



United Nations

Department of
Economic and
Social Affairs

Future Population Trends and Their Measurement

(P. Gerland, Population Division, DESA, United Nations)

Insights from [World Population Prospects 2024](#) and [World Urbanization Prospects 2018](#)

[WorldPop 10th Anniversary Event on Mapping the Future of Spatial Demography](#)



University of Southampton (UK), 9 October 2024

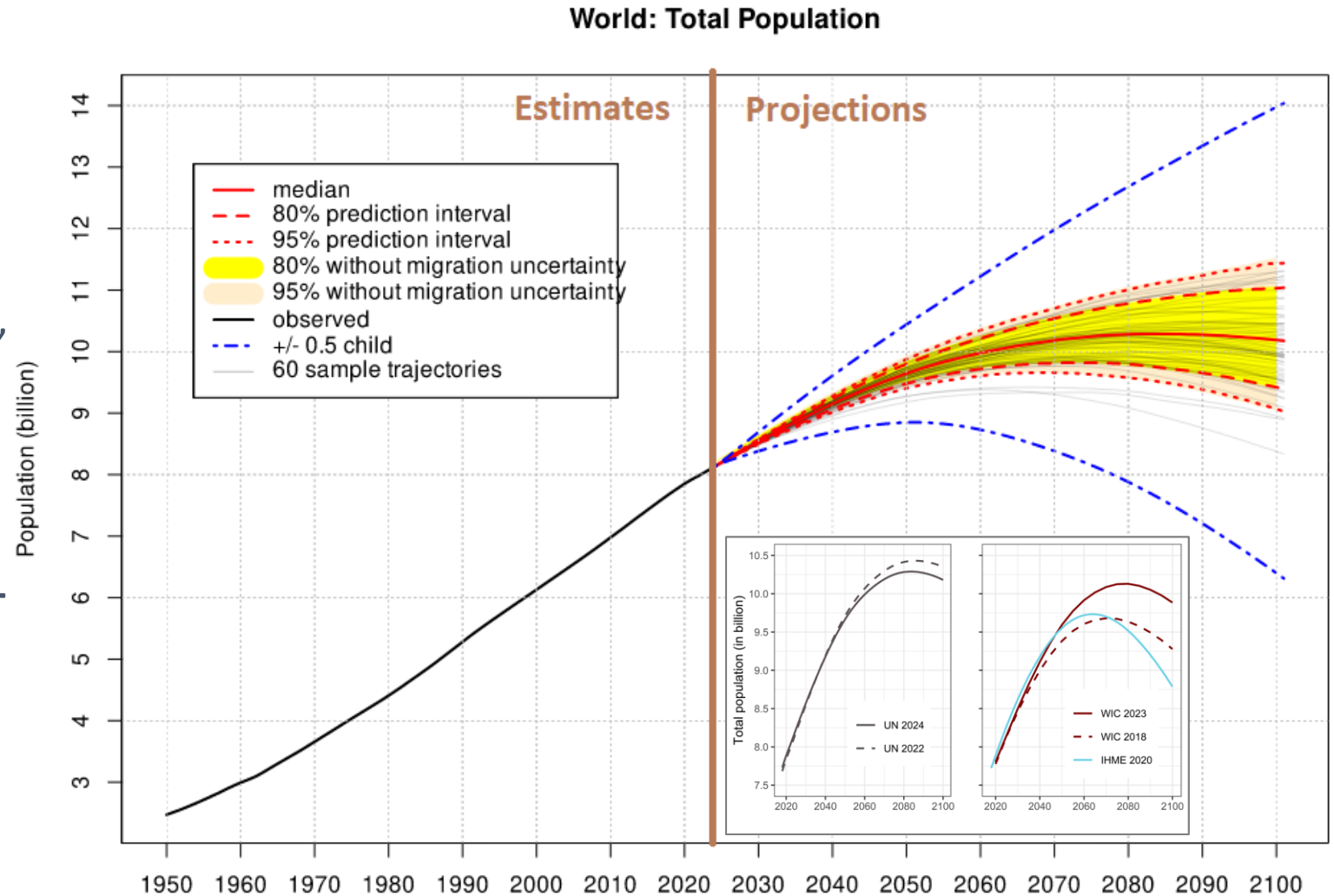
The views and opinions expressed in these slides are those of the author and do not necessarily represent those of the United Nations. The designations employed and the materials in these slides do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Aims of the UN World Population Prospects (WPP)

- What is the WPP?
 - Official UN estimates and projections of populations and key demographic indicators (fertility, mortality, migration), all by age and sex.
 - Covers 237 countries and areas (and more than 300 aggregates)
 - Annual estimates from 1950 to 2023, projections until 2100.
 - Fully updated every two years
- Significance
 - Provides a standardized and consistent set of demographic data for all countries spanning 150 years.
 - Used to inform policy decisions, assess future needs, and monitor progress towards Sustainable Development Goals (SDGs), incl. about ¼ of the SDG indicators.

Global Population Peak and Decline

- **Current Global Population:** As of mid-2024, the world's population stands at about 8.2 billion, showcasing significant growth.
- **Scientific consensus** (UN, IIASA, IHME) that world population will continue to grow at least up to mid-century.
- Global population **expected to peak at 10.3 billion by the mid-2080s**, followed by a gradual decline to 10.2 billion by 2100.
- Shift in peak projection timeline due to rapid declines in fertility.



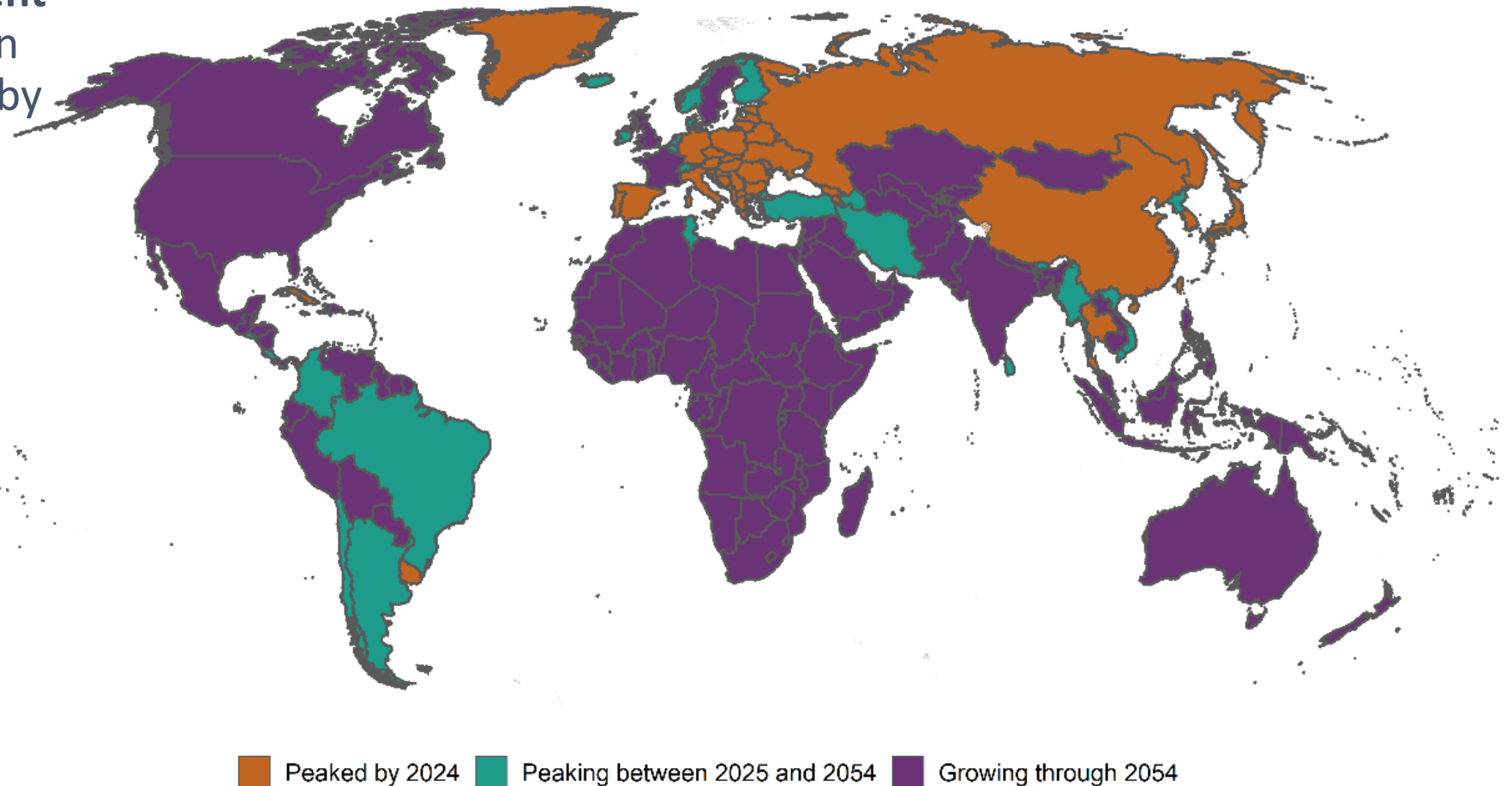
© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO. United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

Regional Trends and Population Peaks

Diverse population trajectories across different world regions, focusing on the three groups defined by the timing of their population peaks.

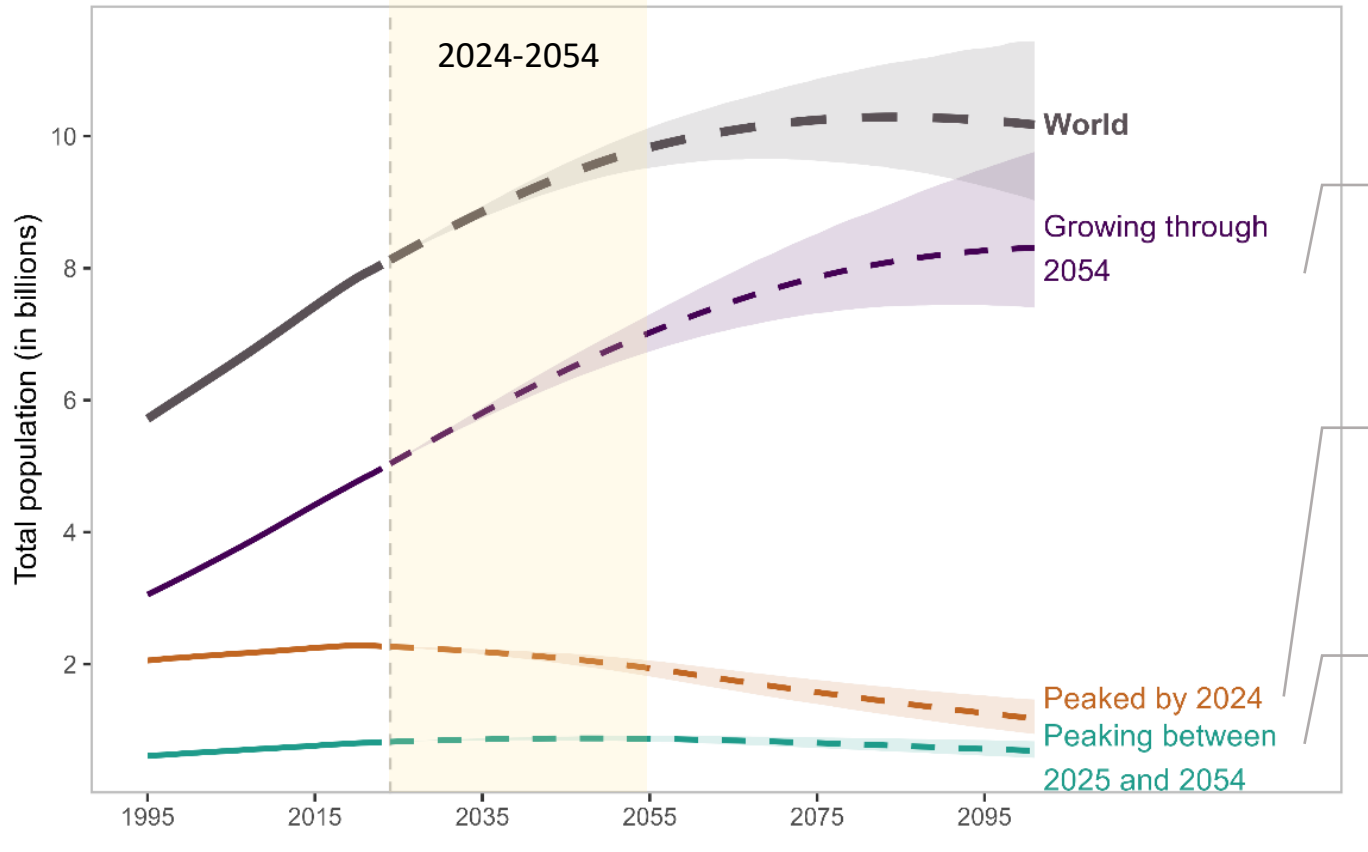
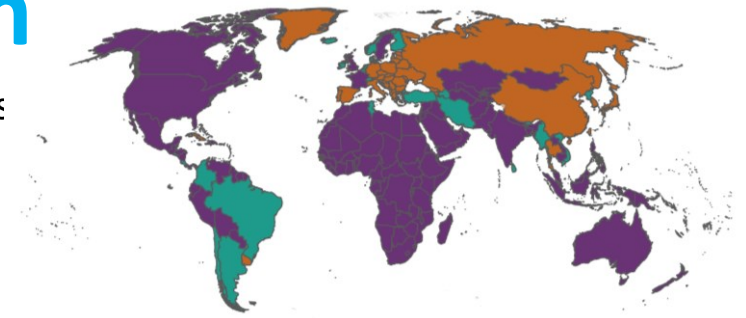
- 1. Already peaked**
(63 countries, 28% of global pop.)
- 2. Likely peak by 2054**
(48 countries, 10% of global pop.)
- 3. Continuing growth through 2054**
(126 countries, 62% of global pop.)

Countries peak or are expected to peak in population size at different points in time



One group of countries will greatly influence global population growth

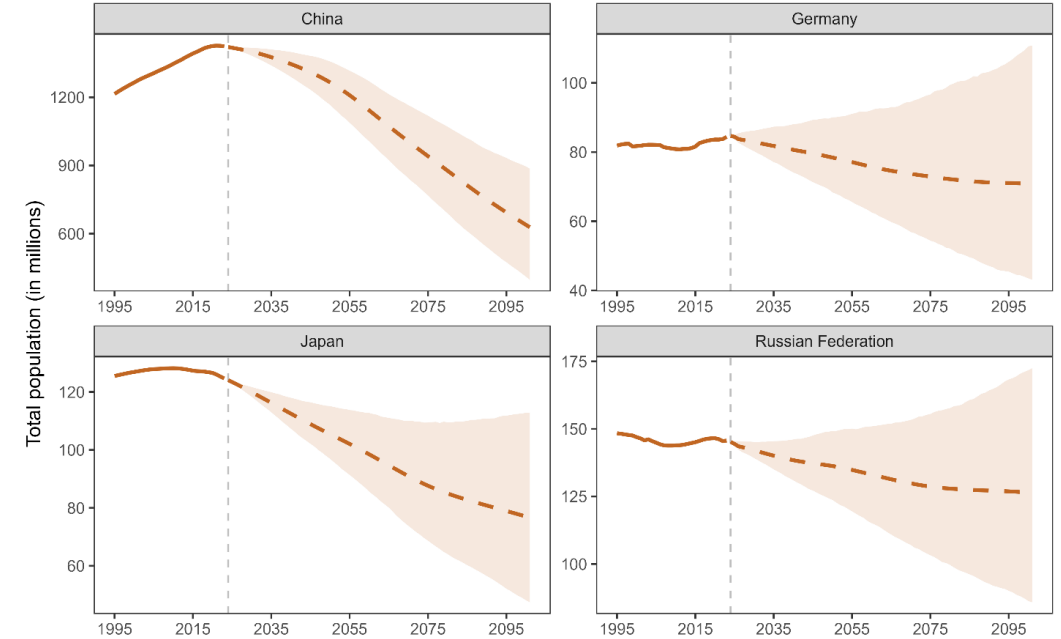
Total population, globally and for countries and areas by timing of the peak Estimates (1995-2023) and projections (2024-2100)



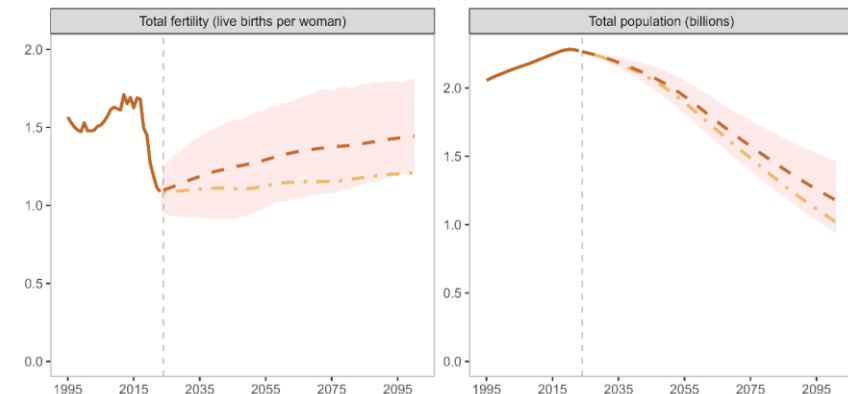
- 126 countries and areas and 62% of global population (2024)
- 38% increase through 2054
- 63 countries and areas with 28% of global population (2024)
- 14% decline through 2054
- 48 countries and areas with 10% of global population (2024)
- 5% increase through 2054

Group 1: Countries where populations have Peaked

- **Examples:** China, Germany, Japan, Russia
- 14% population decline projected by 2054
- **Key drivers:** Low fertility, population momentum
- **Policy focus:** Supporting families, adapting to aging
- Population stabilization or limited decline may create opportunities to reduce inequalities within countries (health, education, social protection, etc.) and move towards more sustainable patterns of production and consumption.
- Rapid population decline in some contexts may pose a challenge, requiring innovative policy responses to address potential macroeconomic, labour market and social protection issues.

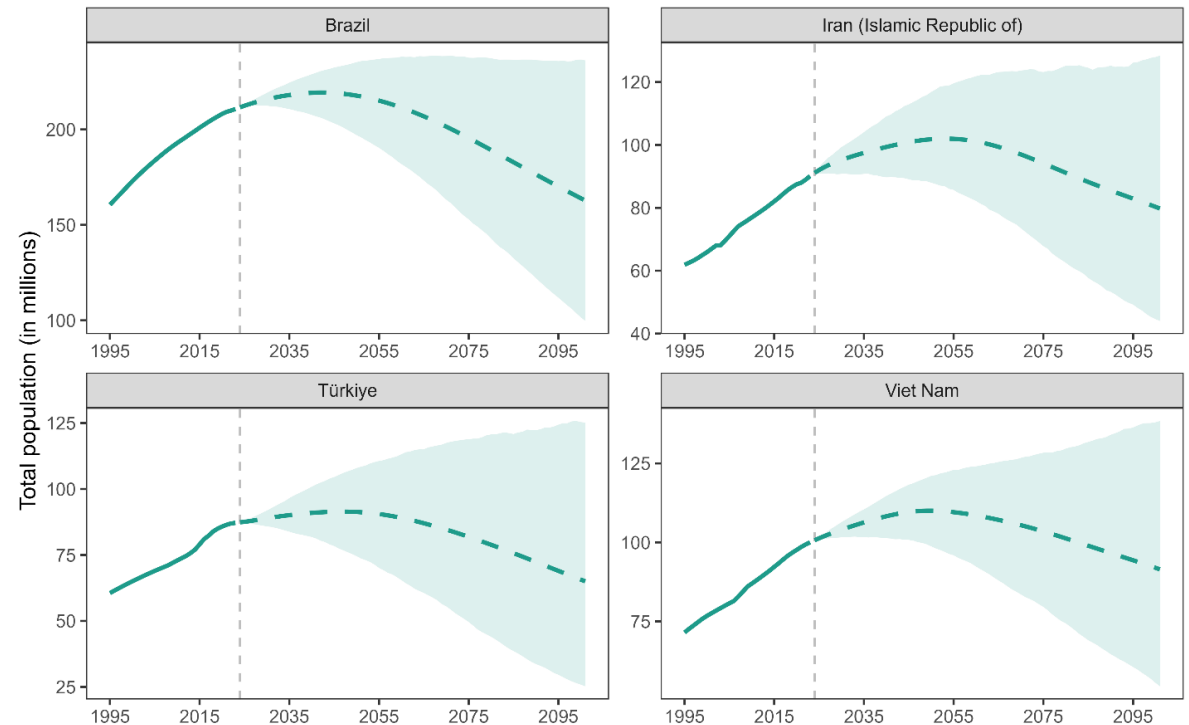


Total fertility and population: projections (medium scenario) with 95% prediction intervals and scenario with constant fertility (dash-dotted line), 2024–2100



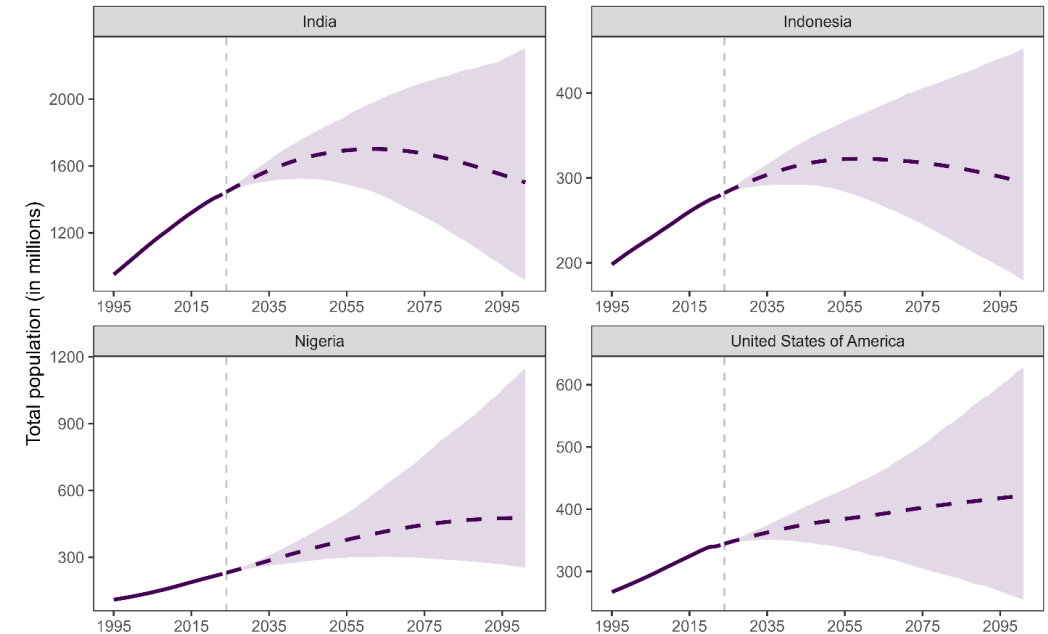
Group 2: Countries Likely to Peak by 2054

- **Examples:** Brazil, Iran, Türkiye, Viet Nam
- 5% population increase projected by 2054
- **Key drivers:** Declining fertility, mortality improvements
- **Policy focus:** Leveraging demographic dividend, preparing for aging
- Countries in this group face similar challenges and opportunities as those populations that already peaked and those that will continue to grow.
- Need to balance the immediate demands of a population that is younger and still growing with the emerging demands of a population that is older and no longer growing.

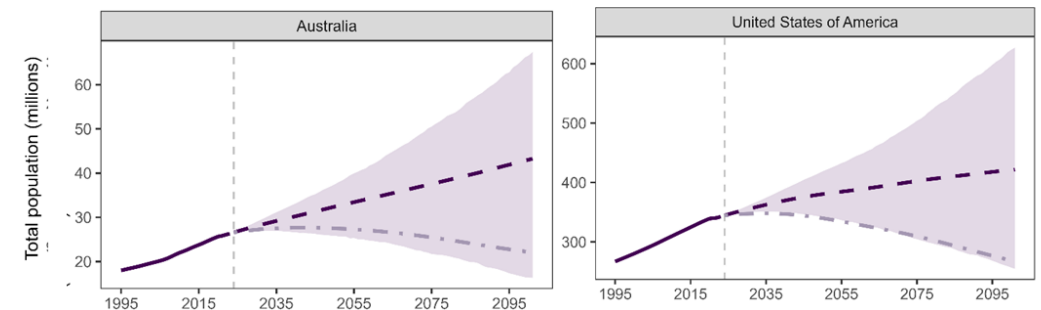


Group 3: Countries Growing Through 2054

- Countries in this group are at different stages in the demographic transition.
- **Examples:** India, Nigeria, Pakistan, USA
- 38% population increase projected by 2054
- **Wide variation within group** (e.g. migration-driven vs. fertility-driven growth)
 - Sub-Saharan African countries in this group are projected to see their population increase by 79% over the next 30 years to reach 2.2 billion in 2054.
 - Rapid growth is likely to increase the scale of investments and efforts required to eradicate poverty, end hunger and malnutrition, ensure universal access to health care, education, and job creation.
 - For some populations, immigration will be the main driver of future population growth.
 - In the absence of migration, their populations would likely peak much earlier and at a lower level.



Total population for selected countries by timing of the peak
Estimates (1995-2023) and projections (2024-2100), medium scenario and **scenario with zero net migration**



Measuring Future Population Trends

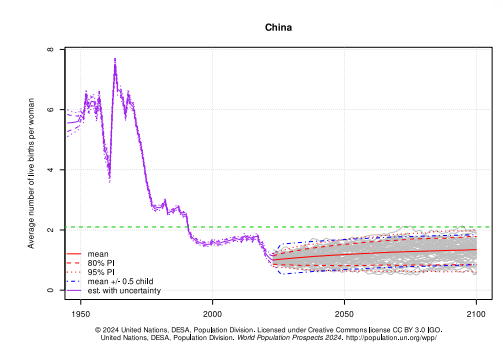
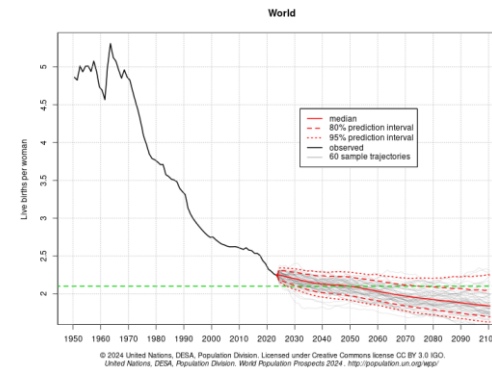
- **Population change depends on components of demographic change and a balancing equation for demographic accounting**
- This is represented by the following relationship:



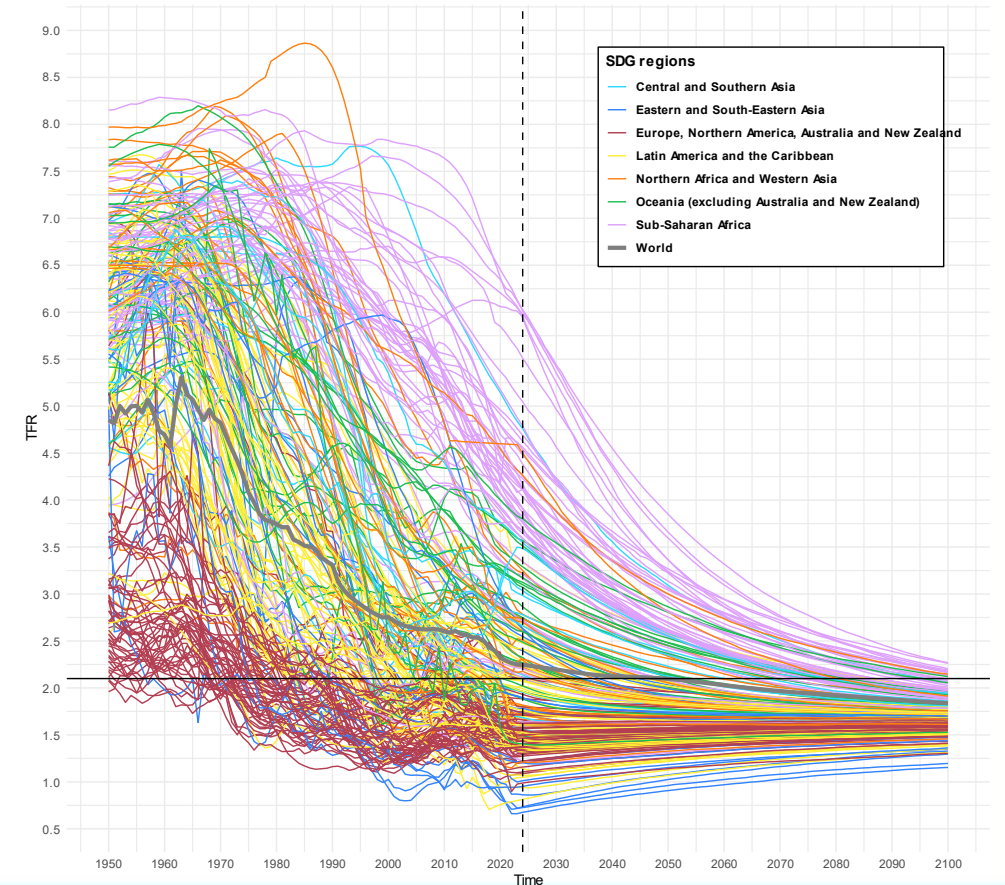
- Population estimates (and projections) are derived by combining estimates and projections of components.

Fertility Rate Trends

- **Decline in Global Fertility Rates:** Current global fertility rate is 2.3 live births per woman, down from 3.3 in 1990, indicating shifting reproductive behaviors worldwide and contributing to slower population growth.
- More than half of the world's population now lives in countries with fertility below replacement levels (2.1 births per woman).
- **Ultra-Low Fertility:** Some countries like China and Italy experience ultra-low fertility below 1.4 live births per woman.
- Global fertility rate is projected to decline to 2.1 (i.e., below replacement-level fertility) by the late 2040s.

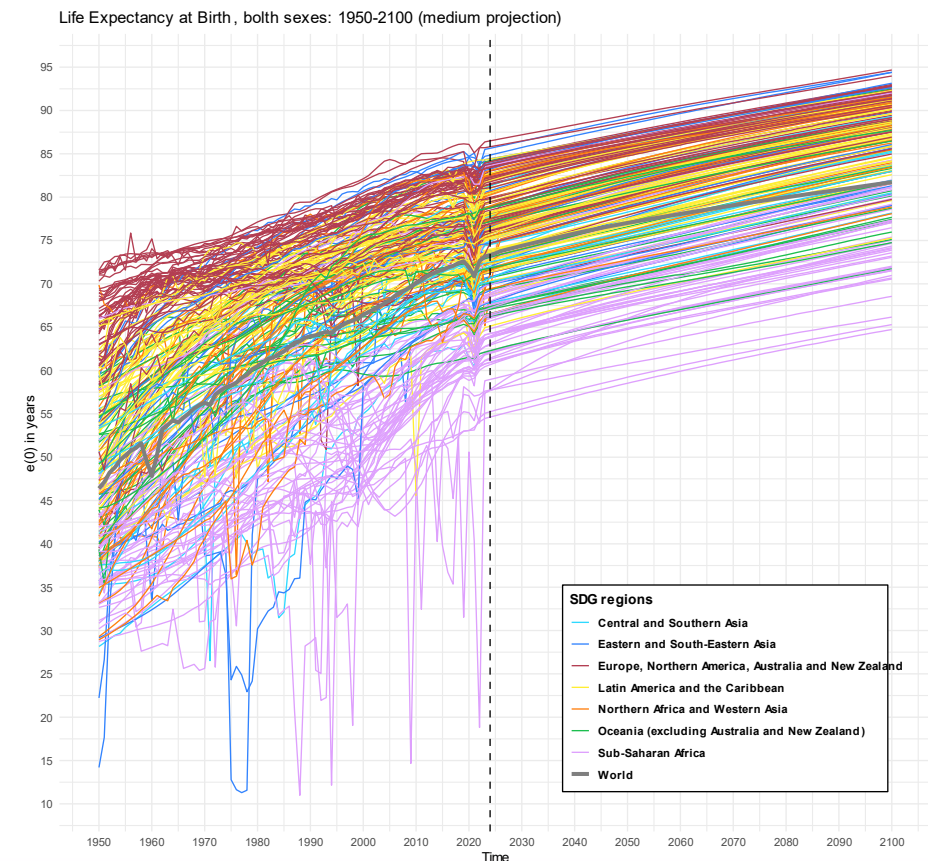
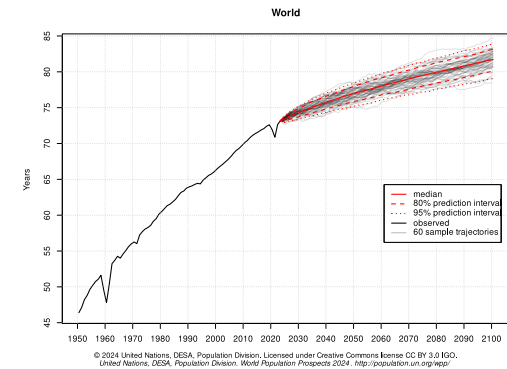


Total Fertility Rate: 1950-2100 (medium projection)



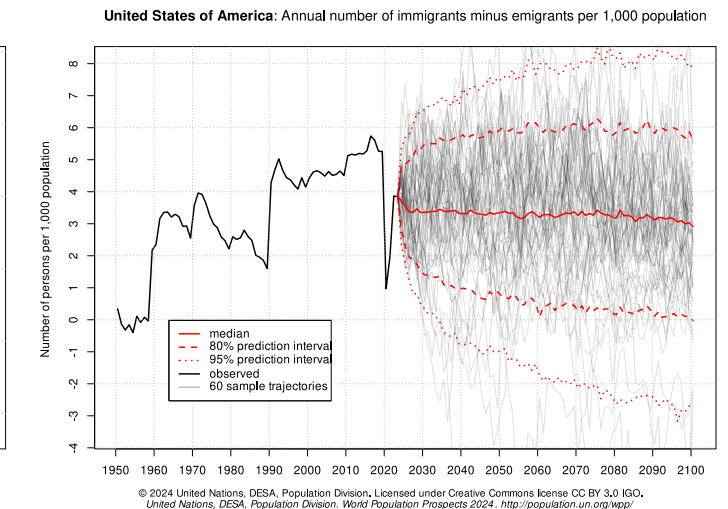
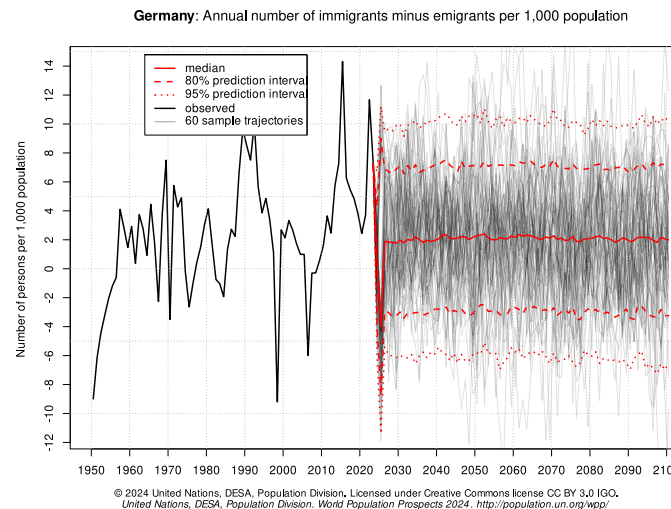
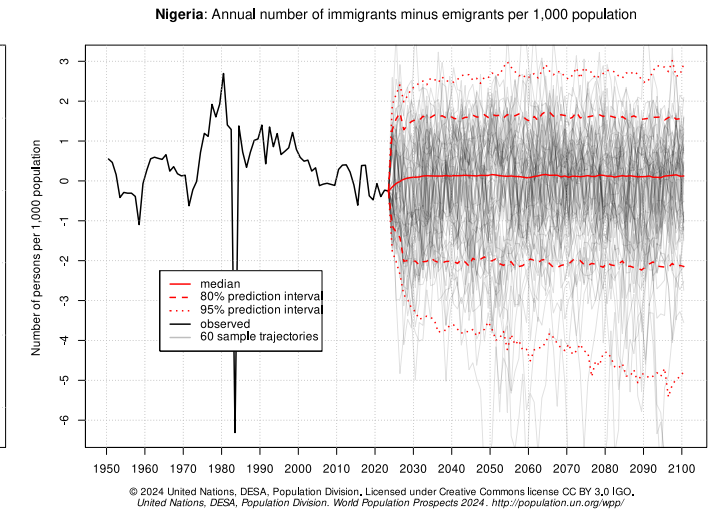
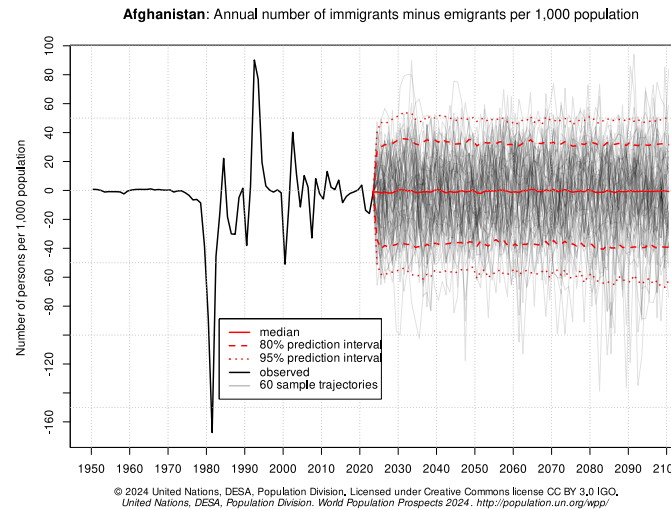
Life Expectancy and Mortality Trends

- Global life expectancy continues to increase.
- Global life expectancy in 2024 is 73.3 years, and it is expected to rise to 77.4 years by 2054.
- COVID-19 significantly reduced global life expectancy, exacerbating existing health disparities and demographic inequalities.
- Life expectancy rebounded after the COVID-19 pandemic, reflecting long term mortality trends, and influenced by regional healthcare systems' resilience, vaccination rates and natural immunity.



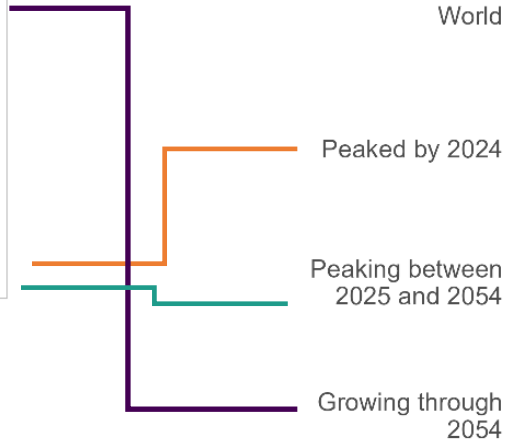
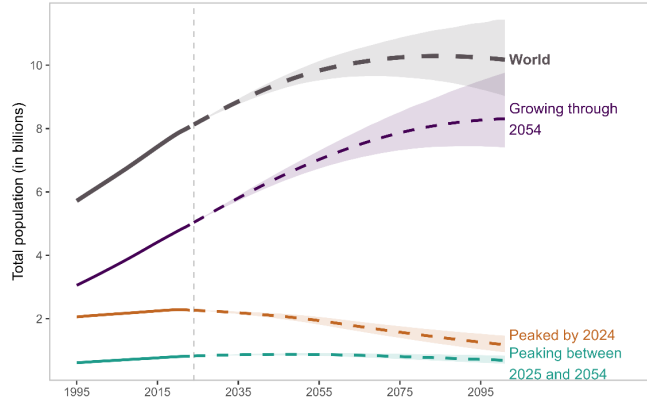
Migration's Role in Population Change

- A significant factor for some countries.
- Population growth in certain countries will be increasingly driven by migration, particularly in countries with low fertility.
- Introduction of probabilistic models for net international migration projections in WPP 2024.

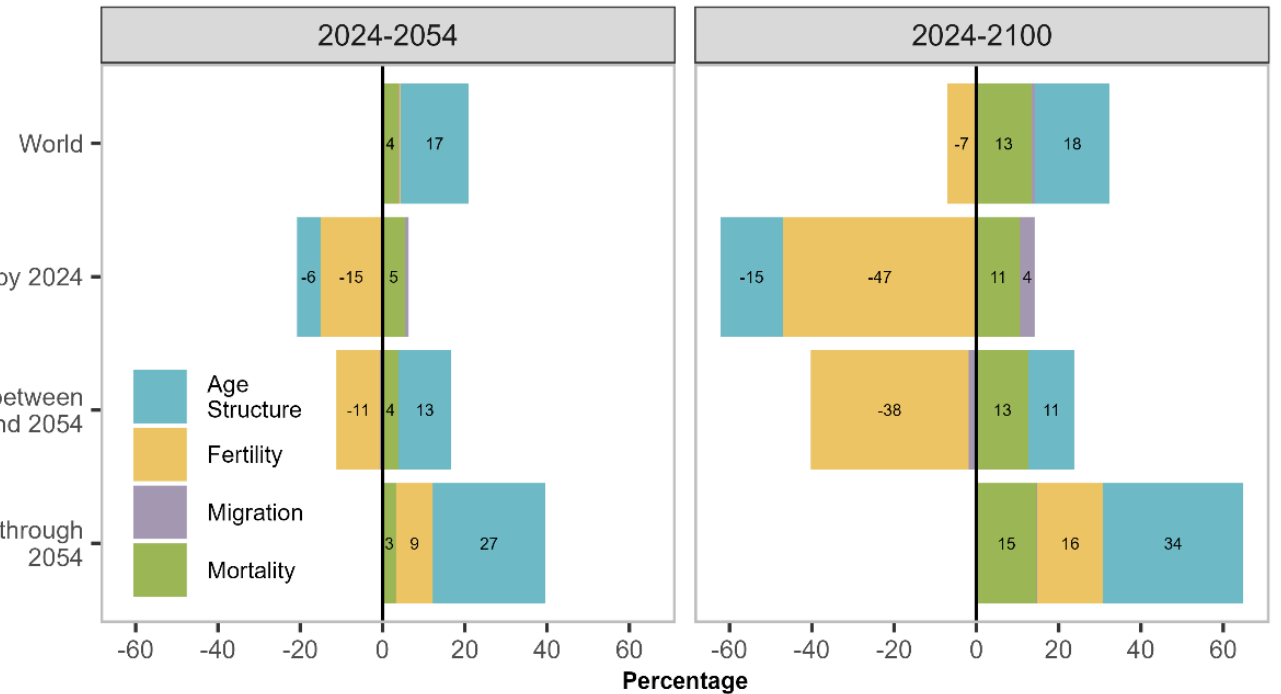


What will drive population growth or decline?

Total population. Estimates (1995-2023) and projections (2024-2100)



Relative contributions of the components of population change to future population size



The **Fertility** component is estimated as the average number of live births per woman over a lifetime.

The **Age structure** component determines the number of women in the core reproductive ages -> population momentum major driver of near-term growth as fertility rates decline.

Demographic Shifts: Aging and Youthful Populations

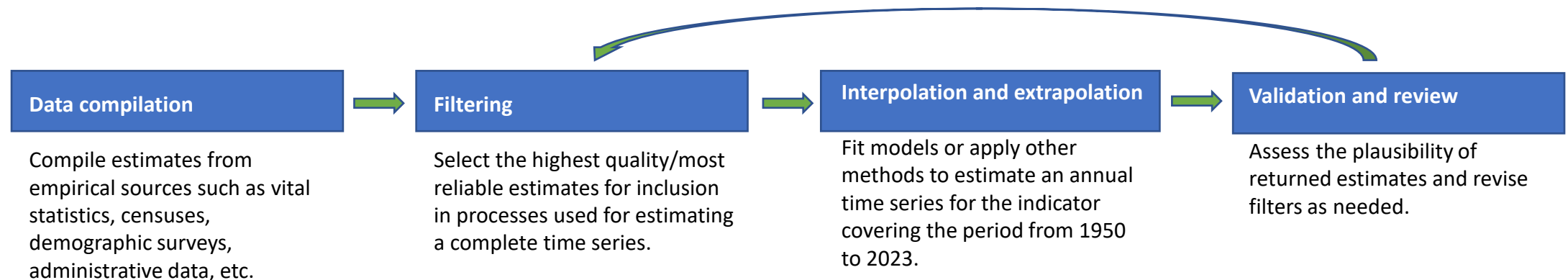
- **Global Aging Population:** By 2080, those aged 65 or older will outnumber children under 18 globally, posing challenges to social systems. This trend is most prominent in countries like Japan and Germany, which will face pressure on healthcare and pensions.
- **Countries with Youthful Populations:** In many developing countries, such as Nigeria and Ethiopia, the working-age population will grow, a window of opportunity for economic growth if investments are made in education and employment
- **Policy implications:** These divergent trends highlight the need for tailored policy responses across regions. Aging populations require proactive policies addressing workforce participation, retirement age, intergenerational equity, healthcare and social welfare, while countries with youthful populations must focus on education and employment.

Urbanization and Spatial Demography

- Global Trends:
 - In 2018, 55% of the global population resided in urban areas, projected to rise to 68% by 2050.
 - Anticipate 2.5 billion increase in the urban population between 2018 and 2050, with 90% concentrated in Asia and Africa.
- Policy Implications:
 - Urbanization will significantly influence population trends and spatial demographics.
 - Sustainable management of urban expansion, especially in lower-income nations.
 - Policies to enhance the lives of both urban and rural residents.
- Methodological and statistical concept upgrade for WUP 2025: new Degree of Urbanization for internationally comparable monitoring and comparison of levels and trends in urbanization globally.

Measurement and Methodologies in WPP

- **Probabilistic Modeling:** WPP uses Bayesian hierarchical models to project fertility, mortality and migration, incorporating uncertainty intervals.
- **Cohort Component Method:** Population estimates and projections rely on the cohort-component method, which estimates population by combining fertility, mortality, and migration data by age and sex over time.
- **Data Sources:** WPP draws from censuses, surveys, and vital registration systems across 237 countries to build population estimates.



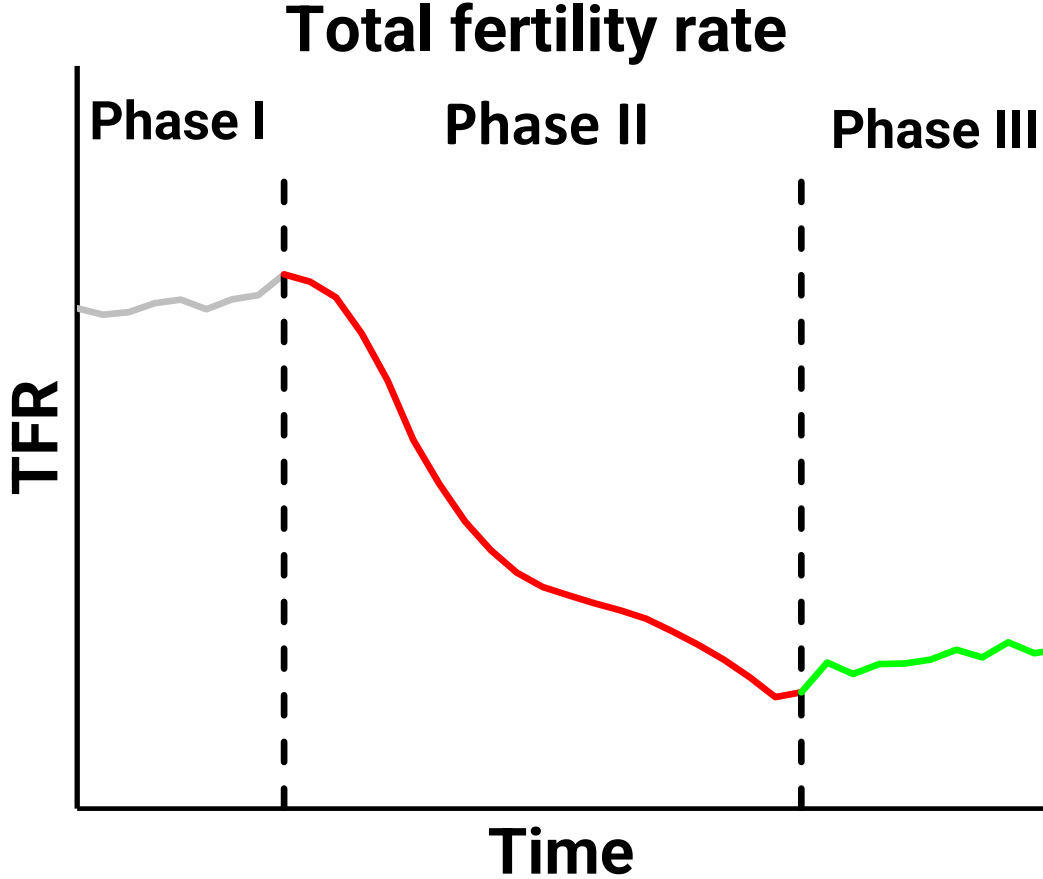
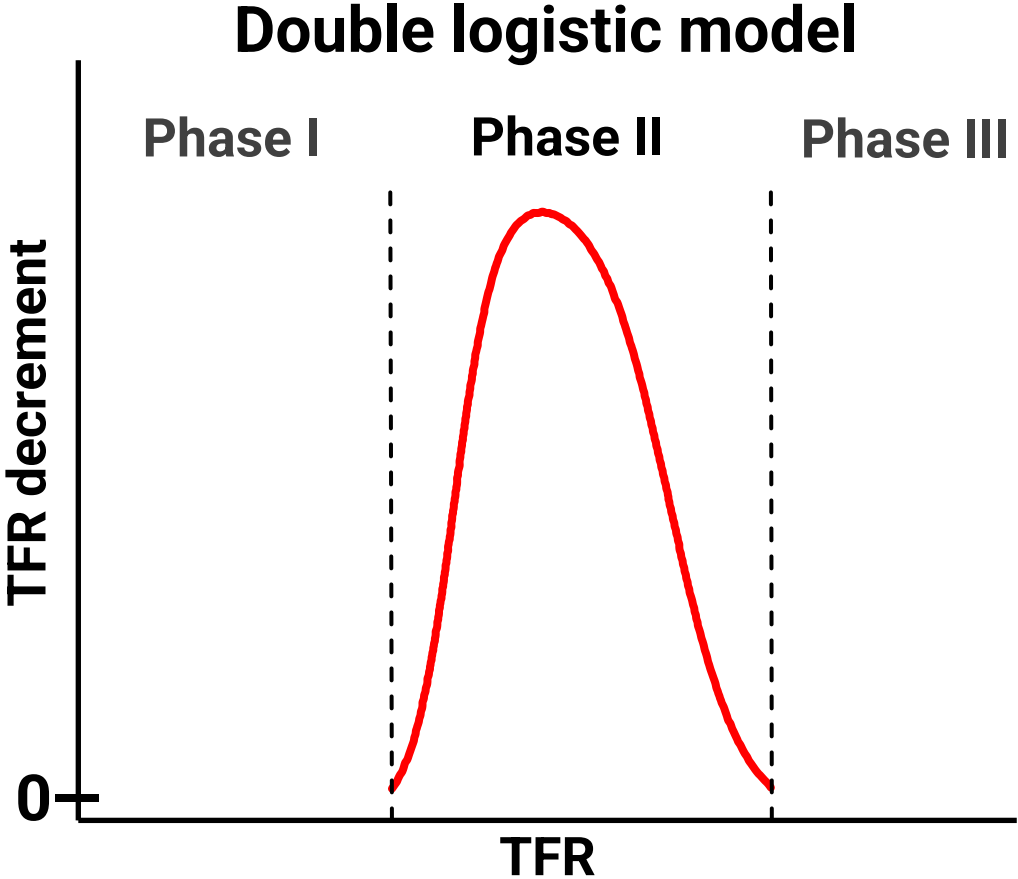
Using historical evidence for projections

- UN projections of fertility, mortality and migration are guided by historical trends in those same variables
- Regularities in historical trends have led to theories of demographic change, which give structure to the projection model
- Model is calibrated for each country using an estimation procedure that relies primarily on data for that country
- Data for other countries influence estimates especially for countries in which the transition is less complete
- Bayesian hierarchical model of past trends, combined with time series model of future trends, yields probabilistic depiction of plausible future outcomes

Theory-based methods

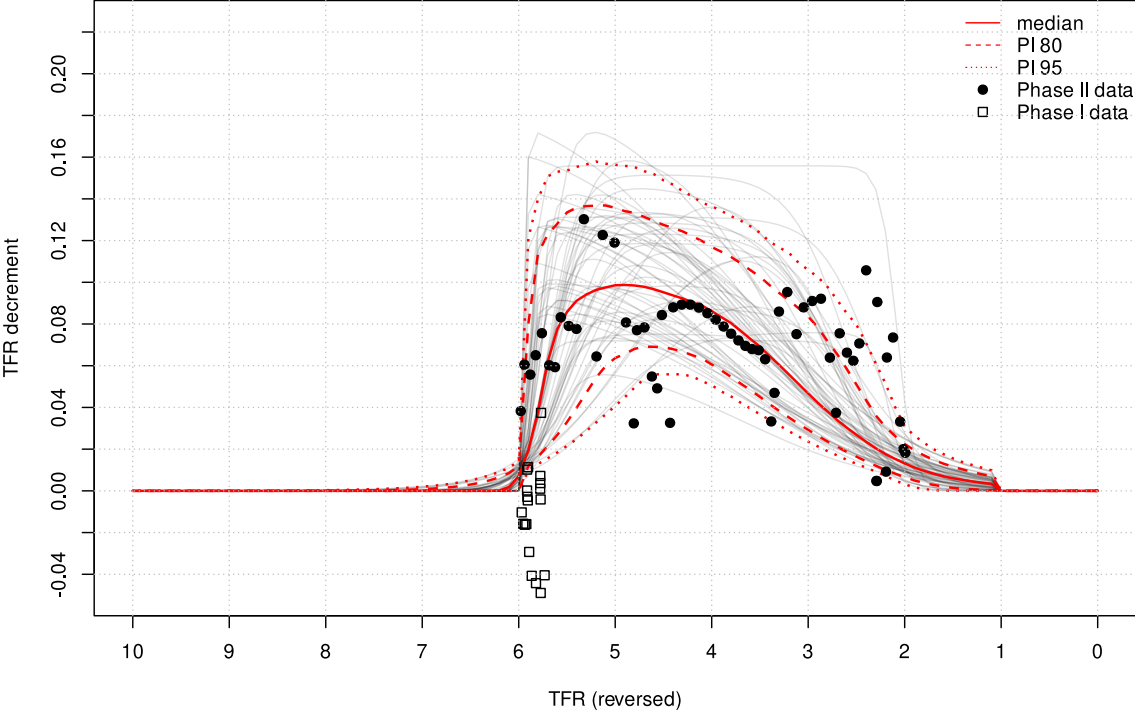
- Theories of the demographic transition share certain common points about the historical decline of fertility and mortality, which are reflected in the structure of the United Nations projection model.
- For **fertility**, there is a transition from high to low values of TFR, typically followed by fluctuations and a modest recovery (i.e., below replacement level).
- For **mortality**, the increase of life expectancy at birth follows an S-curve (slow-rapid-slow change), which remains positive and roughly linear in the final phase.
- For **migration**, use a Bayesian hierarchical first-order autoregressive model to model future trajectories of the crude net migration rate around the world based on historical experience across countries and to account for uncertainties and correlations across countries and over time.

Three phases of TFR trend: Pre-decline, decline and post-decline

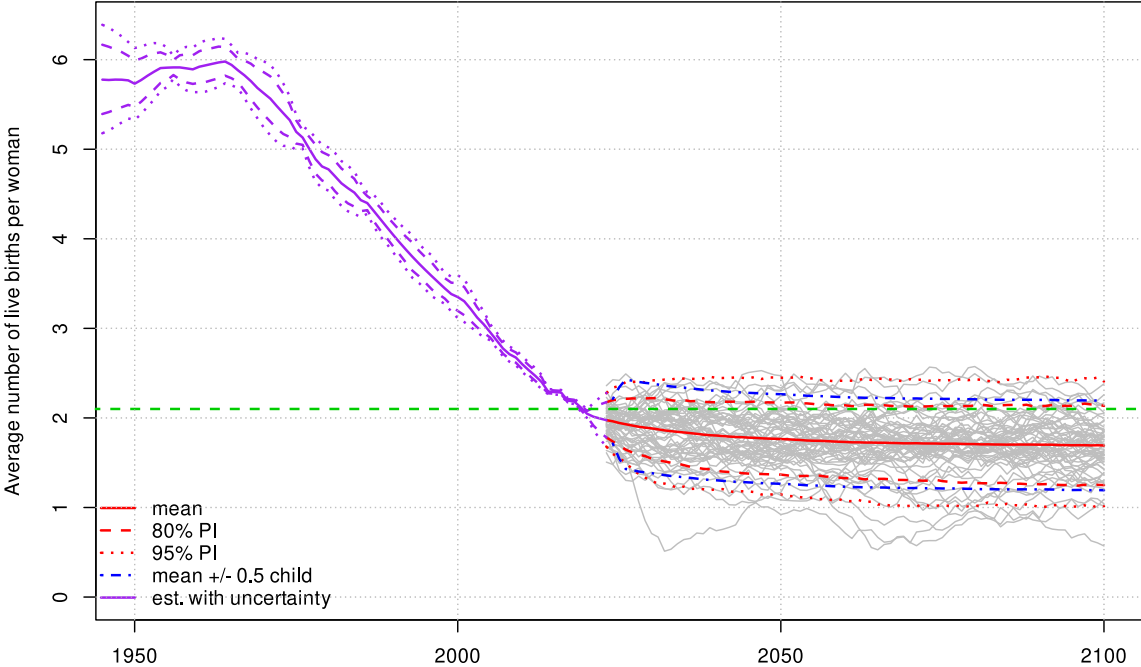


Fertility projection for India

TFR: Rate of decline function



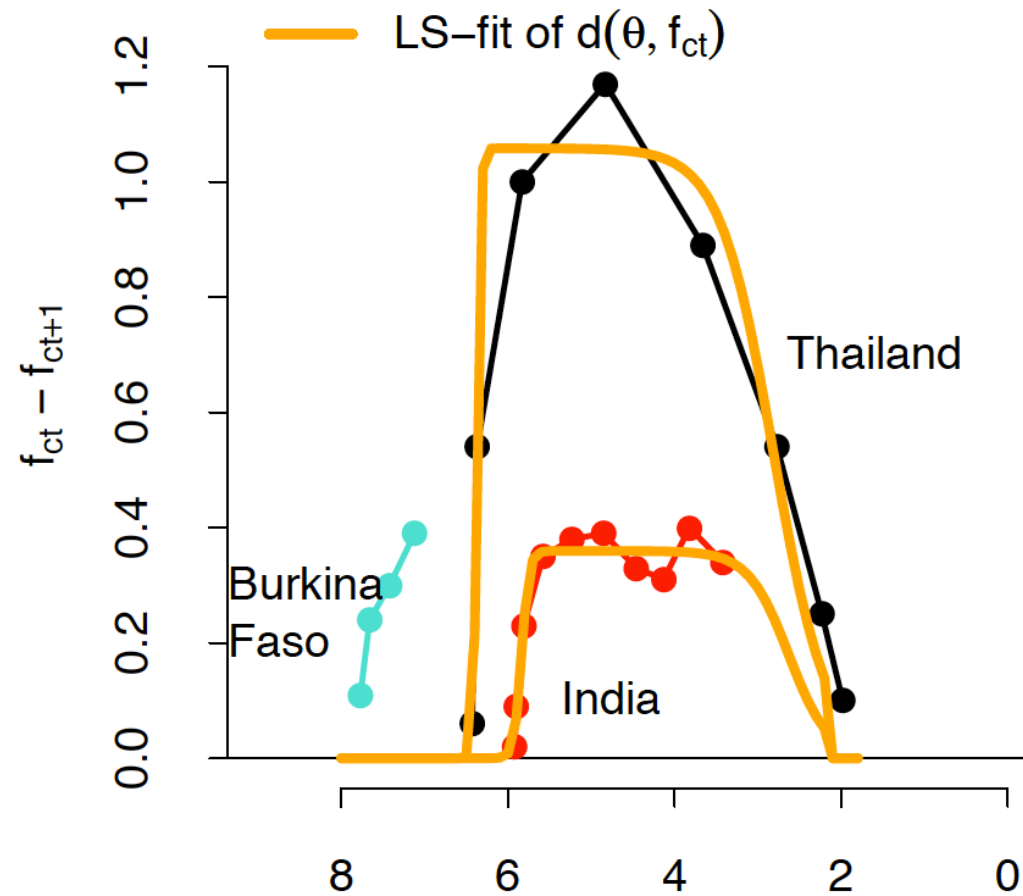
Probabilistic TFR projections



© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO. United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO. United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

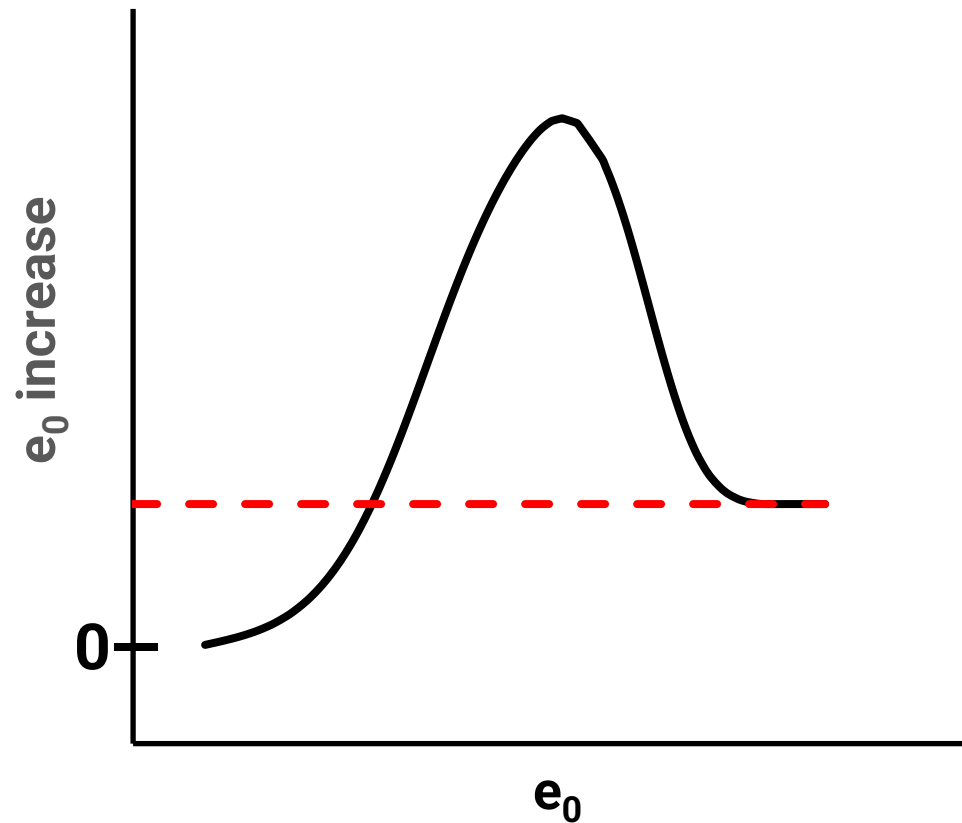
Country-specific estimates of the TFR rate of decline function



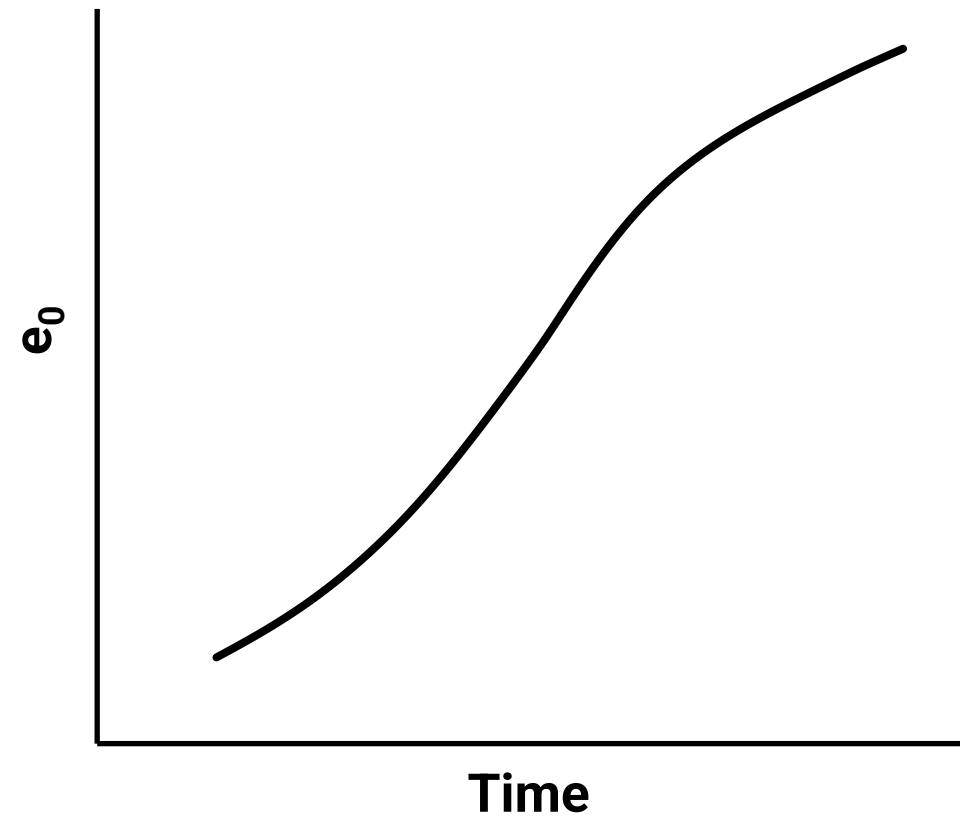
Source: [Alkema L., A.E. Raftery, P. Gerland, S.J. Clark, F. Pelletier, T. Buettner, and G.K. Heilig \(2011\). "Probabilistic Projections of the Total Fertility Rate for All Countries." in: *Demography*, 48:815-839. doi: 10.1007/s13524-011-0040-5 \[open access\]](#)

UN models of historical trend in life expectancy at birth

Double logistic model

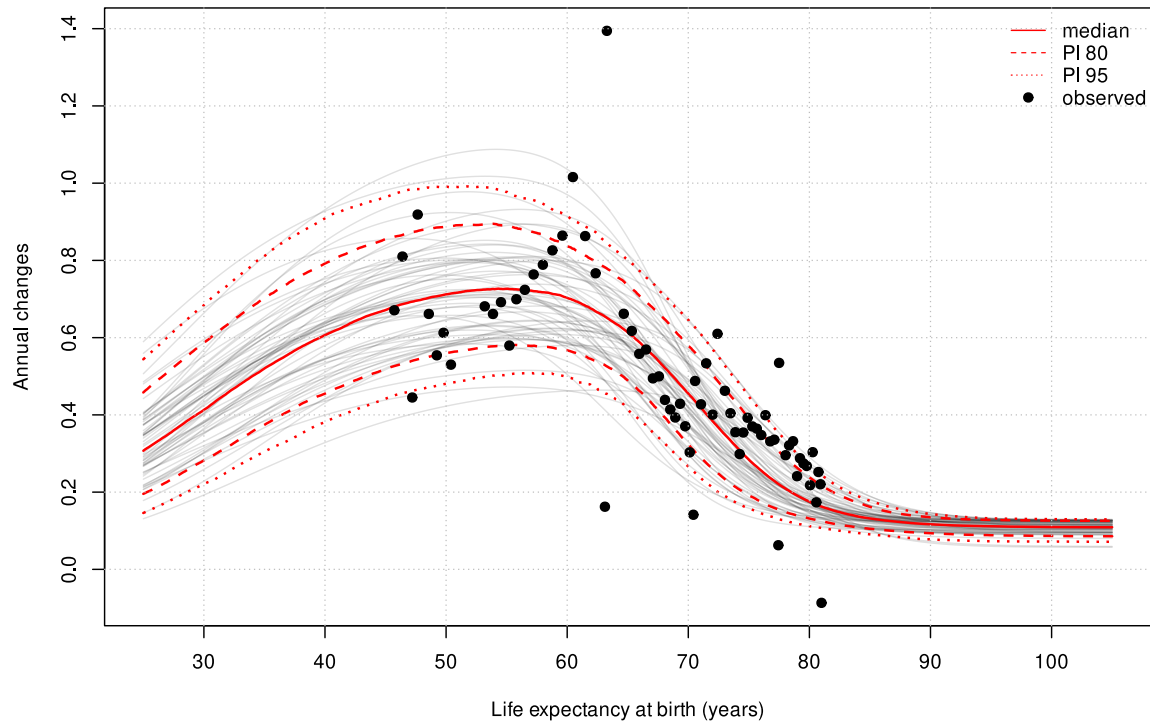


Life expectancy at birth



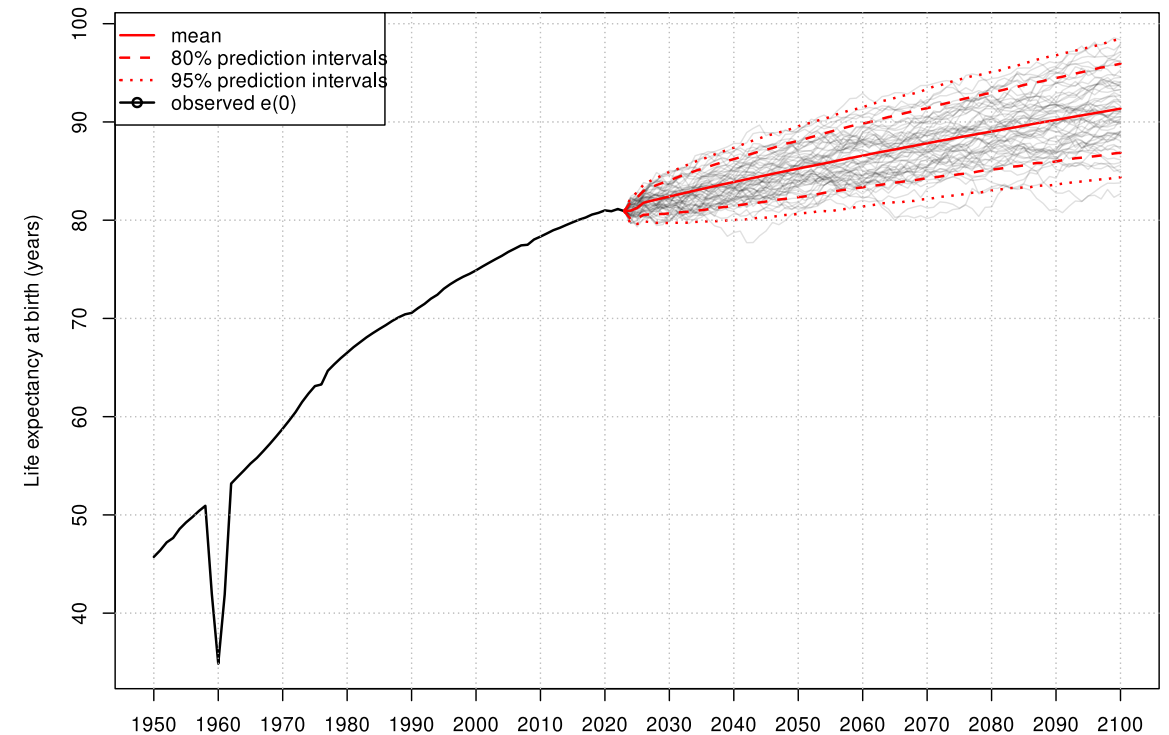
China: female life expectancy at birth projection

Rate of improvement function



© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

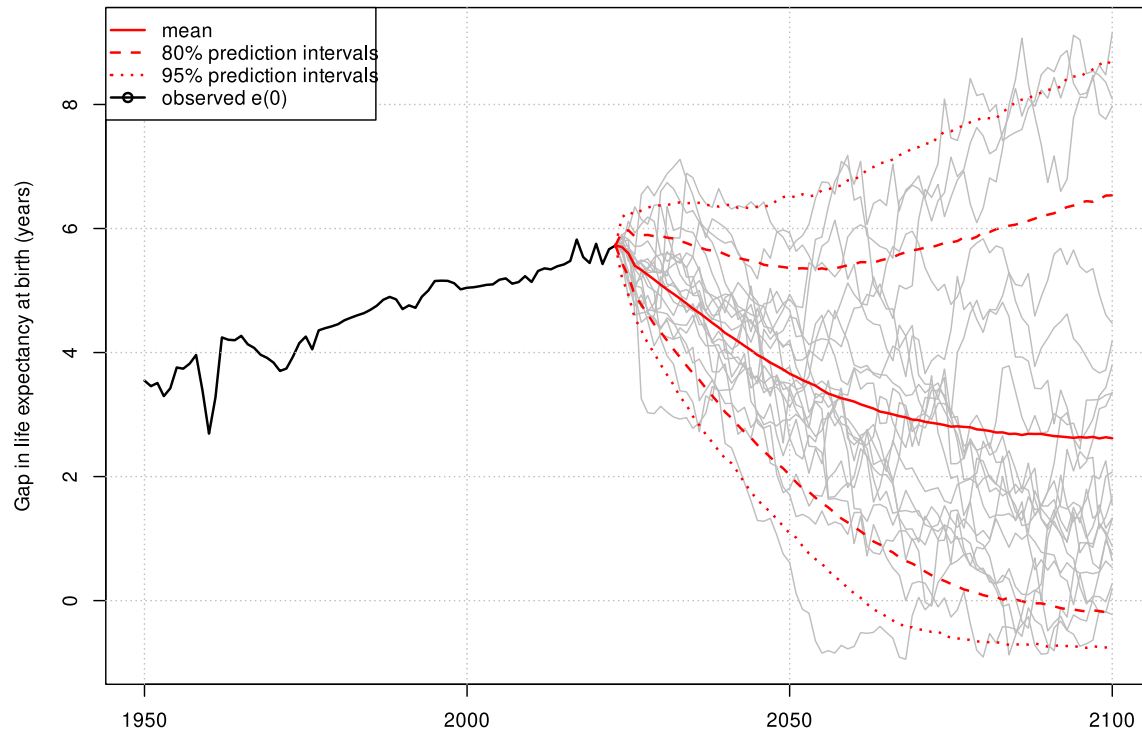
Probabilistic projections



© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

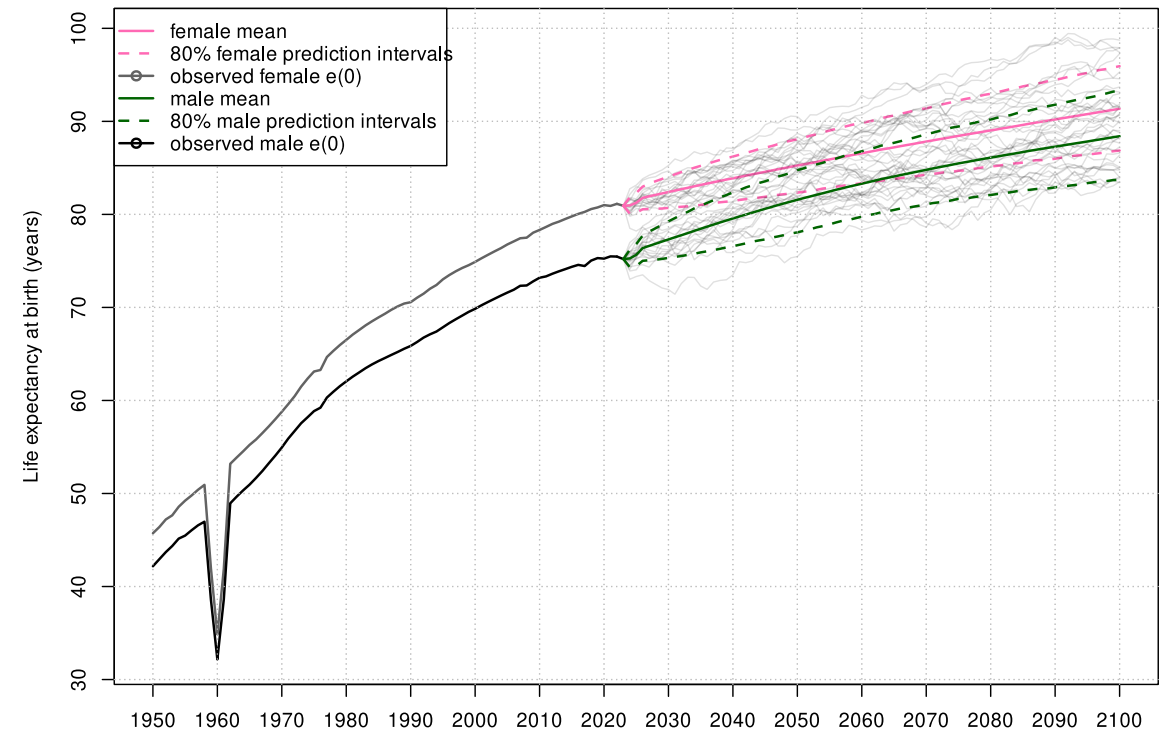
China: male life expectancy at birth projection (correlated model using gender gap)

(female – male) gap



© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

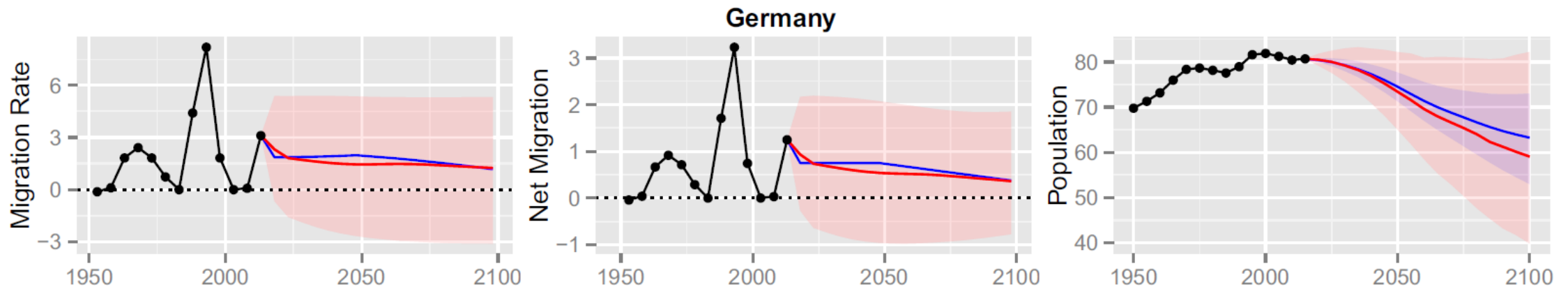
Probabilistic projections



© 2024 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.
United Nations, DESA, Population Division. *World Population Prospects 2024*. <http://population.un.org/wpp/>

WPP 2024: probabilistic projections of international migrations

- Building on the methodological work of Azose and Raftery ([2015](#), [2016](#)) adapted to use annual time series and single age population data
- Use past levels and trends, and reflect past variability in the projection of future crude net migration rates, and incorporate uncertainty in future international migrations into probabilistic population projections in addition to uncertainty in future fertility and mortality.



Azose, J. J., Ševčíková, H., & Raftery, A. E. (2016). [Probabilistic population projections with migration uncertainty](#). *Proceedings of the National Academy of Sciences*, 113(23), 6460-6465.

Data Availability for Population Estimates (WPP 2024)

- National statistical sources (either taken as-is or adjusted after in-depth evaluation) for 1950-2023, including:
 - **2,025 censuses** and 320 post-enumerations surveys
 - **2,970 surveys** (440 since 2015)
 - **vital registration systems** from **169 countries or areas**

Most recent census data:

- 48% of countries or areas (n=114) have data since 2019 (and 54 per cent of the world population)
- 18% (n=43) from 2014-2018, 24% (n=57) from 2009-2013, 10% (n=23) before 2009

Latest available birth statistics (and their completeness) vary significantly by region:

- 83% of countries or areas (n=196) have fertility data since 2019, 14% (n=32) from 2014-18, 3% (n=8) before 2012
- Only 73% of the countries, territories and areas register at least 90% of births occurred (UNSD).

Data Availability for Population Estimates (WPP 2024)

Latest available mortality statistics vary significantly by region

- 120 countries or areas with good VR statistics for empirical life tables by age and sex, 117 countries or areas with empirical mortality rates by sex and age too sparse or of insufficient quality to estimate the complete annual time series of mortality rates.
- Only 68% of the countries, territories and areas have at least 90% of deaths occurred (UNSD).

Number of countries with data on age- and sex-specific deaths from complete vital registration for the years 2020 to 2023 (as of March 2024)

	Number of countries with 90 per cent or higher death registration	Proportion of total global deaths covered by complete VR (per cent)
2020	106	35
2021	100	30
2022	51	15
2023	5	1

- Under-five mortality: 78% of countries or areas (n=184) have data since 2019, 15% (n=35) from 2014-18, 3% (n=7) from 2009-13, and 2% (n=6) before 2009.
- Adult mortality: 65% of countries or areas (n=154) have data since 2019, 25% (n=60) from 2014-18, 6% (n=15) from 2009-13, 3% (n=6) before 2009, and 1% (n=2) no data.

Data Availability for Population Estimates (WPP 2024)

Great variability in data sources and reliability over time and locations for (net) international migration estimates

- Official annual estimates (e.g., NSOs, Eurostat, n=54)
 - Estimates of migrant flows (e.g., Eurostat, OECD, n=56)
 - Foreign-born stocks (UN estimates) and implied annual change
 - Administrative data (e.g., work permits issued/renewed)
 - Literature review for major forced migration historical events
 - Intercensal net residual migration for countries with good VR or residual from cohort-component projection compared to census or population register
 - UNHCR estimates of refugee stocks (and implied annual change)
- n=67
distinct
locations

Recent Methodological Enhancements in WPP



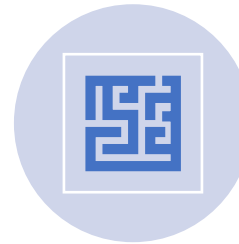
Transition to annual time series and single year age groups: Enhances granularity and accuracy.



Enhanced statistical modelling of age patterns for fertility, mortality, and migration



Refinement of mortality estimates: systematic accounting for mortality crises, and improvements in estimating mortality at older ages contribute to more accurate projections, especially in aging societies.



Probabilistic projections for migration: incorporating uncertainty in migration projections.



Data Transparency and Accessibility: Enhanced data compilation and validation processes, and availability of underlying empirical country data and methodologies for users.

Uncertainty in Population Projections

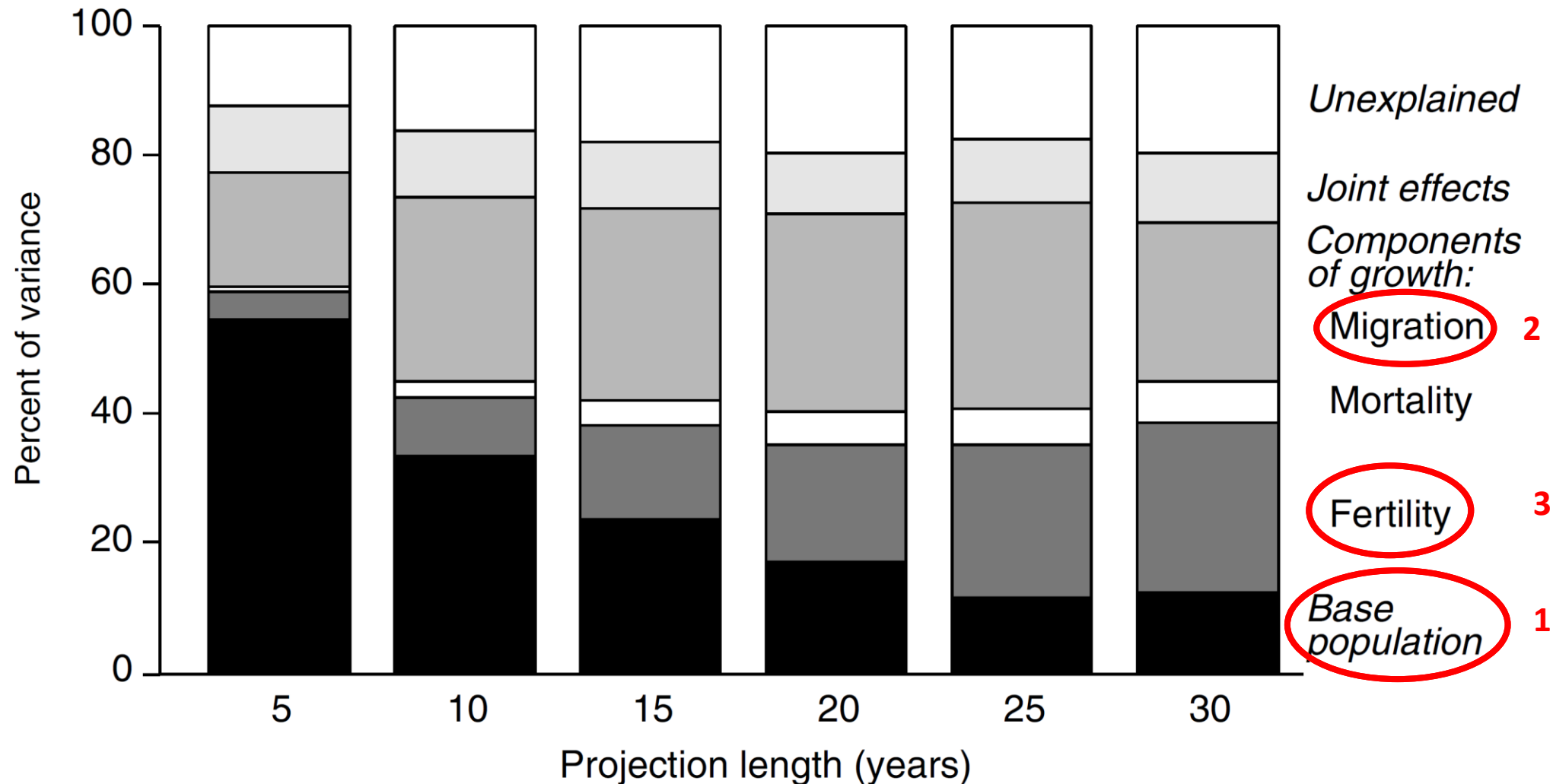
- Probabilistic methods quantify range of plausible outcomes
- Increasing uncertainty over longer time horizons
- Key sources: Future fertility, mortality, and migration trends
- Importance of considering multiple scenarios
- Future Research:
 - Additional SDG-relevant conditional probabilistic projection scenarios.
 - Incorporating the impact of climate change and other environmental factors on population trends.

Population projection accuracy: factors influencing forecast errors

- Gap/lag between latest available data and base year used for projection
- [Accuracy and reliability of the baseline population]
- Degree of disaggregation (sex, age, and other characteristics)
- Length of projection horizon (i.e., next 5-10 years vs. 1-3 future generations)
- Assumptions (fertility; mortality; migration)
[and accuracy and reliability of past empirical estimates]
- [changing] demographic trends, reversal of trends, crises and new emerging issues (e.g., AIDS)

See **Keilman, N. (2001)** Data quality and accuracy of United Nations population projections, 1950-95. *Population Studies* 55: 149-164.

Sources of error vary in importance with the length of the projection horizon: 1950-1995.



Data Gaps and Challenges



Limited availability of timely and reliable data, particularly in low-income countries.



Need for timely, high-quality vital registration systems, and greater use of administrative data.



Remaining importance of population and housing censuses for more than 2/3 of countries.



Challenges in measuring migration flows accurately.



Addressing data gaps is essential for improving the accuracy and usefulness of population projections.



Potential of new data sources (e.g. "big data", satellite imagery), especially for geospatial analysis and modelling at the subnational level.

Conclusion

Global population dynamics are undergoing rapid transitions.

Diverse demographic futures require tailored policy responses:

- Rapid growth: Education, health, employment, housing, infrastructure
- Population aging: Pensions, healthcare, labor force and technological innovations
- Decline: Economic dynamism, infrastructure optimization

Understanding future population trends is essential for:

- Informing policy decisions related to resource allocation, infrastructure development, and social welfare programs.
- Monitoring progress towards achieving the SDGs.
- Address the needs of aging populations in countries with declining fertility.
- Enhance investment in infrastructure and services in rapidly urbanizing regions.
- Prioritize sustainable practices to accommodate future population trends.

Growing importance of Spatial Demography

- Increasing demand for subnational population estimates and projections.
- Linking demographic and environmental data.
- Mapping population vulnerability to climate change.
- Supporting localized policy interventions.
- Potential synergies between WPP, WUP, [GHS-POP grid](#) and [WorldPop](#) methodologies.
- Continued collaboration is essential for creating sustainable, inclusive, and resilient future demographics.

References

- United Nations (2024a). [World Population Prospects 2024: Ten Key Messages](#)
- United Nations (2024b). [World Population Prospects 2024: Summary of Results](#). UN DESA/POP/2024/TR/NO. 9.
- United Nations (2024c). [World Population Prospects 2024: Methodology of the United Nations population estimates and projections](#). Working Paper, No. UN DESA/POP/2024/DC/No. 10.
- United Nations (2019a). [World Urbanization Prospects 2018: Highlights](#) (ST/ESA/SER.A/421).
- United Nations (2019b). [World Urbanization Prospects: The 2018 Revision: Report](#) (ST/ESA/SER.A/420).
- United Nations (2018). [World Urbanization Prospects: The 2018 Revision, Methodology](#). Working Paper No. ESA/P/WP.252.