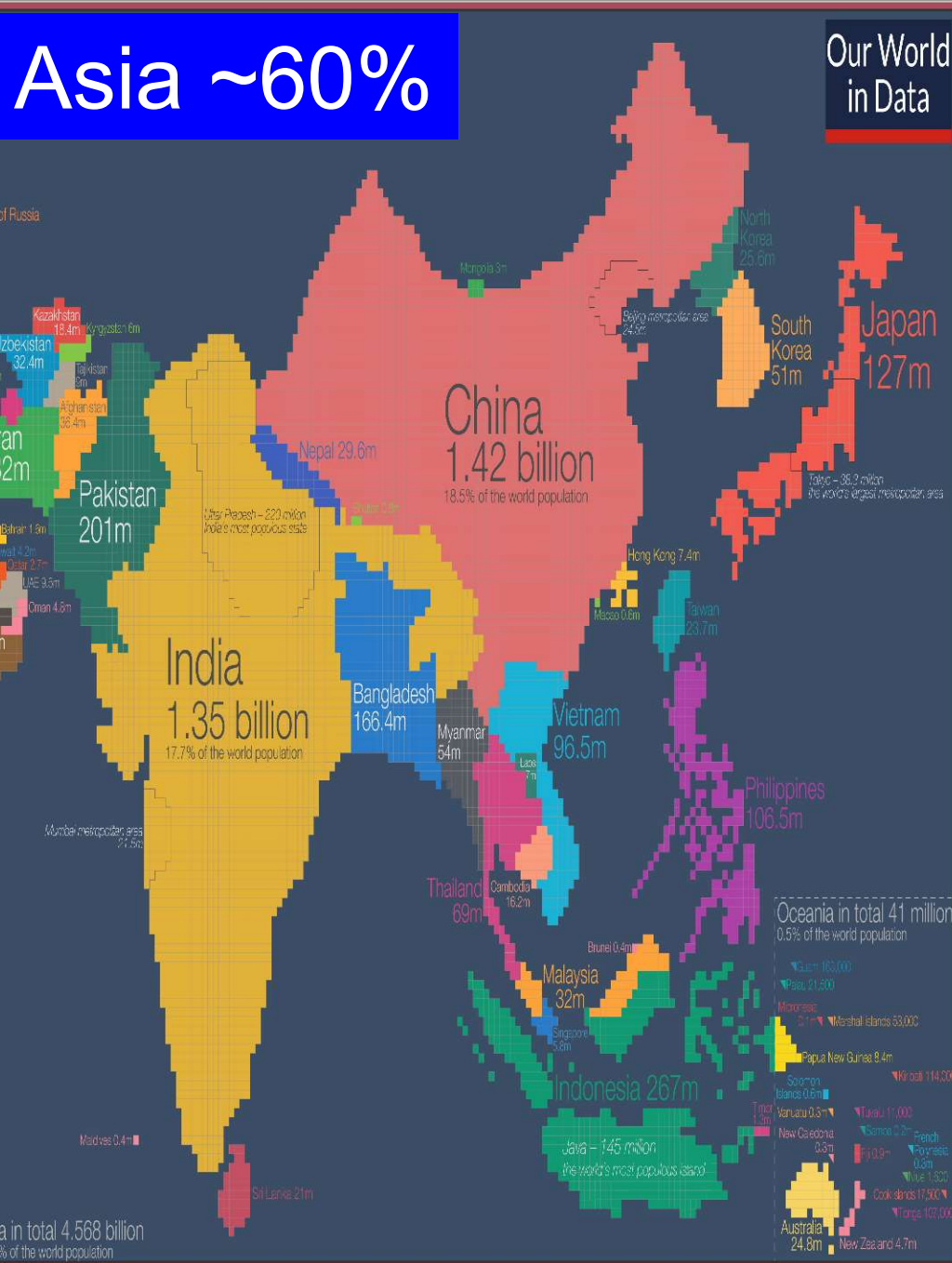


Eur. ~9%

Africa ~17%



Asia ~60%

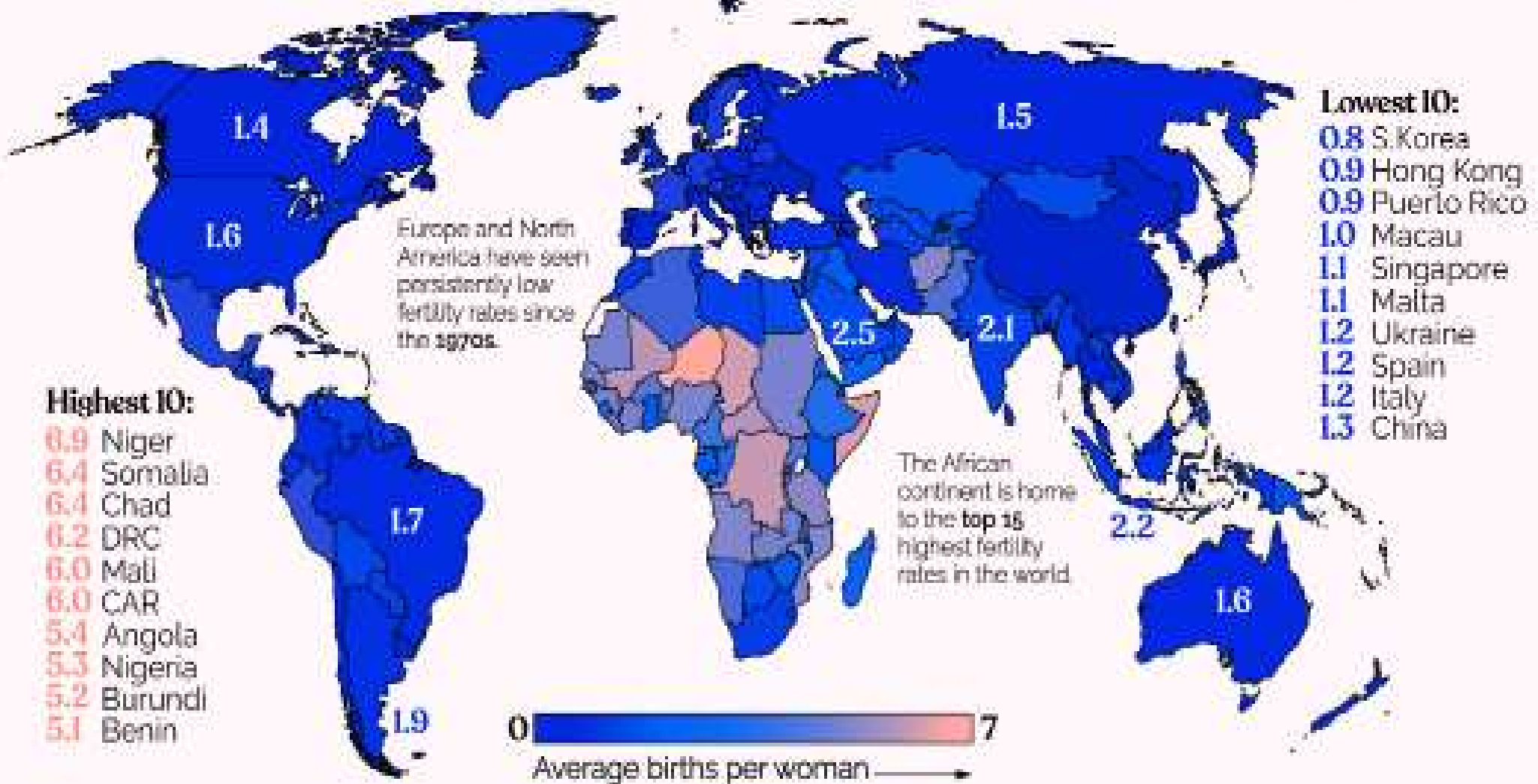


A Global Snapshot of Fertility

In 2020, nearly two-thirds of the world's population lived in a region where the fertility rate is below the critical 2.1 threshold, which allows one generation to exactly replace itself.

2.7 2000

2.5 2010



Highest 10:

- 6.9 Niger
- 6.4 Somalia
- 6.4 Chad
- 6.2 DRC
- 6.0 Mali
- 6.0 CAR
- 5.4 Angola
- 5.3 Nigeria
- 5.2 Burundi
- 5.1 Benin

Lowest 10:

- 0.8 S. Korea
- 0.9 Hong Kong
- 0.9 Puerto Rico
- 1.0 Macau
- 1.1 Singapore
- 1.1 Malta
- 1.2 Ukraine
- 1.2 Spain
- 1.2 Italy
- 1.3 China

Large regions of high fertility remain.

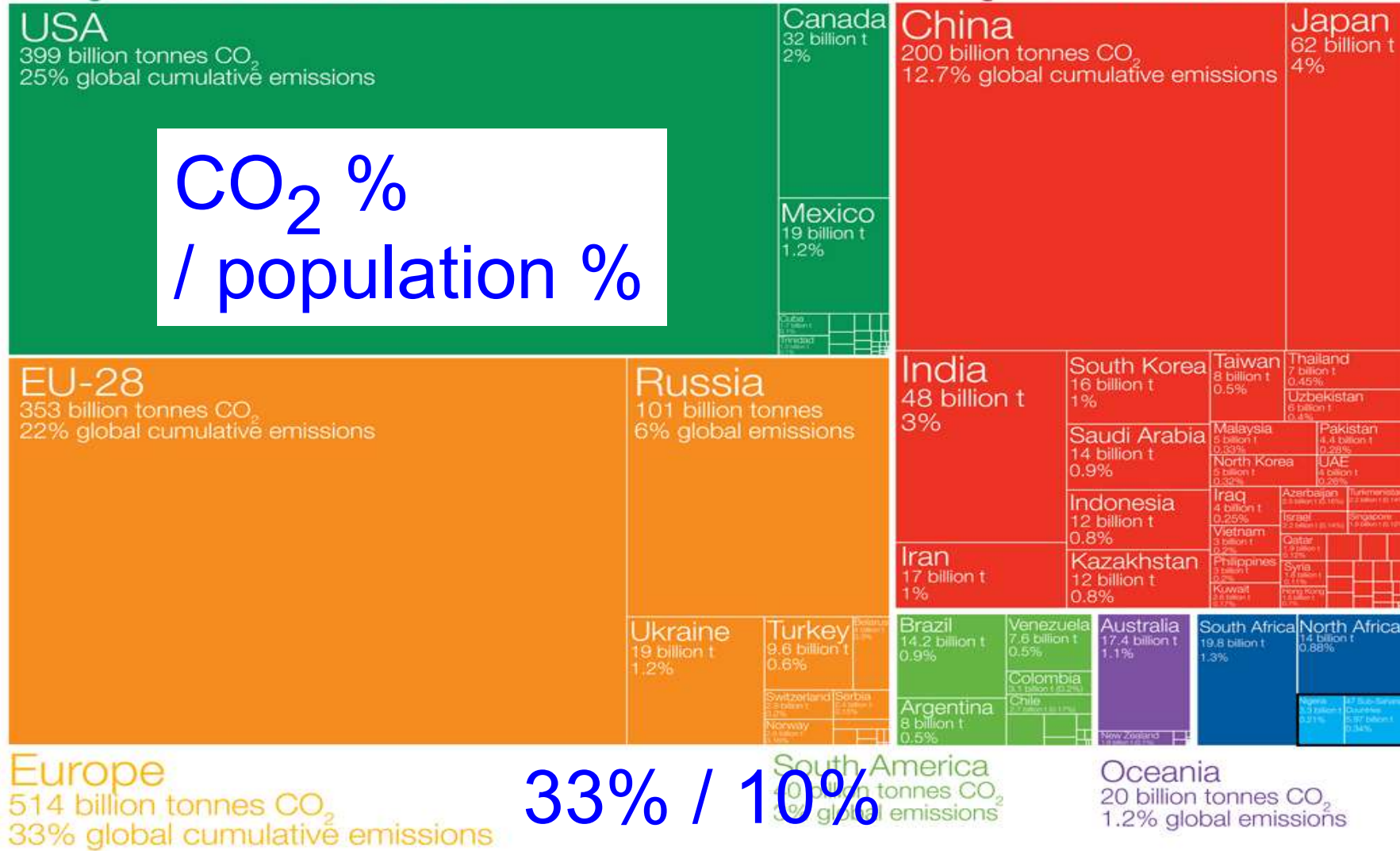
In mid-2023, total fertility rate remains above replacement level, on average, in sub-Saharan Africa (4.3), Oceania except Australia, New Zealand (3.4), Northern Africa (3.0), Central Asia (3.2), Afghanistan (5.4), Pakistan (3.4).

Population Reference Bureau, *World Population Data Sheet 2023*

Who has contributed most to global CO₂ emissions?

North America 29% / 5%
 457 billion tonnes CO₂
 29% global cumulative emissions

Asia 29% / 60%
 457 billion tonnes CO₂
 29% global cumulative emissions



Africa 43 billion tonnes CO₂
 2.73% global emissions
 1 Billion+ People

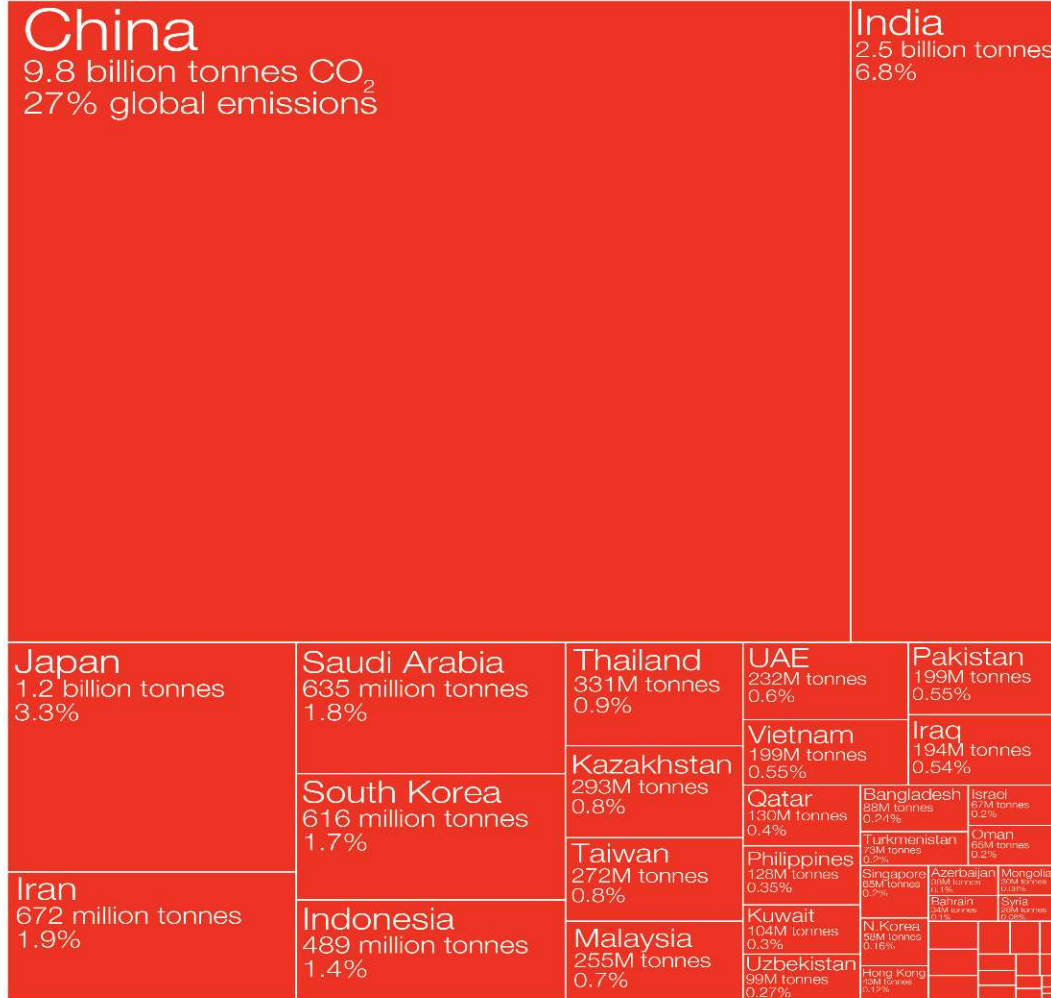
Cumulative carbon dioxide (CO₂) emissions over the period from 1751 to 2017. Figures are based on production-based emissions which measure CO₂ produced domestically from fossil fuel combustion and cement, and do not correct for emissions embedded in trade (i.e. consumption-based). Emissions from international travel are not included. Figures for the 28 countries in the European Union have been grouped as the 'EU-28' since international targets and negotiations are typically set as a collaborative target between EU countries. Values may not sum to 100% due to rounding.

Data source: Calculated by Our World in Data based on data from the Global Carbon Project (GCP) and Carbon Dioxide Analysis Center (CDIAC). This visualization has been adapted with permission by the Energy for Growth Hub based on the original work by OurWorldinData.org.

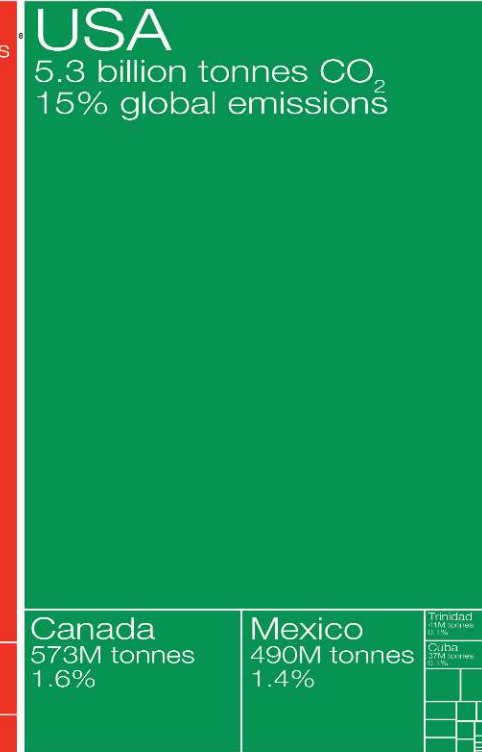
Who emits the most CO₂?

Global carbon dioxide (CO₂) emissions were 36.2 billion tonnes in 2017.

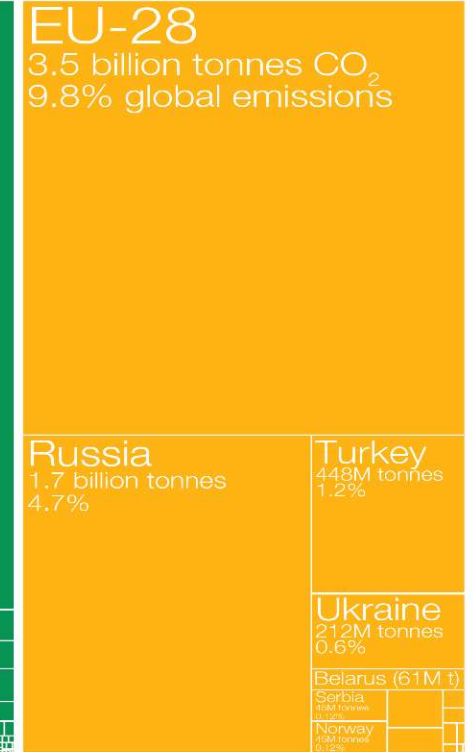
Asia
19 billion tonnes CO₂
53% global emissions



North America
6.5 billion tonnes CO₂
18% global emissions



Europe
6.1 billion tonnes CO₂
17% global emissions



Africa
1.3 billion tonnes CO₂
3.7% global emissions

South America
1.1 billion tonnes CO₂
3.2% global emissions

Oceania
0.5 billion tonnes CO₂
1.3% global emissions

International aviation & shipping
1.15 billion tonnes
3.2%

Shown are national production-based emissions in 2017. Production-based emissions measure CO₂ produced domestically from fossil fuel combustion and cement, and do not adjust for emissions embedded in trade (i.e. consumption-based).

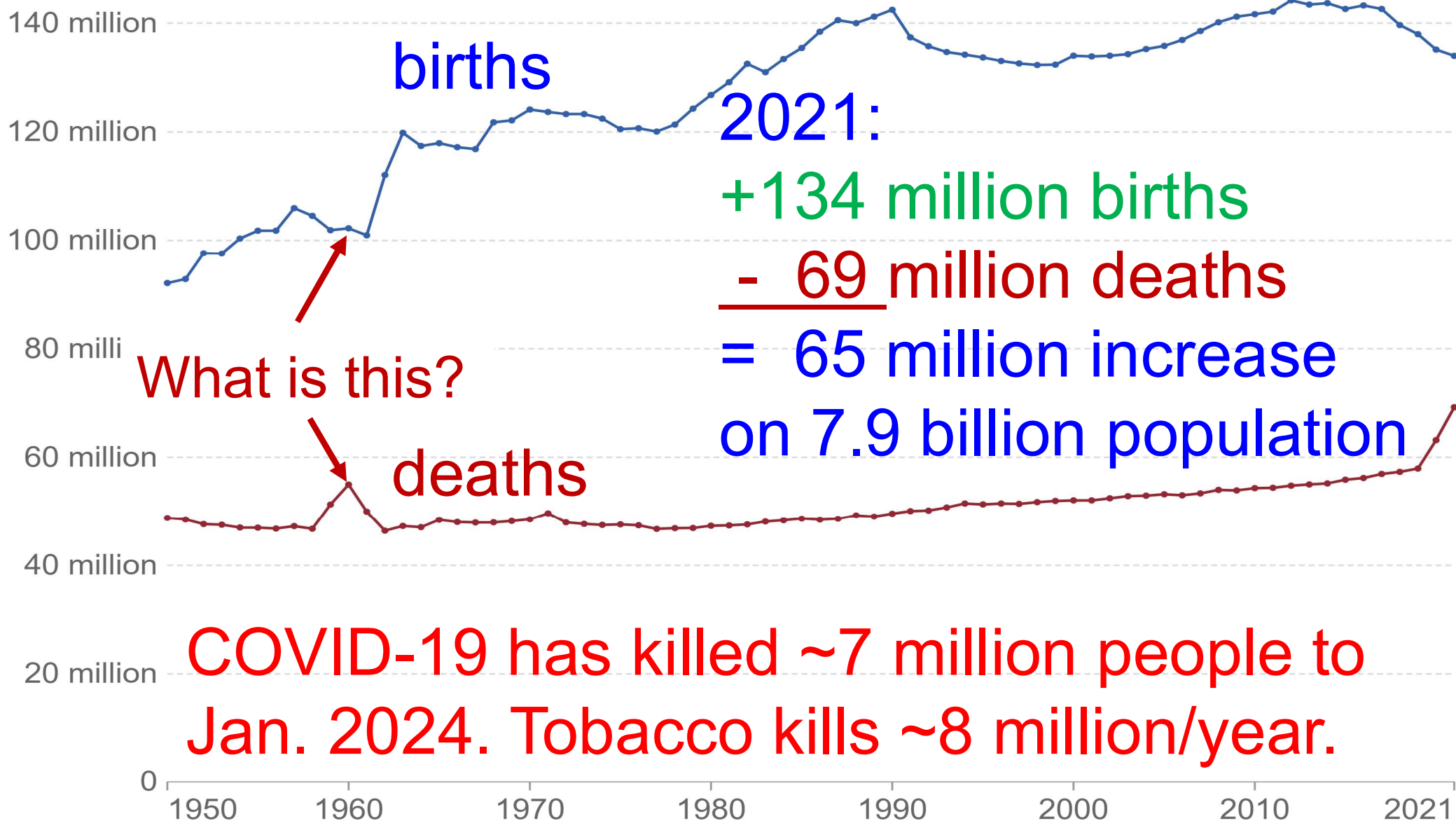
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Data source: Global Carbon Project (GCP).

This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.

Licensed under CC-BY by the author Hannah Ritchie.

Population grew ~80 million/year before COVID-19; now slower.



COVID-19 has killed ~7 million people to Jan. 2024. Tobacco kills ~8 million/year.

40% of global pregnancies are unintended.
45% of pregnancies in USA are unintended.

213 million pregnancies occurred worldwide in 2012, 190 million (89%) in developing world.

85 million pregnancies (40%) were unintended,

47% unintended in more developed,

39% unintended in less developed,

35% unintended in Africa,

56% unintended in LAC.

[Visit bedsider.org](http://bedsider.org)



USA unintended pregnancies

In 2011, 45% (2.8 million) of the 6.1 million pregnancies in the United States were unintended:

27% were "wanted later";

18% were "unwanted."

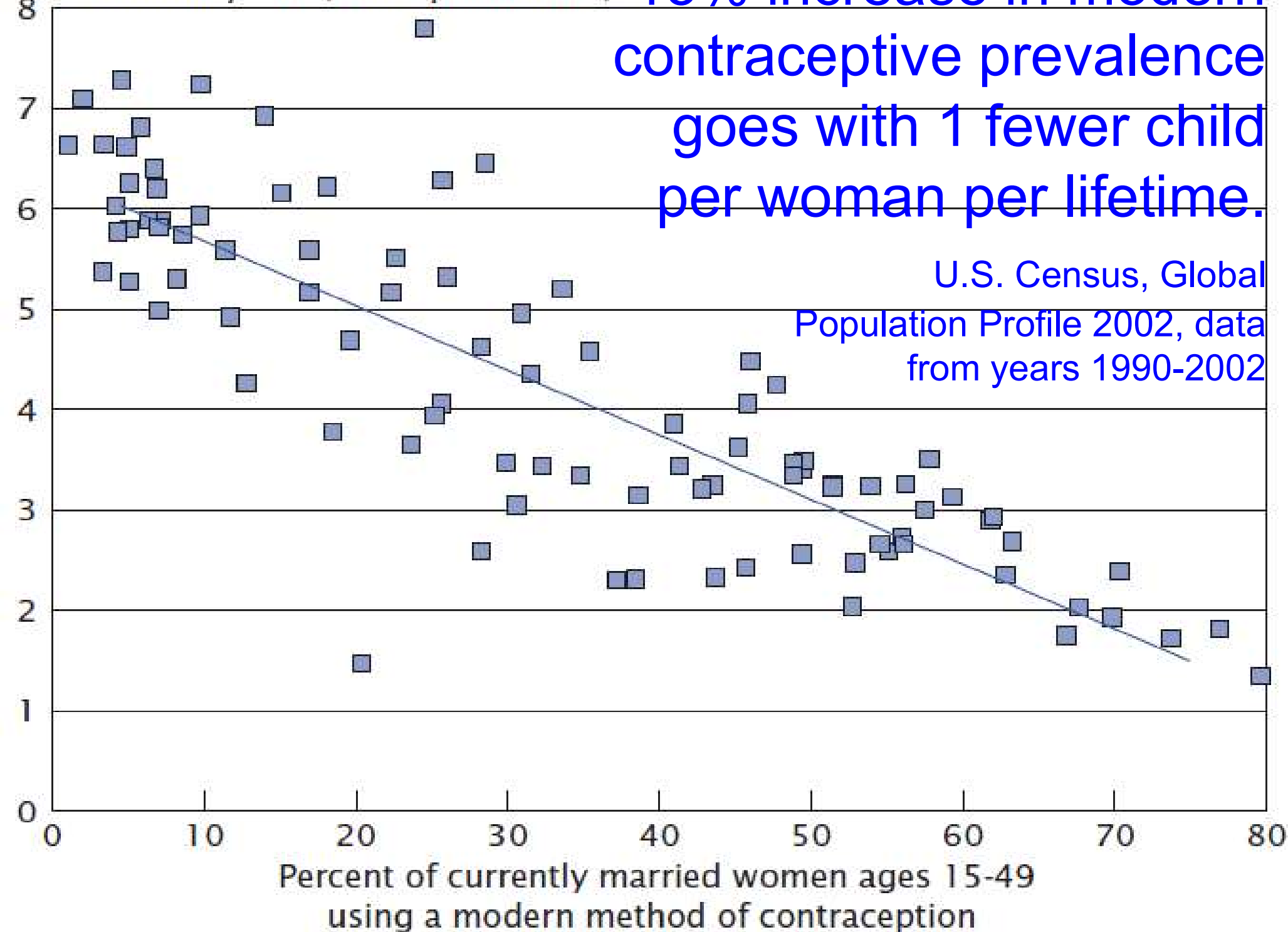
<https://www.guttmacher.org/fact-sheet/unintended-pregnancy-united-states>

Visit bedsider.org

Total fertility rate (births per woman)

15% increase in modern
contraceptive prevalence
goes with 1 fewer child
per woman per lifetime.

U.S. Census, Global
Population Profile 2002, data
from years 1990-2002



Food & hunger

Engel's law

1857, International Statistical Institute Bulletin 1895

In human diets, food expenditures increase with income & family size, but the ratio of food expenditures to all expenditures decreases with increasing income.

Roughly, food expenditures $\sim \log(\text{income})$, so food/total $\sim \log(\text{income})/\text{income}$ falls as income rises.

→ The poorer people are, the bigger the share of the household budget taken by food.

Bennett's law

Geographical Review 1941

In human diets, the ratio of calories derived from cereals (wheat, rye, rice, barley, oats, corn, millets, grain sorghums) & tubers (white potatoes, sweet potatoes, cassava) to all calories consumed is lower, the higher a household's or country's income.

→ Prices of cereals & tubers affect poor people more than they affect the rich.

→ Meat consumption rises as income rises.

Cereal production, utilization and stocks

Million tonnes

Million tonnes

cereal production & use were
Global 2.8 billion tonnes in 2023-24.



Production (left axis)

Utilization (left axis)

Stocks (right axis)

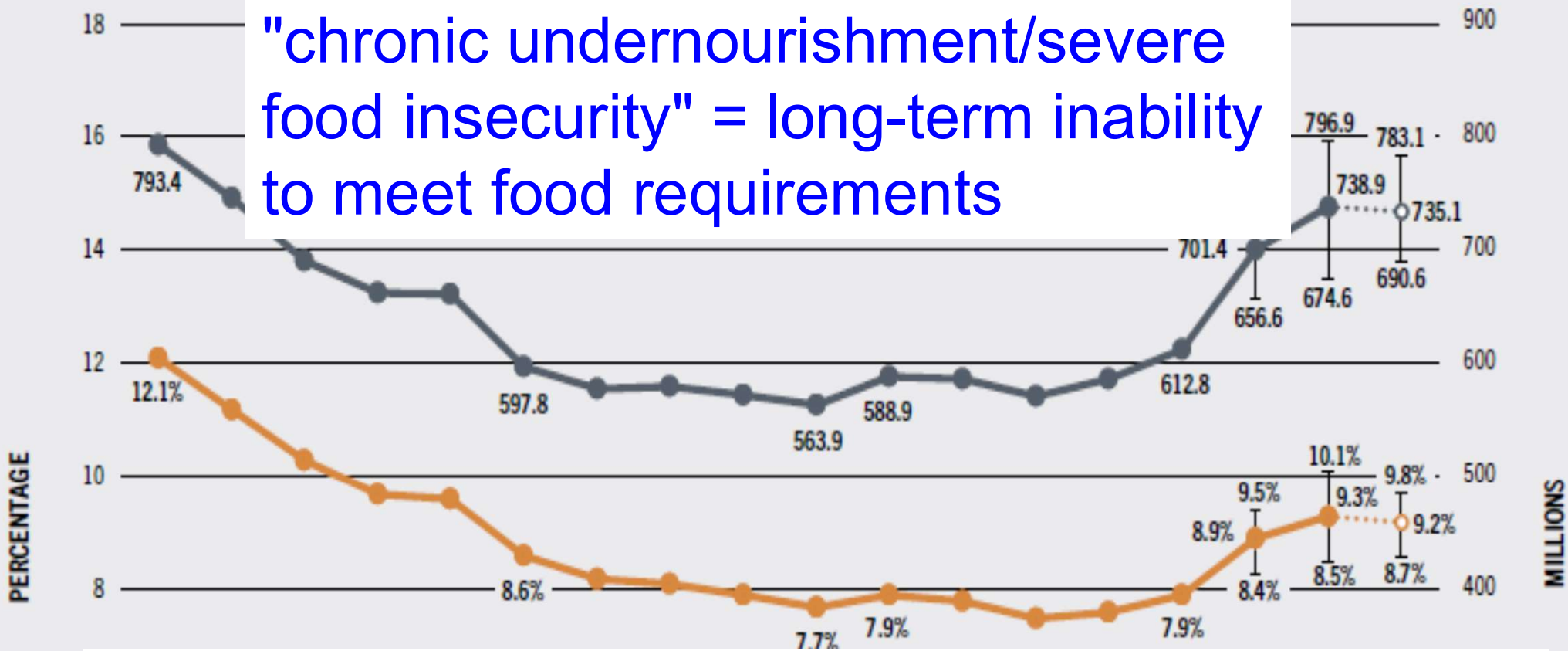
FAO World Food Situation
Release date: 2023-08-12

1 tonne (1000 kg) of carbohydrate supplies enough energy for 4-5 people for 1 year.

200 kg of this grain provides	kilocalories per day for a year
Rice	2,000
Wheat pasta	2,032
Corn (maize)	1,984
Oatmeal	2,028

2.8 bln tonnes of cereals have enough calories for 11-14 billion people.

"chronic undernourishment/severe food insecurity" = long-term inability to meet food requirements



One person in ten is chronically hungry now. Global number & % of chronically undernourished rose since 2014.

FAO, IFAD, UNICEF, WFP, WHO State of Food Security and Nutrition in the World 2023

2005 2010 2015 2022

1/23/2024 2008-11-25

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43

● Prevalence of undernourishment (percentage, left axis) ● Number of undernourished (millions, right axis)

WORLD CEREAL MARKET AT A GLANCE

FAO Food Outlook June 2021, p. 1

People ate
1171 / 2778
= 42% of
cereal
grains used
in 2020/21.

58% fed
animals &
machines.

1/23/2024

Gentrification of food

	2019/0	2020/21 <i>estim.</i>	2021/22 <i>f'cast</i>	Change: 2021/22 over 2020/21
	<i>million tonnes</i>			<i>%</i>
WORLD BALANCE				
Production	2 710.7	2 768.6	2 820.9	1.9
Trade ¹	440.1	468.0	469.3	0.3
Total utilization	2 713.7	2 778.2	2 825.7	1.7
Food	1 151.4	1 170.7	1 183.9	1.1
Feed	1 007.8	1 050.5	1 070.2	1.9
Other uses	554.5	557.0	571.6	2.6
Ending stocks ²	822.3	808.8	811.5	0.3
SUPPLY AND DEMAND INDICATORS				
Per caput food consumption:				
World (kg/yr)	149.3	150.2	150.3	0.1
LIFDC (kg/yr)	152.3	153.7	153.4	-0.2

Hunger is economically invisible.

Chronically undernourished people exercise less demand (supported by customers' orders and capacity to pay) in world food markets than those who demand meat, biofuels, & other non-food uses of cereal grains.

Poor people, especially poor children, do not outbid rich people's demand to feed animals & machines.

Markets serve people with money.

A market works only for people with enough money to pay for what the market offers. One must pay to play in grain markets. People with insufficient money are excluded from markets.

Absent public or private social safety nets, poor people at the bottom of the income distribution do not satisfy the assumptions of the economic theory of markets.

Chronic hunger versus famine

Chronic hunger affects
many more people

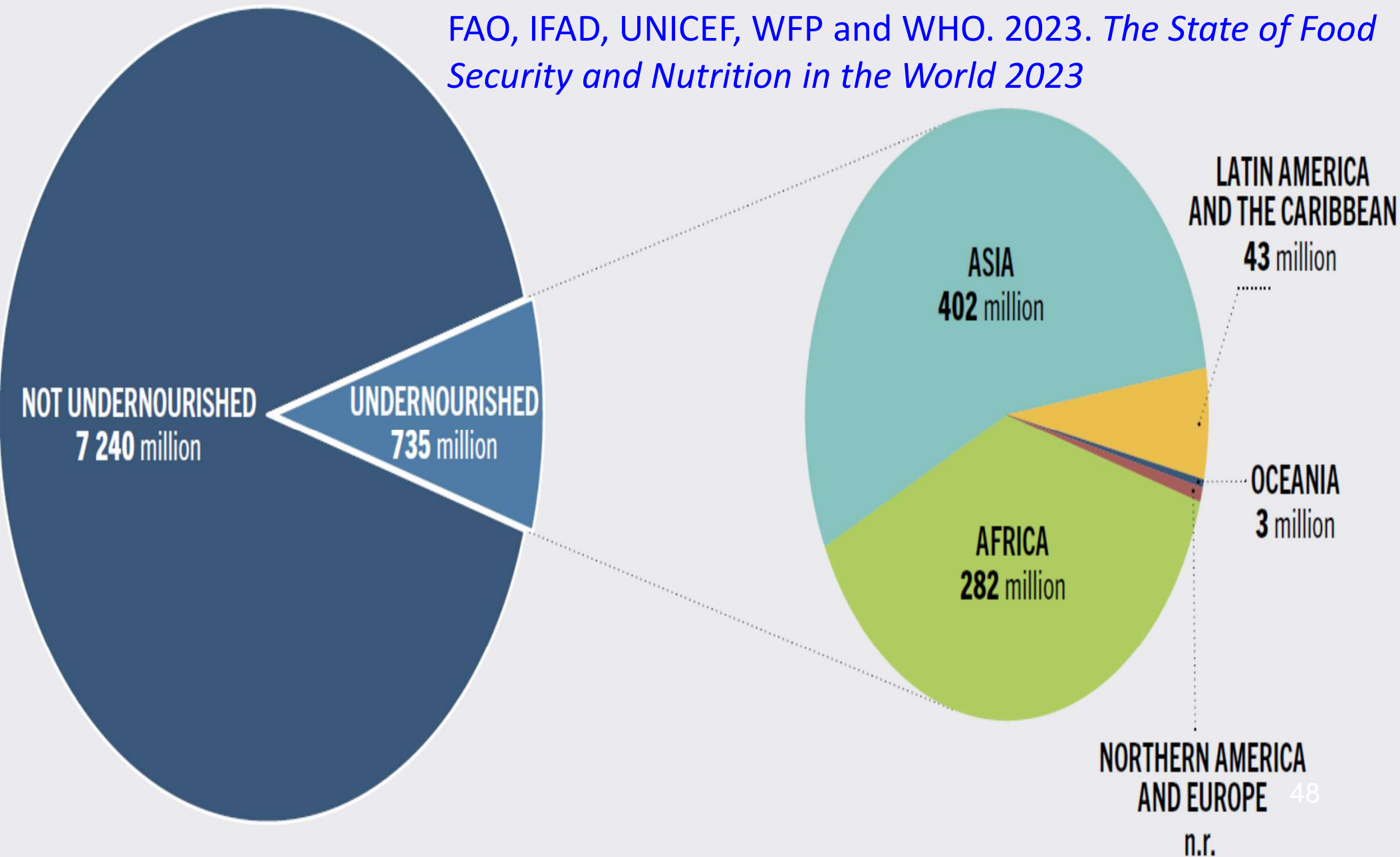
(750-800 million, ~1 in 10)

than famine

(40-50 million, ~1 in 200).

In 2022, 55% (402 mln) of hungry people were in Asia, 38% (282 mln) in Africa.

FAO, IFAD, UNICEF, WFP and WHO. 2023. *The State of Food Security and Nutrition in the World 2023*



What is stunting?

Child suffers stunting if child's height falls 2 or more standard deviations below median height of child of that age by World Health Organization Child Growth Standards.

WHO Nutrition Landscape Information System

STUNTING

149.2 million

Levels and trends in child malnutrition
UNICEF / WHO / World Bank Group
Joint Child Malnutrition Estimates 2021

Stunting affected an estimated
22.0 per cent or 149.2 million
children under 5 globally in 2020*

WASTING

45.4 million

In 2020,* wasting continued to
threaten the lives of an estimated
6.7 per cent or 45.4 million children
under 5 globally

OVERWEIGHT

38.9 million

An estimated 5.7 per cent or
38.9 million children under 5
around the world were affected
by overweight in 2020*

Example: stunting in India

India 2005-06 boys (n=25,118)
India 2005-06 girls (n=22,977)
WHO standards



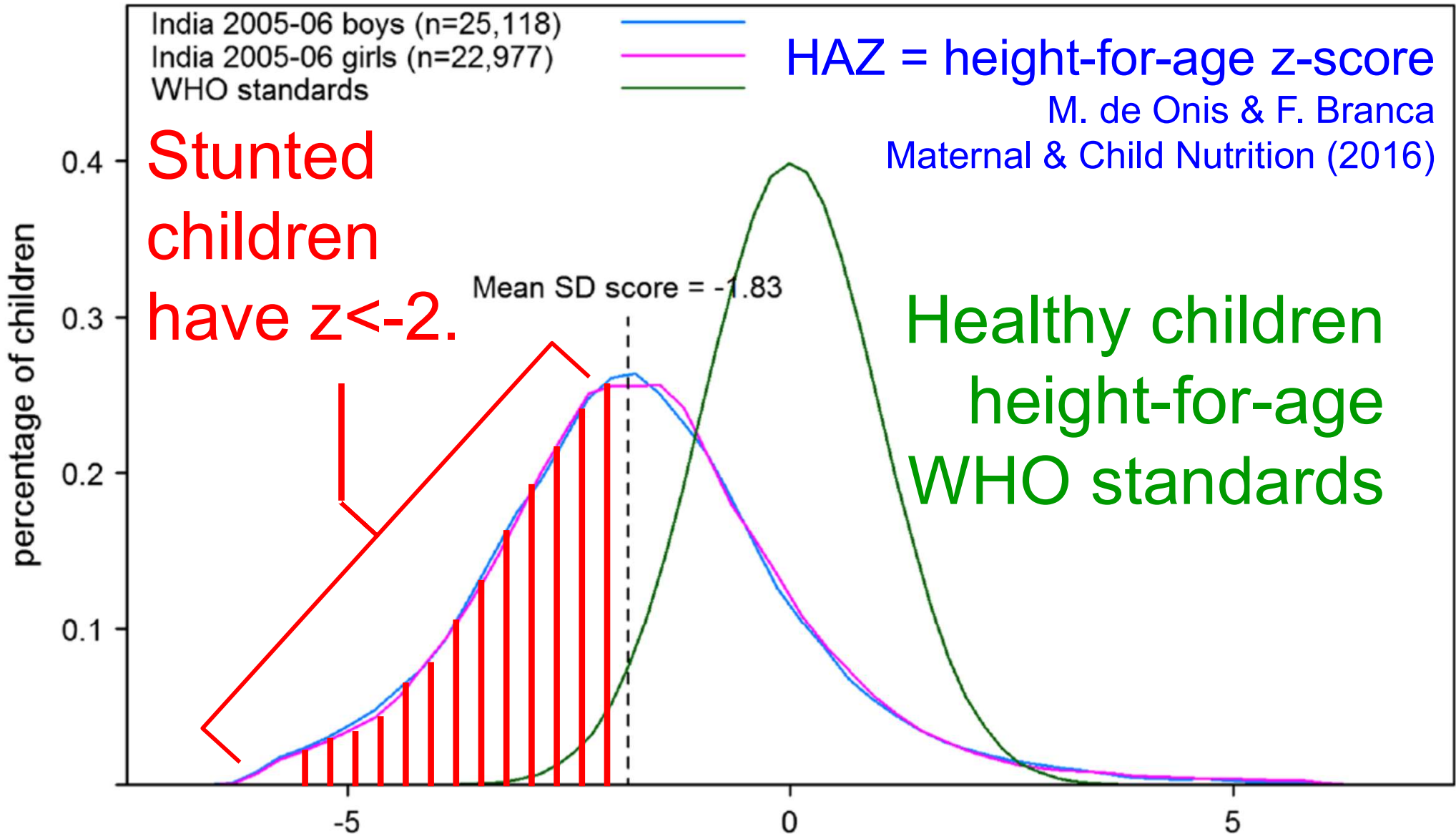
HAZ = height-for-age z-score

M. de Onis & F. Branca

Maternal & Child Nutrition (2016)

Stunted children have $z < -2$.

Healthy children height-for-age WHO standards



z-score = standard deviations from median for age

Guatemala: 42.8% of children under 5 y were stunted, 2020.

FAO, IFAD, UNICEF, WFP, WHO
State of Food Security & Nutrition in the World 2021

Mayan descent, Guatemala



Mayan descent, USA

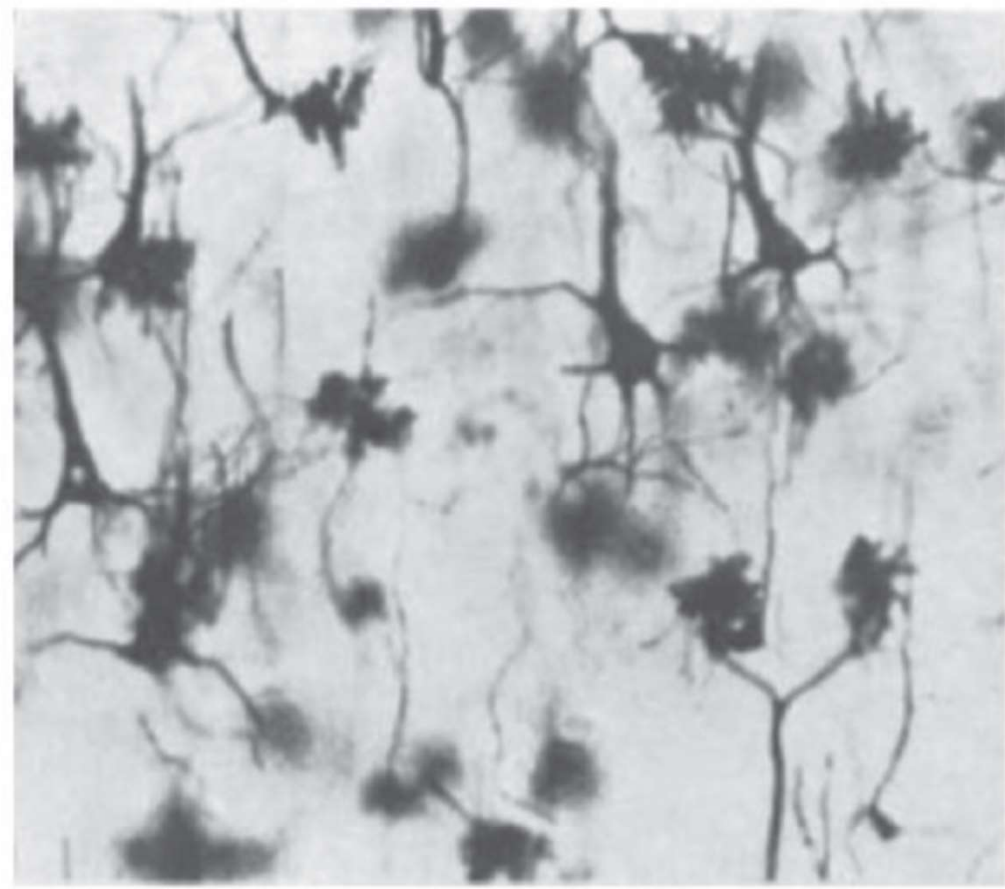
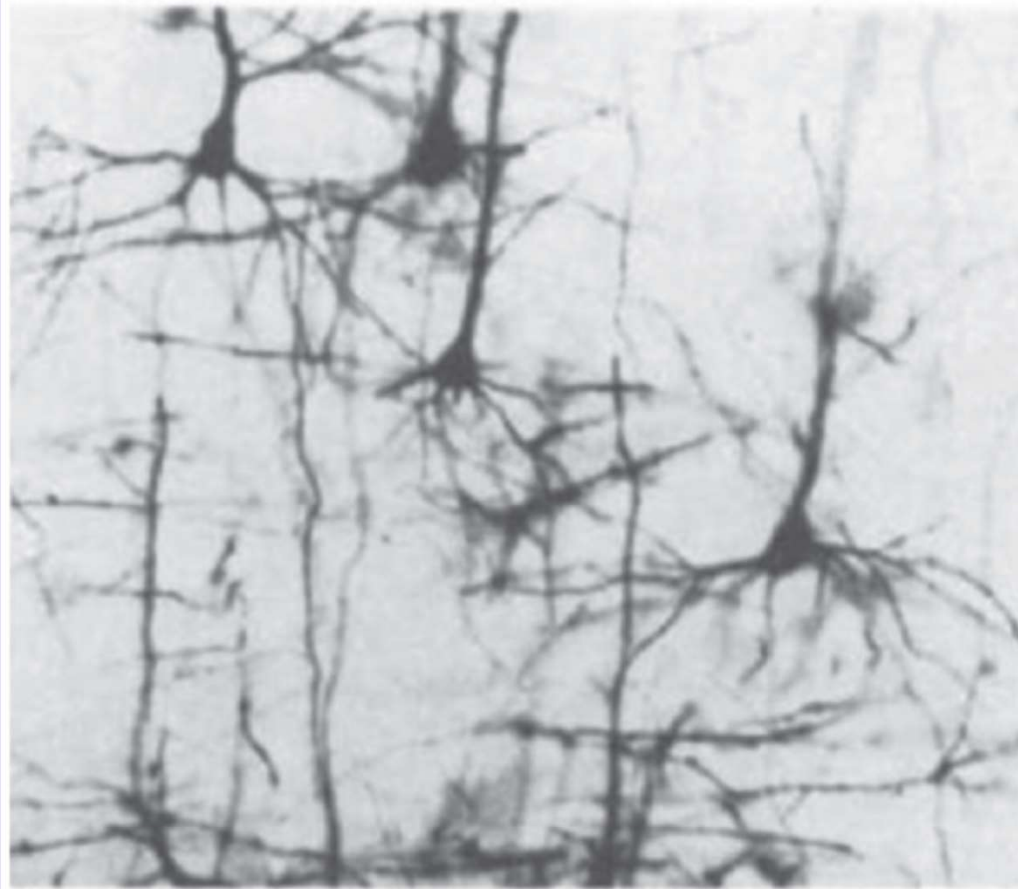


Undernourishment alters brain.

M. de Onis & F. Branca 2016 from Cordero et al. 1993

Well-nourished infant

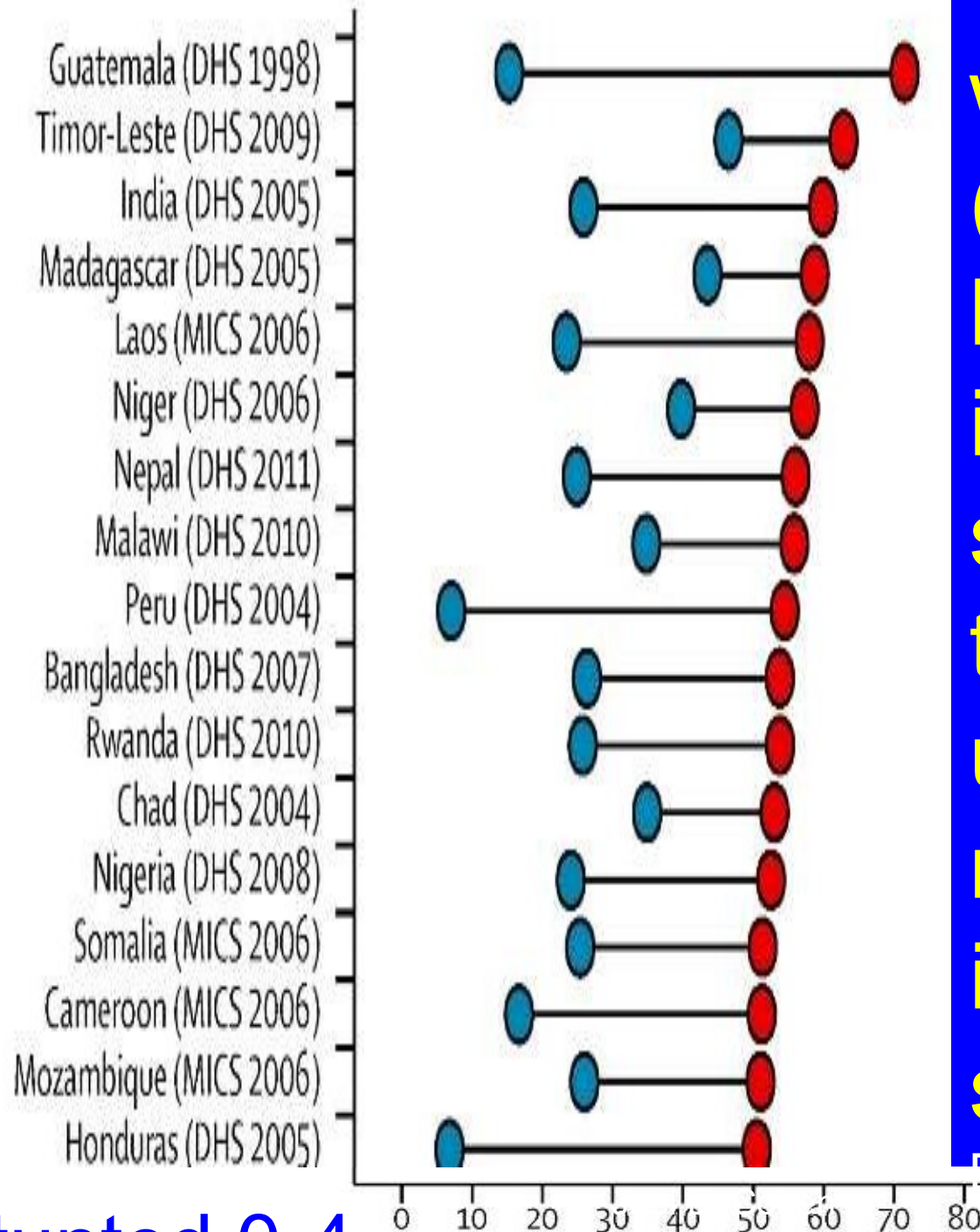
Undernourished infant



Typical brain cells
Extensive branching

Impaired brain cells
Limited branching
Abnormal, shorter branches

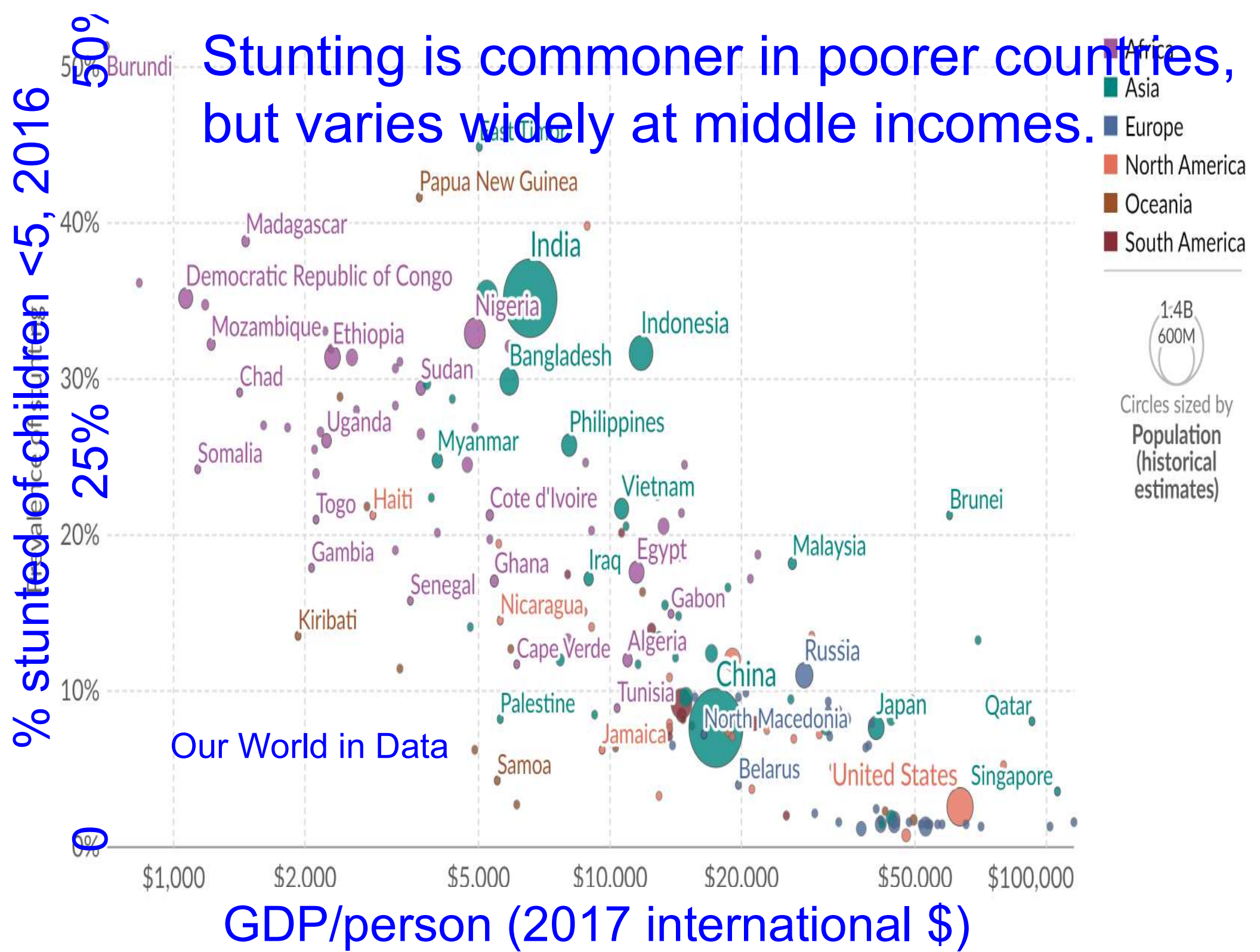
Stunting (HAZ <-2)



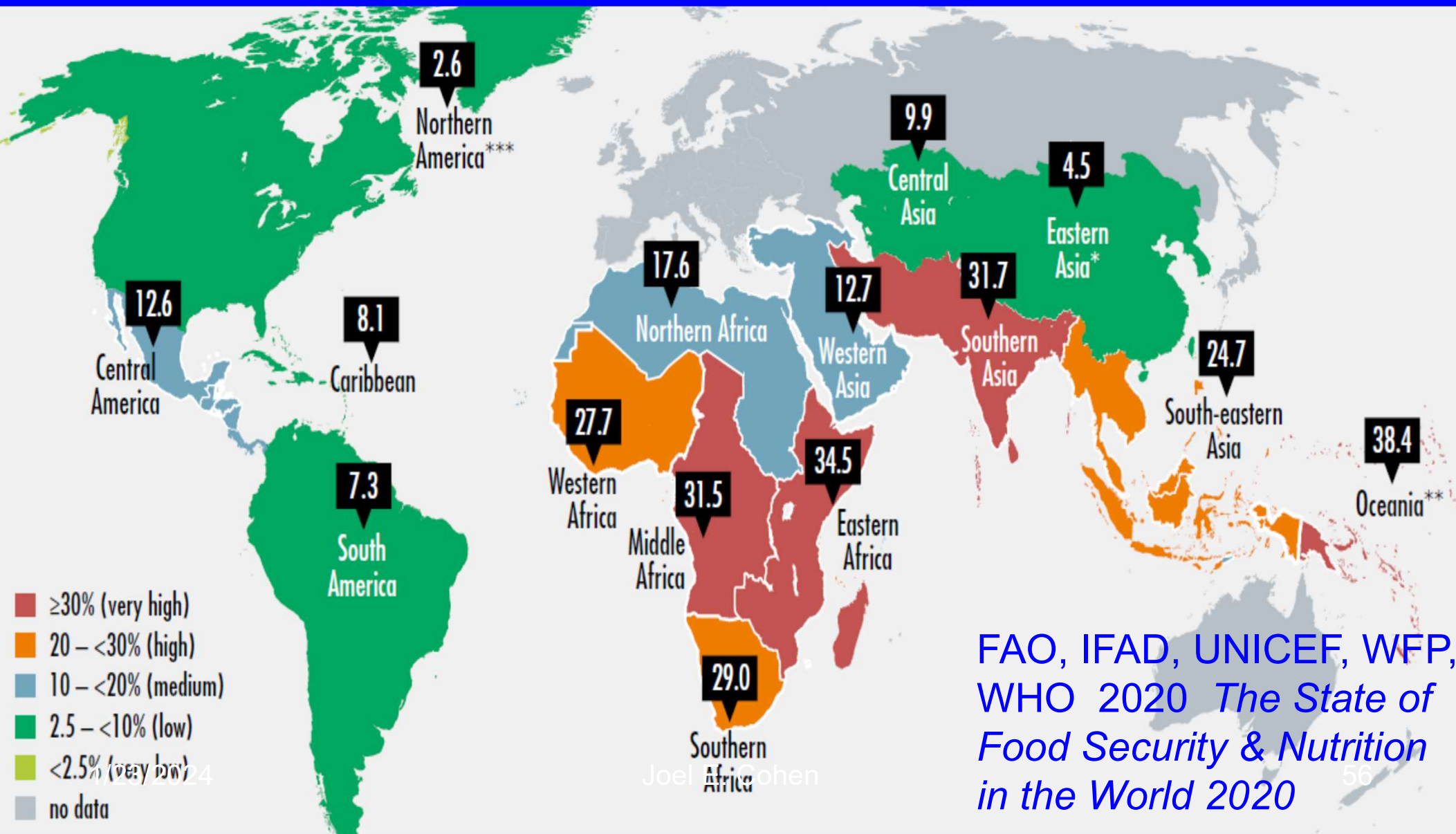
Within countries, wealth quintile (lowest=red, highest=blue) influences child stunting more than sex or urban-rural residence influence stunting.

Black et al. *Lancet* 2013

Stunting is commoner in poorer countries, but varies widely at middle incomes.



% of children <5 who are stunted is highest across mid-Africa & south Asia.



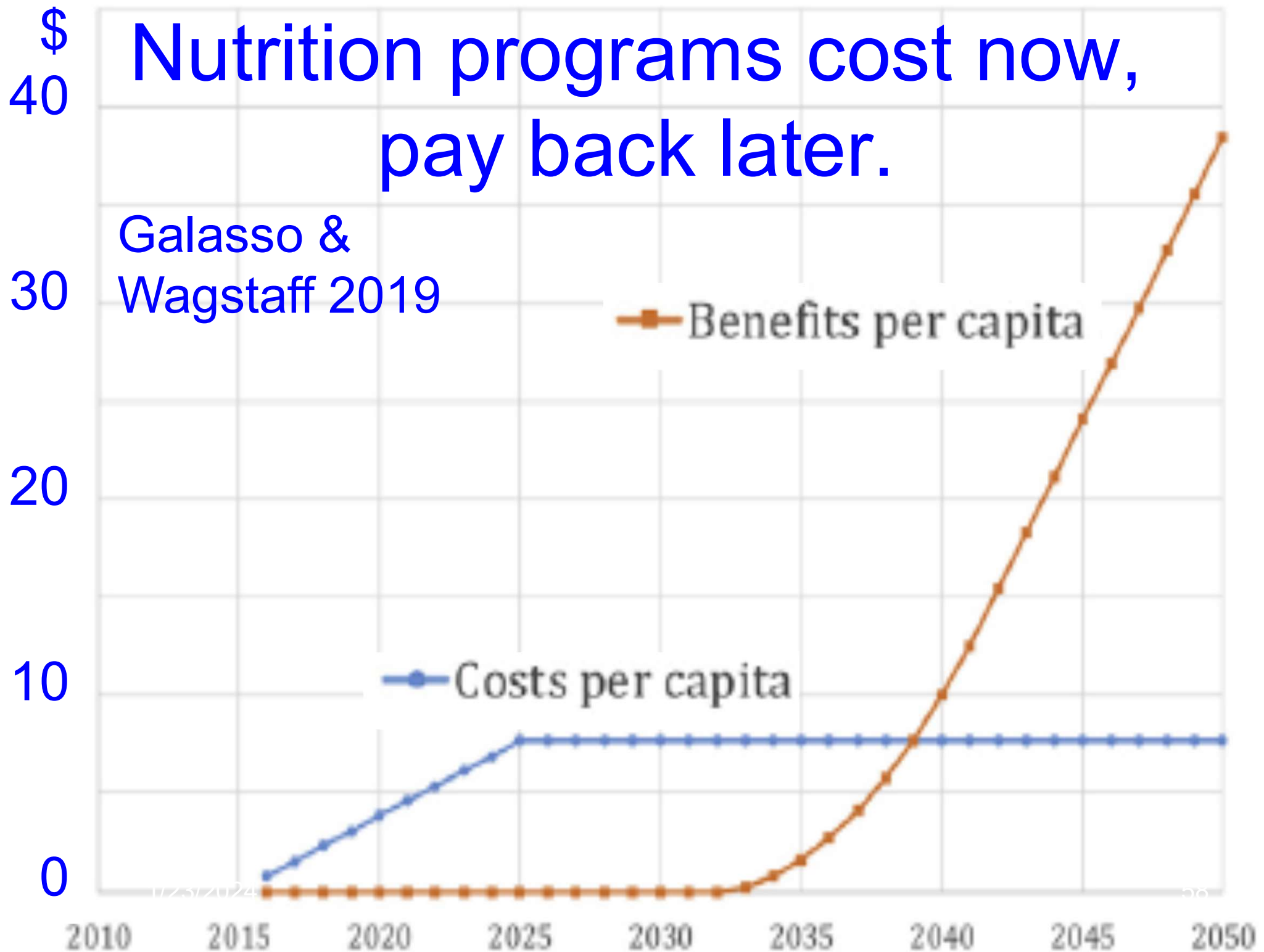
Stunting threatens human development.

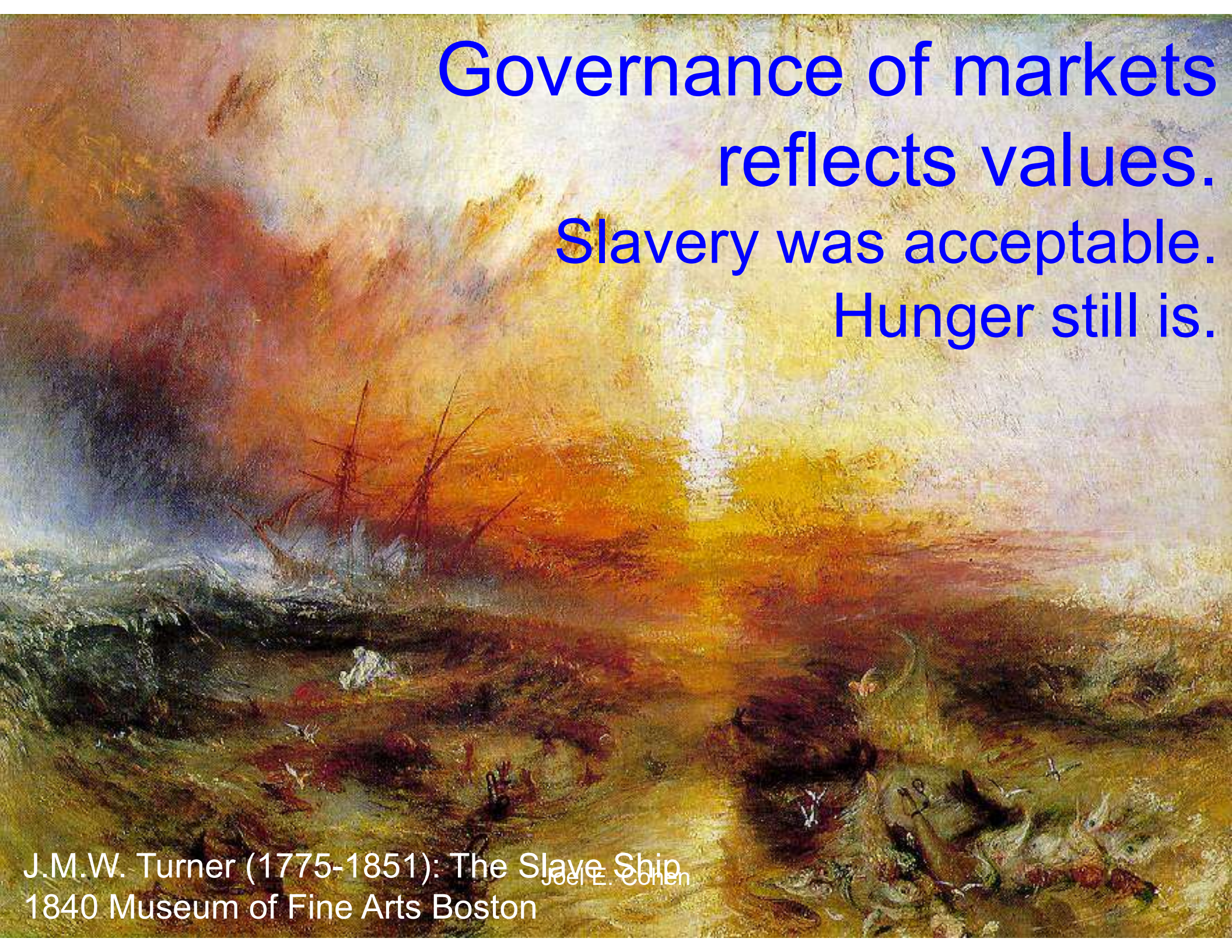
“The severe irreversible physical and neurocognitive damage that accompanies stunted growth poses a major threat to human development.”

Mercedes de Onis, Francesco Branca
Maternal & Child Nutrition 2016

Nutrition programs cost now, pay back later.

Galasso &
Wagstaff 2019



The background of the slide is a reproduction of the painting 'The Slave Ship' by J.M.W. Turner. The painting depicts a three-masted sailing ship on a dark, stormy sea. The sky is filled with dramatic, swirling clouds in shades of orange, red, and white, suggesting a sunset or sunrise. The overall mood is somber and dramatic. Overlaid on the right side of the painting is blue text.

Governance of markets
reflects values.
Slavery was acceptable.
Hunger still is.

J.M.W. Turner (1775-1851): *The Slave Ship*
1840 Museum of Fine Arts Boston

Thank you! Questions?

Najibullah Musaffer / Aina Photo



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Joel E. Cohen