Population

Mark Goldberg

Topics

- Historical trends in world population

- Projections of future trends by selected area
  - Estimates
  - Methodology for projections
    - Population dynamics
    - Lifetables
    - Assumptions

Topics

- Factors affecting population growth
- What influences the drivers of population?
  - Fertility
  - Family planning/birth control measures
    - Efficacy of individual measures
    - Effectiveness of programs
      - Methods for evaluating programs

  - Mortality
  - Immigration
  - Other forces affecting populations

Topics

- Case studies
  - USA
  - The Philippines
  - Bangladesh
- Climate change and population: Sea level rise in Bangladesh
- Population density and cascading effects
- Infections diseases (flu pandemic)
- Carrying capacity

Historical Trends in the World Population

Recent Trends in Canadian, U.S., and World Populations

- **Canada   35,163,430**
- **U.S.   316,938,713   Oct 24, 2013**
- **World   7,119,799,760**

- **Canada   34,956,076**
- **U.S.   314,626,924   Oct 22, 2012**
- **World   7,047,317,311**

- **Canada   34,501,798   UN est 34,017,000**
- **U.S.   312,453,381   Oct 19, 2011   310,384,000**
- **World   6,969,418,490   6,895,889,000**

- **Canada   34,108,752   Oct 20, 2010**
- **U.S.   310,525,329**
- **World   6,876,344,540**

- **Canada   33,818,331 Oct 21, 2009   UN est. 33,752,000**
- **U.S.   307,750,224   314,692,000**
- **World   6,791,947,273   6,906,558,000**

Annual Change in Population

Year	Canada	US	World
2008-9	605,635	2,173,543	77,898,821
2009-10	290,421	1,928,052	93,073,950
2010-11	393,046	2,775,105	84,397,267
2011-12	454,278	1,826,427	43,568,776
Average	435,845 (1.27%)	2,175,782 (0.70%)	(1.09%)

Rate of Change and Doubling Times

	Average annual increase (%)	Doubling time (years)	Population (millions)
Canada	1.27	54	70
US	0.70	99	634
World	1.09	64	14,200

TABLE 1. WORLD POPULATION MILESTONES

| Population	Year		UN 2000	UN 2010
World population reached				
1 billion in	1804			
2 billion in	1927	(123 years later)		
3 billion in	1960	(33 years later)		
4 billion in	1974	(14 years later)		
5 billion in	1987	(13 years later)		
6 billion in	1999	(12 years later)		
World population may reach				
7 billion in	2012	(13 years later)		2010
8 billion in	2026	(14 years later)		2025
9 billion in	2043	(17 years later)		2044 9.8 billion from extrapolation of current rates

Source: United Nations (2001a).

Population Trends by Region
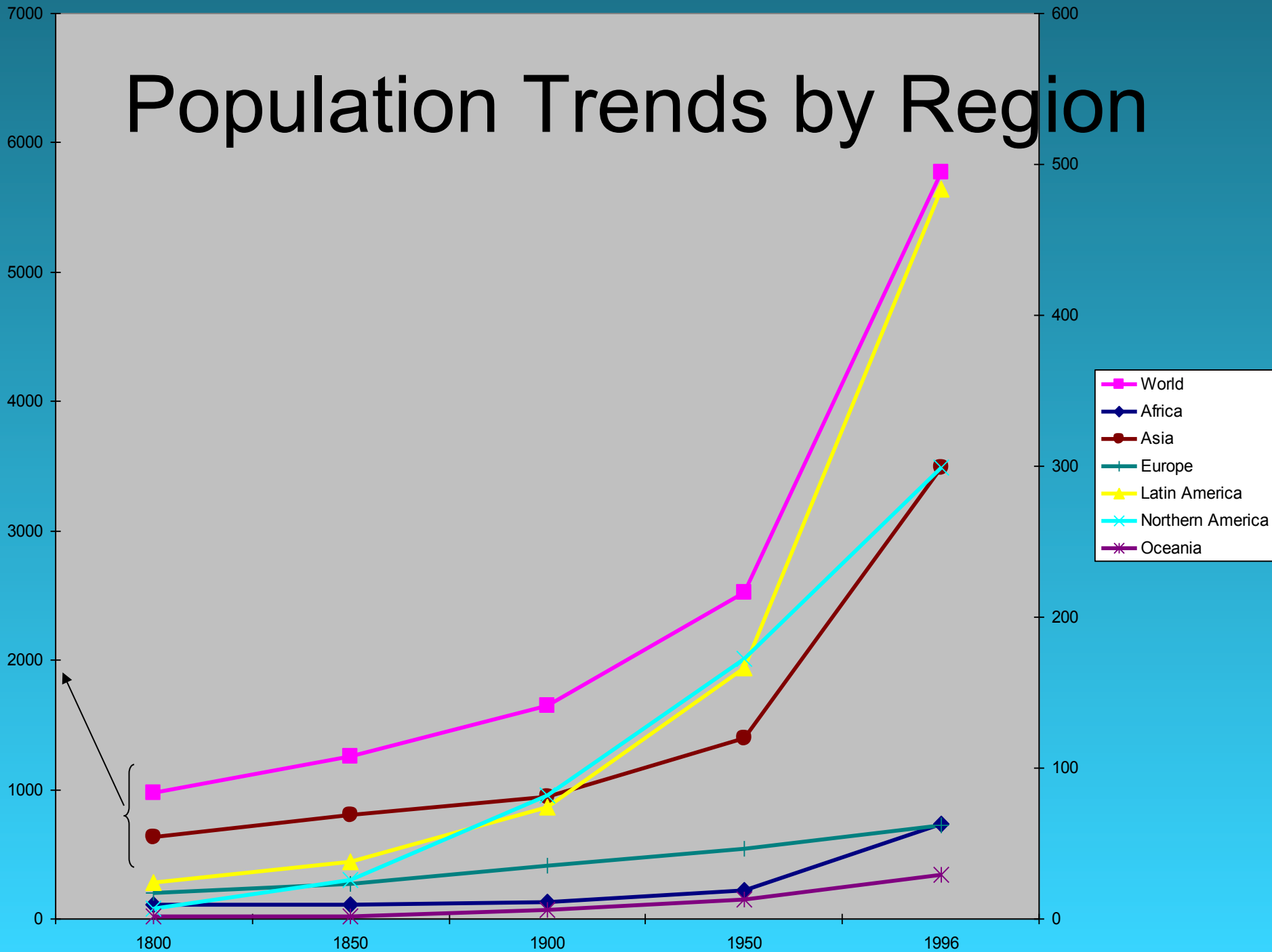
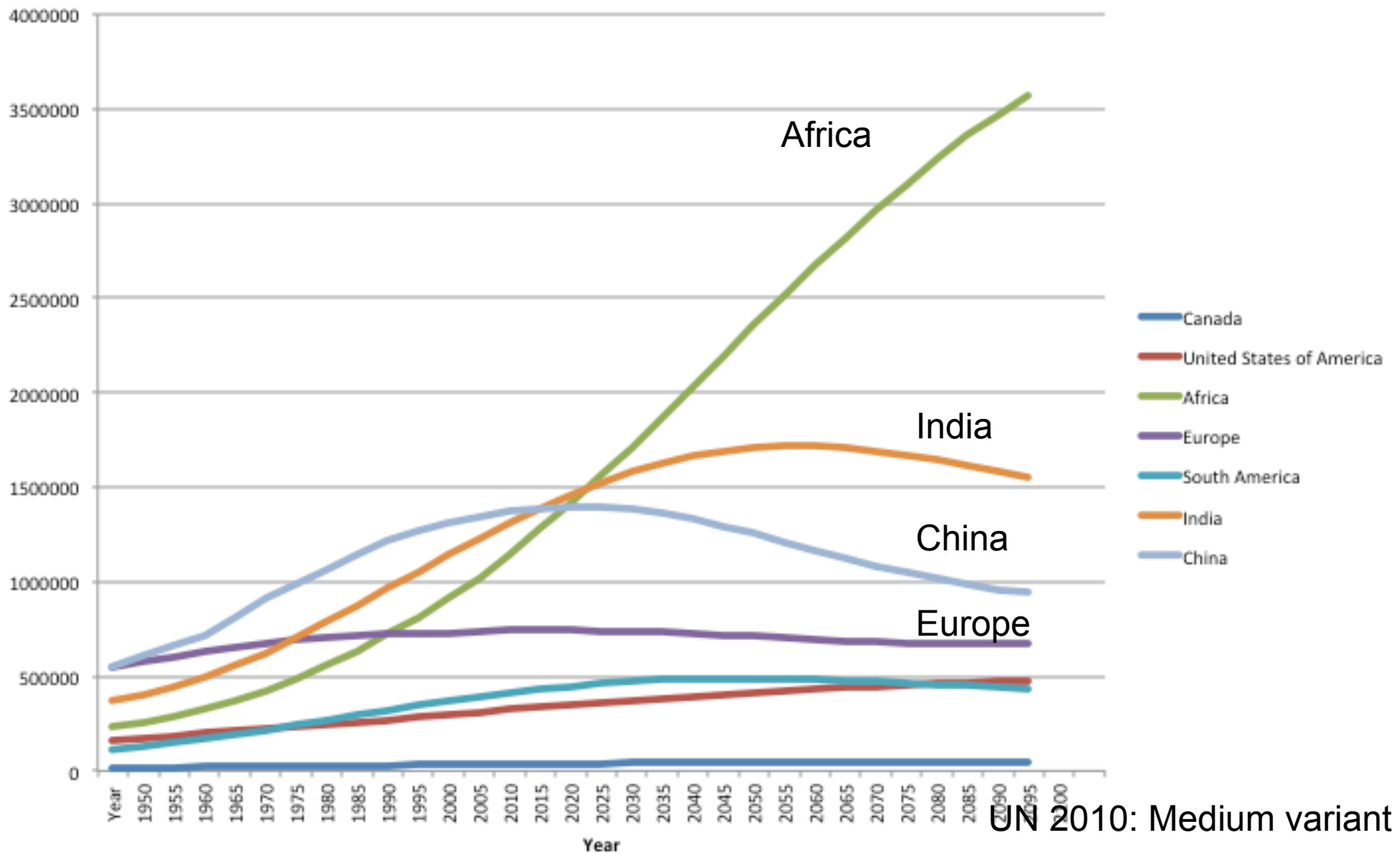# UN World Population Estimates (2010), by Type of Projection Model
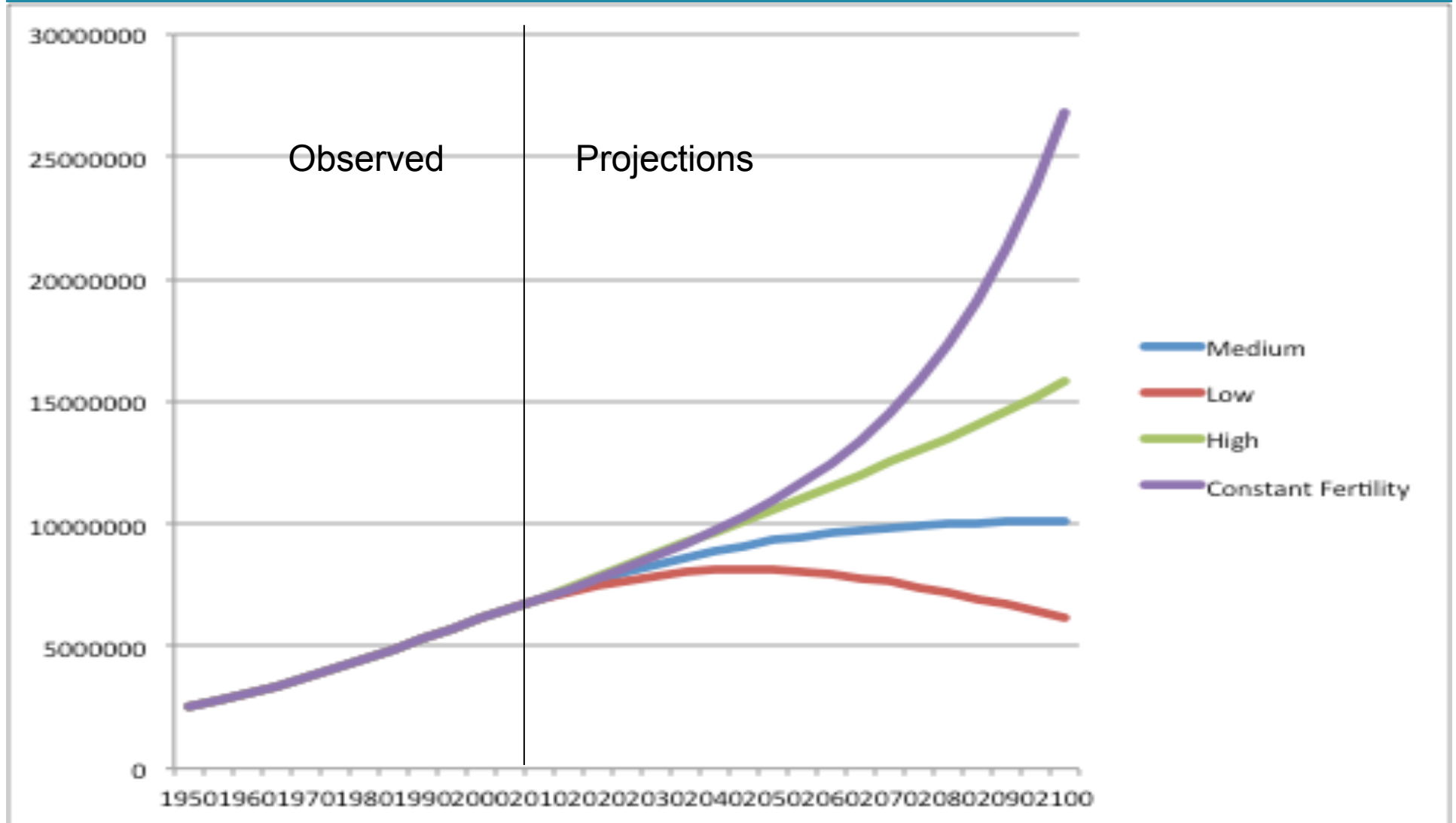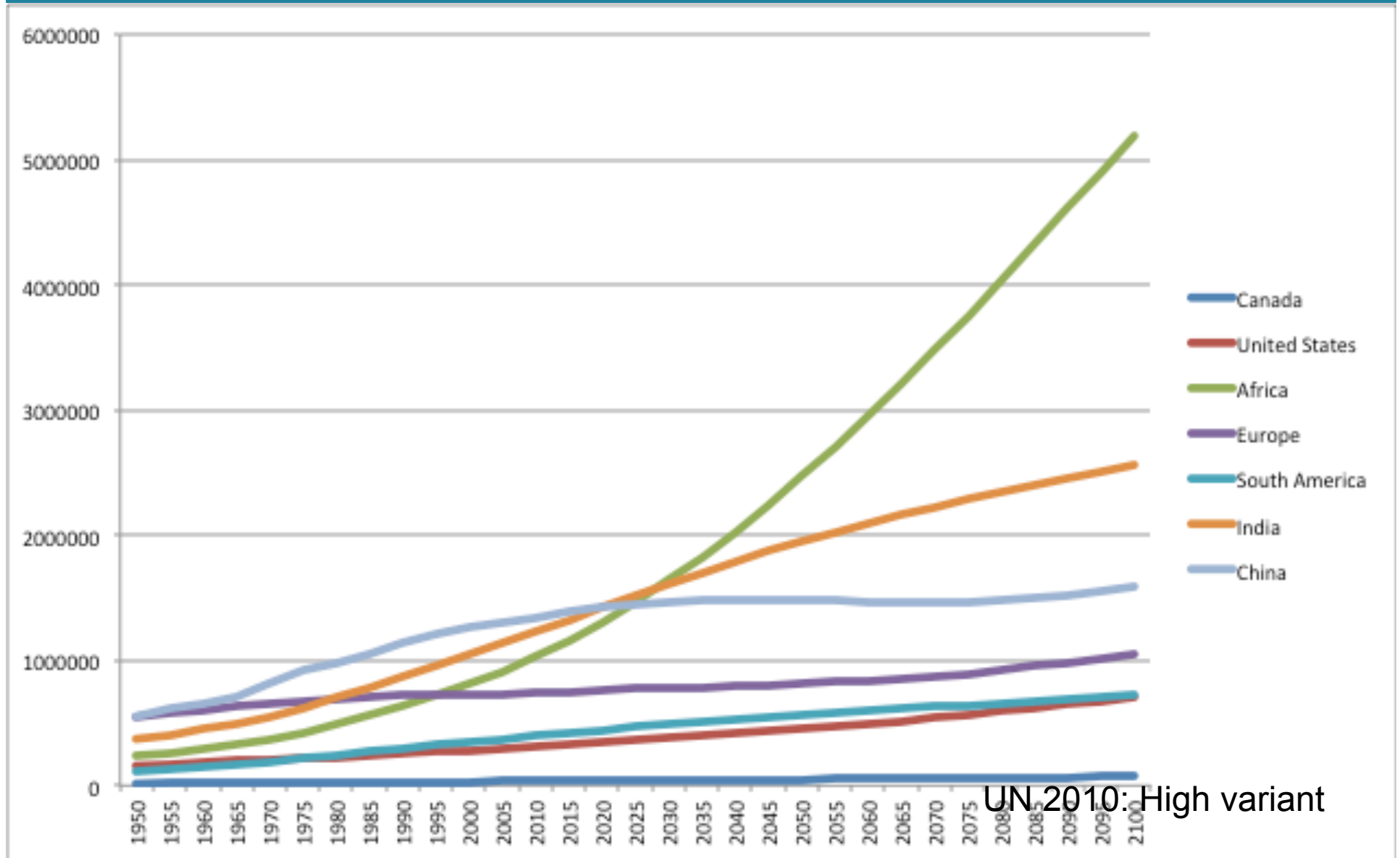
UN Population Estimates (2010): Medium Variant
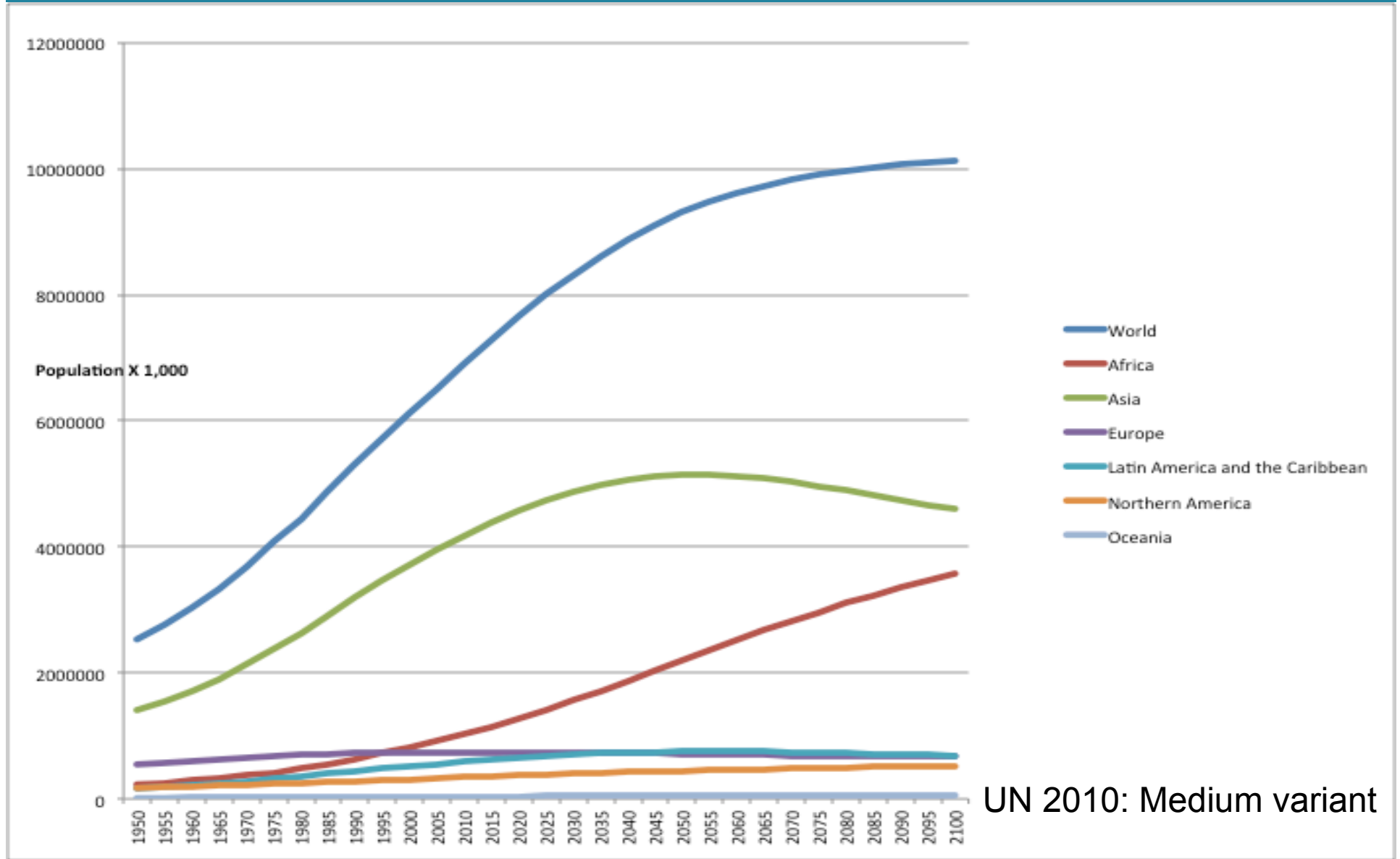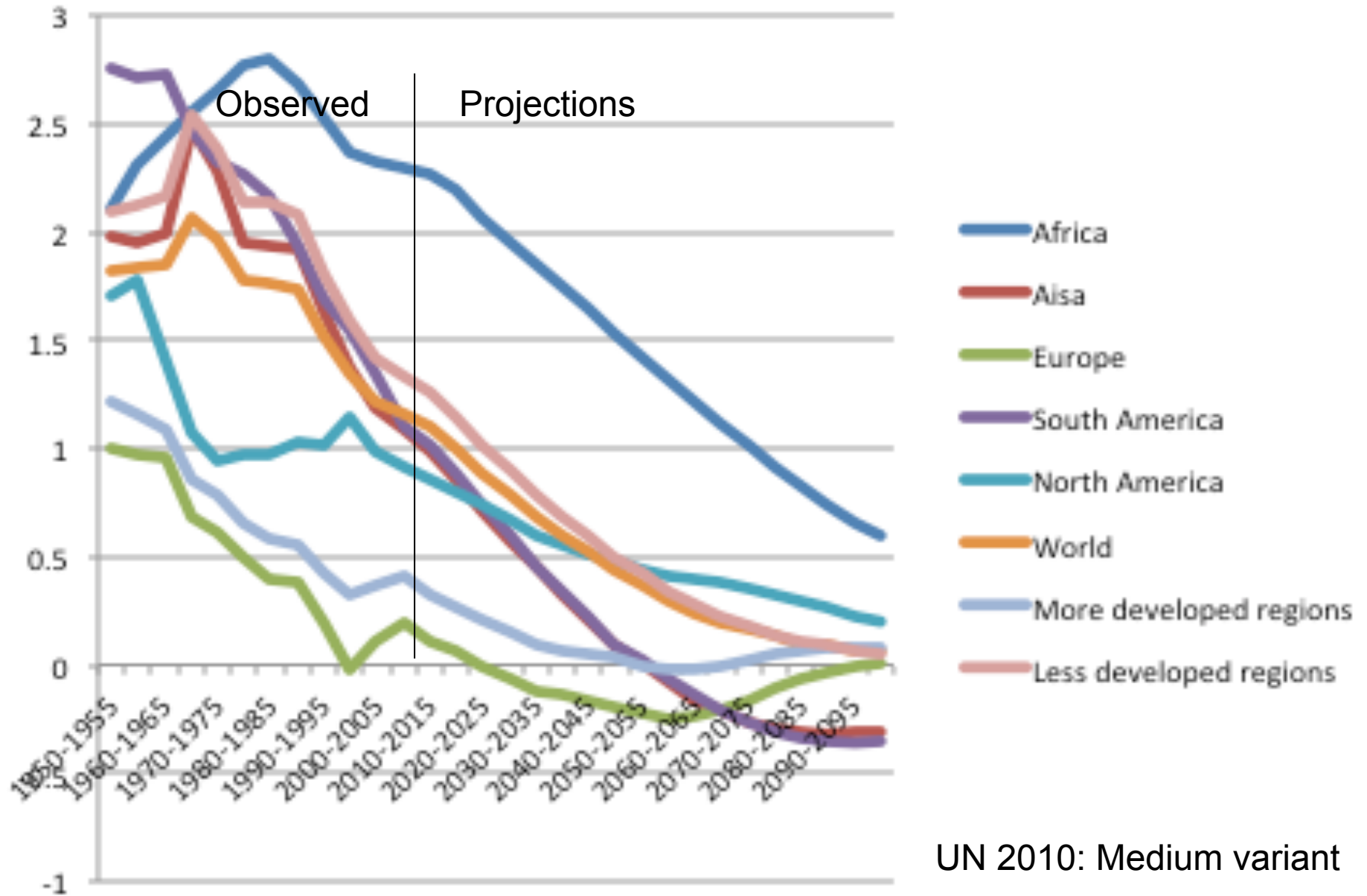

UN 2010: Medium variant

UN Estimates of Population (2010): Medium Variant

UN 2010: Medium variant

UN Estimates of Population (2010): High Variant

UN 2010: High variant

Comparison of Growth Rates (2010)

Observed | Projections

Legend:
- Africa
- Aisa
- Europe
- South America
- North America
- World
- More developed regions
- Less developed regions

UN 2010: Medium variant

Stabilization

- Long-term stabilization of the population occurs if the average number of children is ~2.1 per woman
- Stabilization depends on:
  - Previous birth rates (momentum)
  - Future birth rates
  - Survival (age-specific mortality rates)
 - Migration patterns (for specific countries)

Dynamics
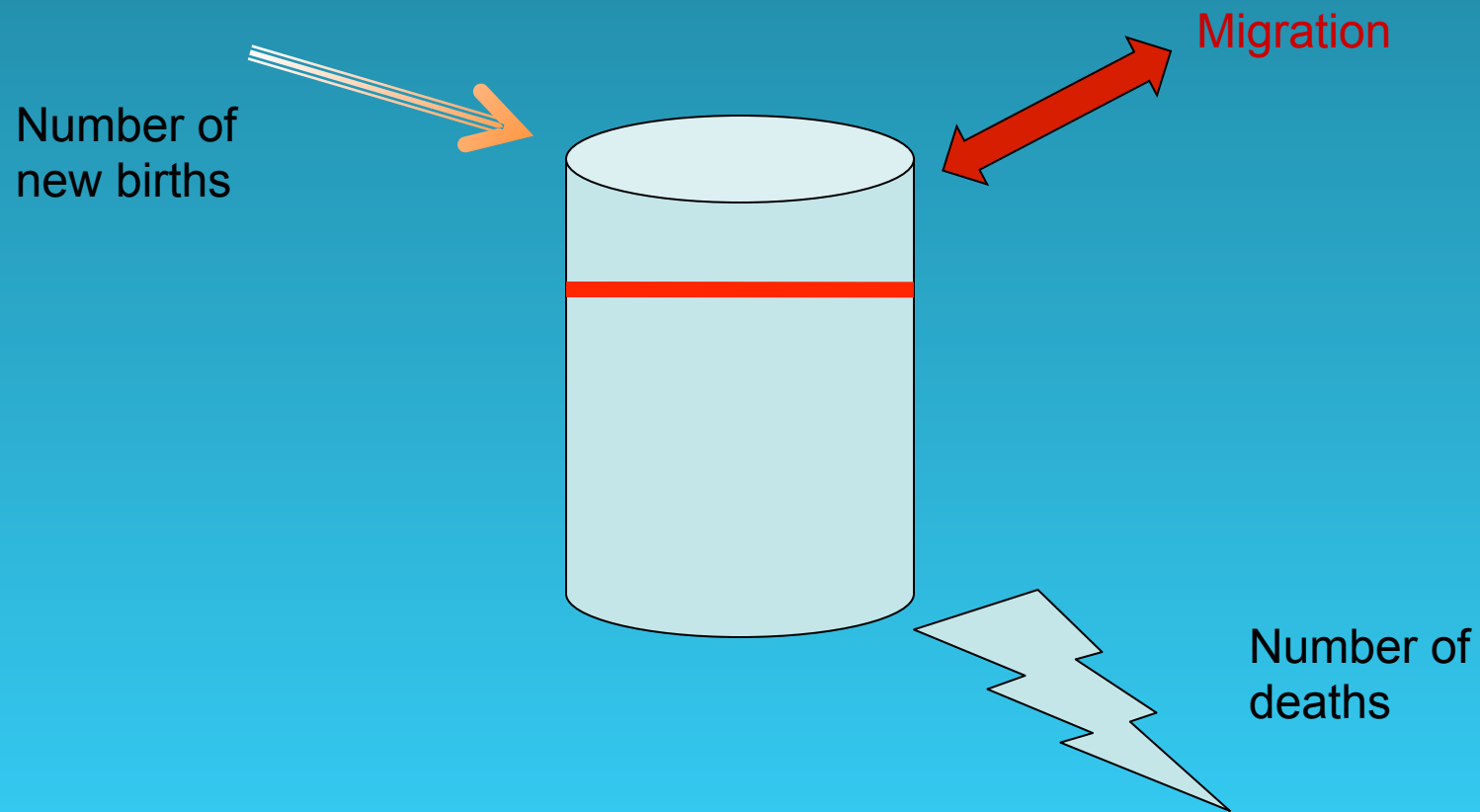
Some Demographic Factors Affecting Population Size

- Birth rate (total fertility rate)
  - Family planning / contraception
- Age-specific mortality rates
  - Lower age-specific mortality rates ➔ greater lifetimes
  - High infant and childhood mortality rates reduce adult populations
- Migration rates

Crude Mortality Rates (per 1,000)
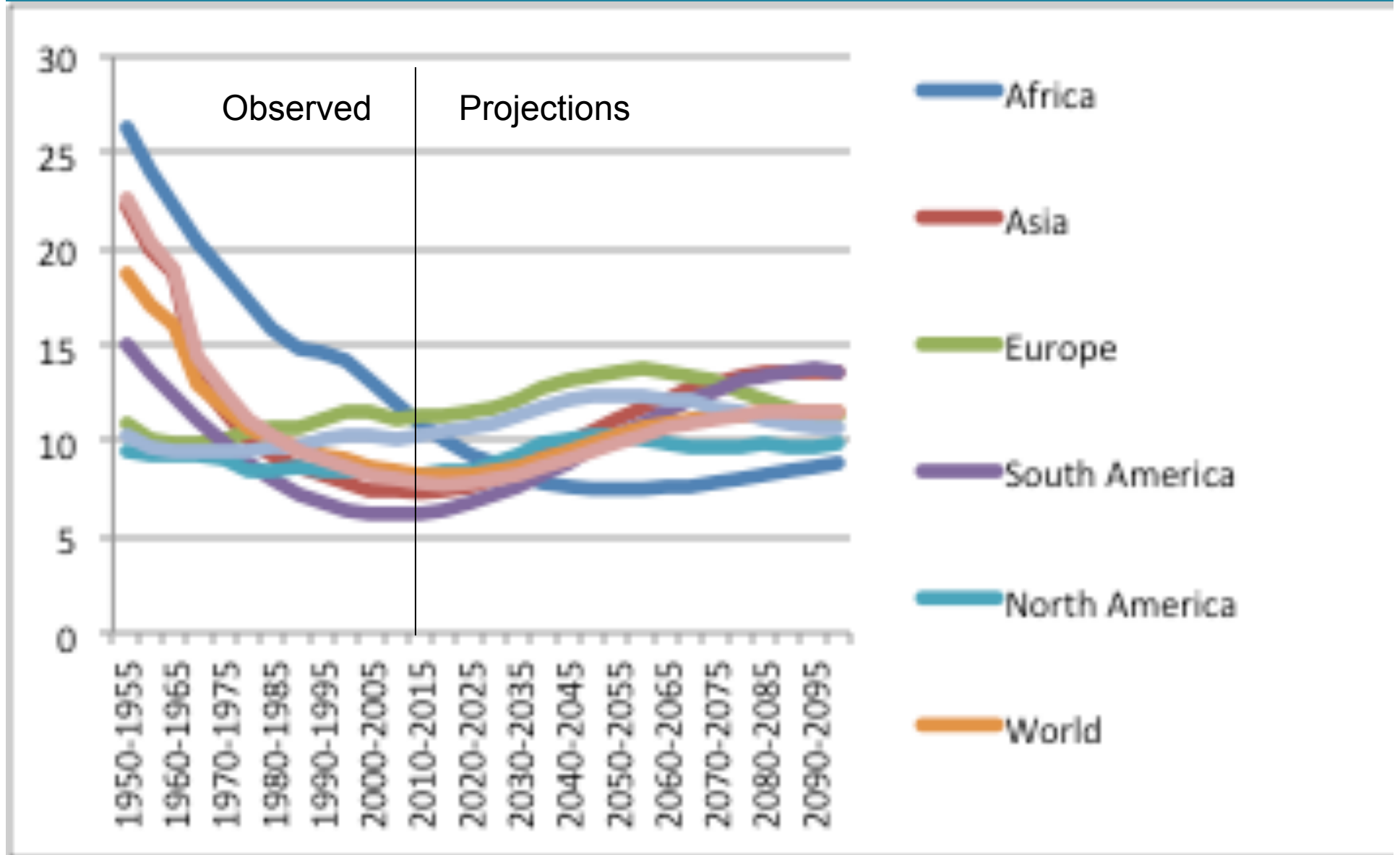
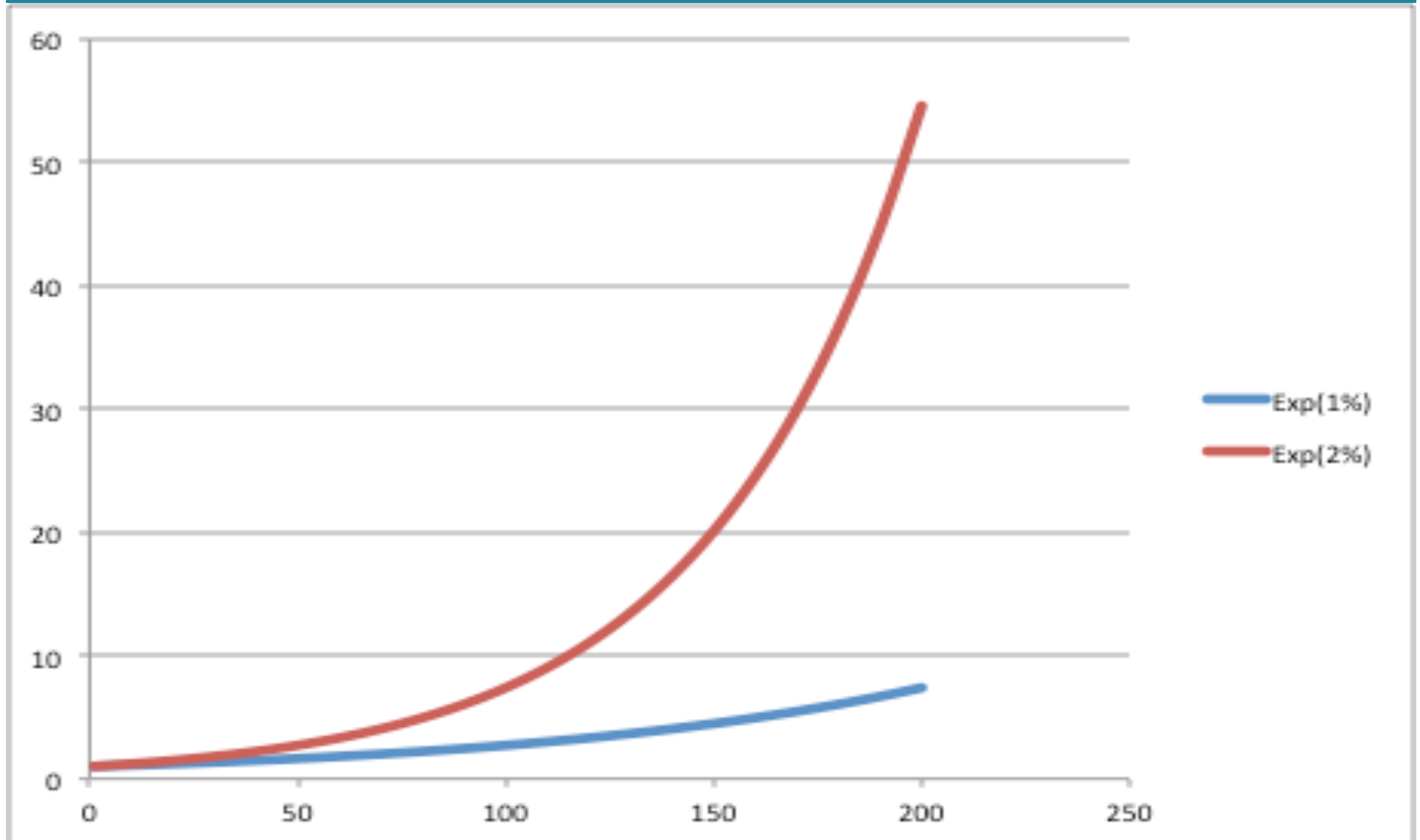# Comparison of Total Fertility Rates (2010): Medium Variant
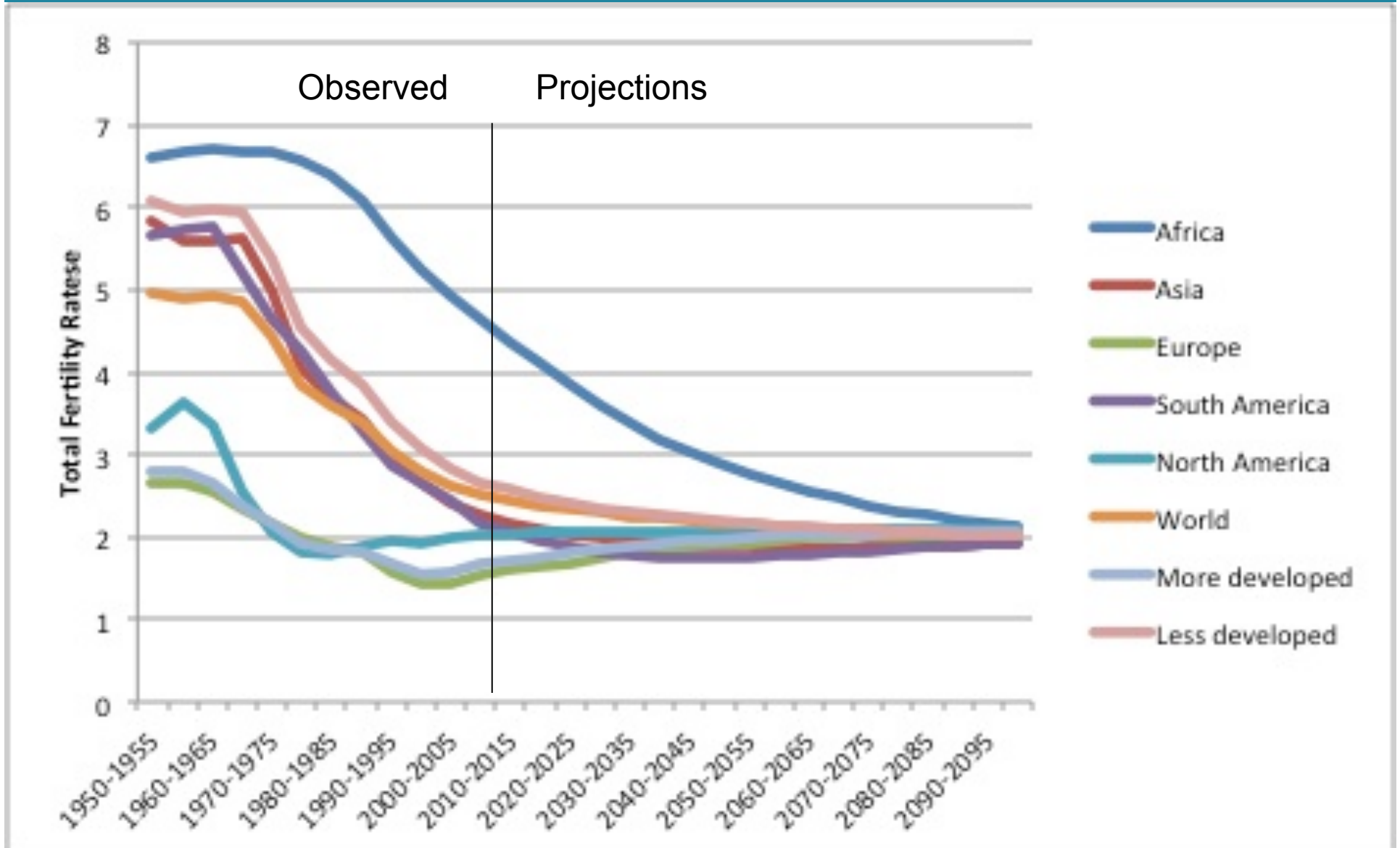
Projections of Population into the Future

Simple Projection Using the Growth Rate in 2012

- Current: 1.09% world growth rate (5-year average)

- 64 year doubling time: by 2076, 14 billion

- By 2100: 18.3 billion

- Assumptions:
  - Growth rate remains constant in time
  - Growth is exponential

Exponential Growth

Simple Projection Using a Constant Increment

## TABLE 3. POPULATION SIZE AND COMPONENTS OF GROWTH BY MAJOR AREA, 1995-2000

Major area	Population 1999 (thousands)	Births	Deaths	Net migration	Total growth
		(annual average, in thousands)			
World total	5 978 401	129 810	52 072	0	77 738
More developed regions	1 185 174	13 224	11 951	1 971	3 243
Less developed regions	4 793 227	116 586	40 121	-1 971	74 494
Africa	766 623	28 115	10 331	-287	17 496
Asia	3 634 279	77 953	27 492	-1 207	49 254
Europe	728 934	7 493	8 248	950	195
Latin America and the Caribbean	511 345	11 554	3 245	-471	7 838
Northern America	307 202	4 172	2 528	930	2 574
Oceania	30 018	527	227	81	381

Source: United Nations Population Division.

Simple Extrapolation of 1999 World Population Using Average, Annual Excess Births over Deaths (77,738,000 (1.3% growth rate))

- $\text{Population}_{2009} = \text{Population}_{2008} + 77,738,000$
- $\text{Population}_{2010} = \text{Population}_{2009} + 77,738,000$
- ………
- $\text{Population}_{2025} = \text{Population}_{2024} + 77,738,000$
- Assumptions:
  - Constant increment in population
  - All rates are constant across time
  - Does not account for aging population

Simple Extrapolation of 1999 World Population Using Excess Births over Deaths (average annual growth 77,738,000 (1.3% growth rate 1995-2000))
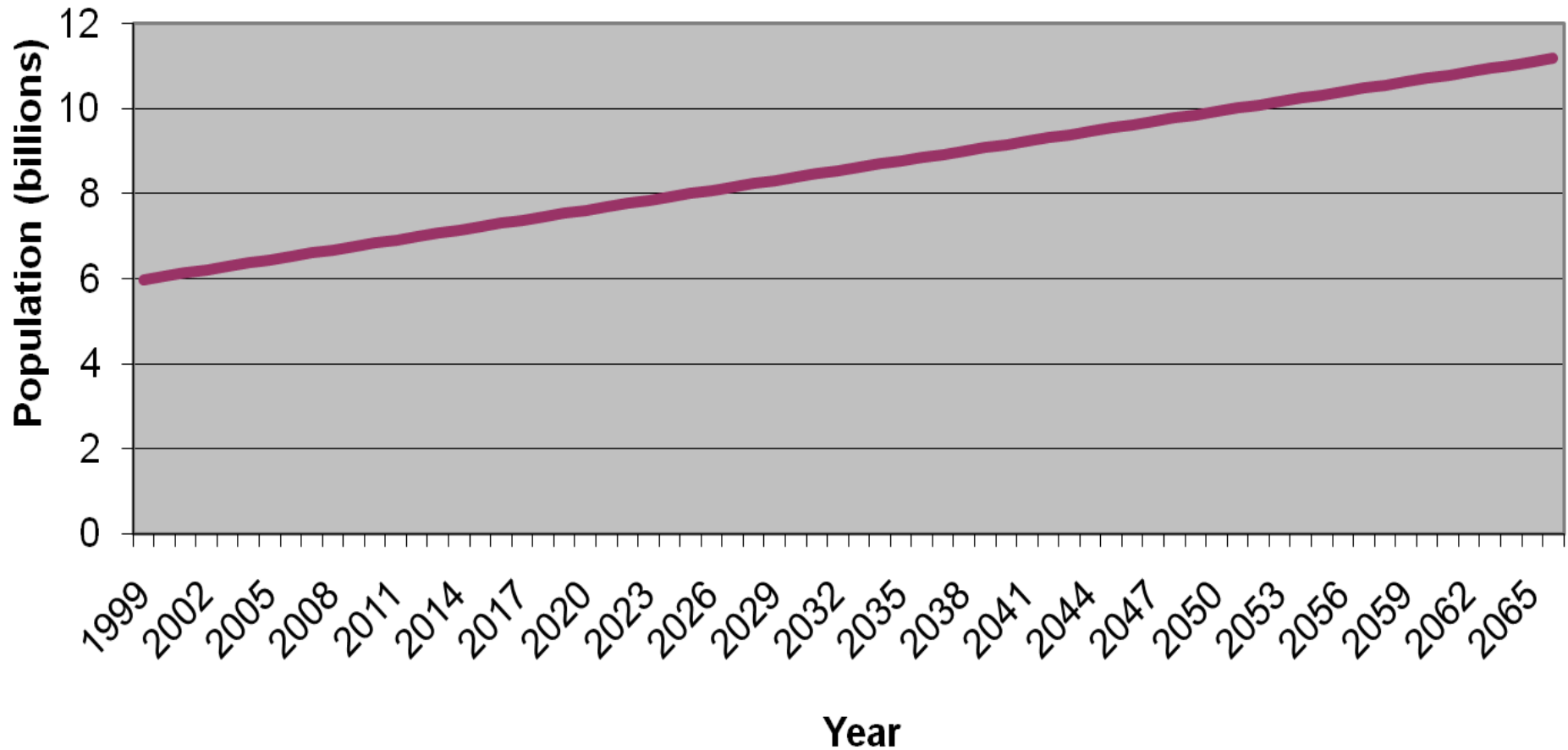
This simple projection gives 10 billion people in 2050

Extrapolations Using Trends

- Use linear regression to estimate the best fitting straight line to the graph of population by year

- Using the estimate slope (increase in population per year) to project into the future:

  – Projected population = Slope X no. of years in the future

Extrapolations using Trends

TABLE 1. WORLD POPULATION MILESTONES

Population		Year	
	World population reached		
1 billion in		1804	
2 billion in		1927	(123 years later)
3 billion in		1960	(33 years later)
4 billion in		1974	(14 years later)
5 billion in		1987	(13 years later)
6 billion in		1999	(12 years later)
	World population may reach		
7 billion in		2012	(13 years later)
8 billion in		2026	(14 years later)
9 billion in		2043	(17 years later)

Source: United Nations (2001a).
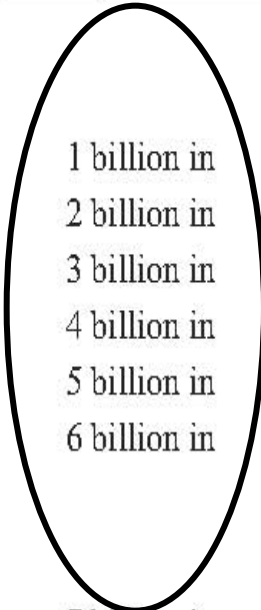
Results of regression model (natural logarithm of population). Expected population (billions) in:

2050	7.9
2100	12.3

Comparison of Simple Projections for the World Population (billions)

Projection Model	2050	2100
Constant 1.09% growth rate from 2010	10.7	18.4
Constant increment of births-deaths, using 1999 data	9.9	13.8
Regression model using historical trends (natural logarithm of population versus time)	7.9	12.3

Simple Projections of Canadian and US Populations: Effect of Immigration

Simplified Calculations for Canada and the US

	Canada	US
2008 Population	33.3 million	304.5 million
Birth rate	11 per 1,000	14 per 1,000
Net immigration rate	7 per 1,000	3 per 1,000
Death rate	7 per 1,000	8 per 1,000
Net	11 per 1,000	9 per 1,000

Source: World Population Datasheet

Simplified versus UN Complex Projections (in thousands)

	Canada			US	
	Simplified (constant increase of 11/1000=1.1%)	UN Low/ medium/ high		Simplified (constant increase of 9/1000=0.9 %)	UN Low/ medium/ high
2025	40,106	37,228 38,585 39,941		354,599	337,475 349,758 362,041
2050	52,722	38,846 43,642 48,791		443,625	357,008 403,101 452,395

UN Estimates of the Net Migration Rates for the US (per 1,000) (Previous UN estimate)

Period	Medium variant	High variant	Low variant	Constant-fertility variant
2000-2005	4.4	4.4	4.4	4.4
2005-2010	3.9	3.9	3.9	3.9
2010-2015	3.4	3.4	3.5	3.4
2015-2020	3.3	3.2	3.4	3.3
2020-2025	3.2	3.0	3.3	3.1
2025-2030	3.1	2.9	3.2	3.0
2030-2035	3.0	2.7	3.2	2.9
2035-2040	2.9	2.6	3.2	2.8
2040-2045	2.8	2.5	3.2	2.7
2045-2050	2.8	2.4	3.2	2.7

Effect of Immigration: Comparison of Simplified Estimates (in thousands)

	Canada		US	
	With (1.1%)	Without (0.4%)	With (0.9%)	Without (0.6%)
2008	33,300		304,500	
2025	40,106	35,638	354,599	337,095
2050	52,722	39,379	443,625	391,474
% 2050: 2008	58.0%	18.3%	45.7%	28.6%

US Population, by Variant
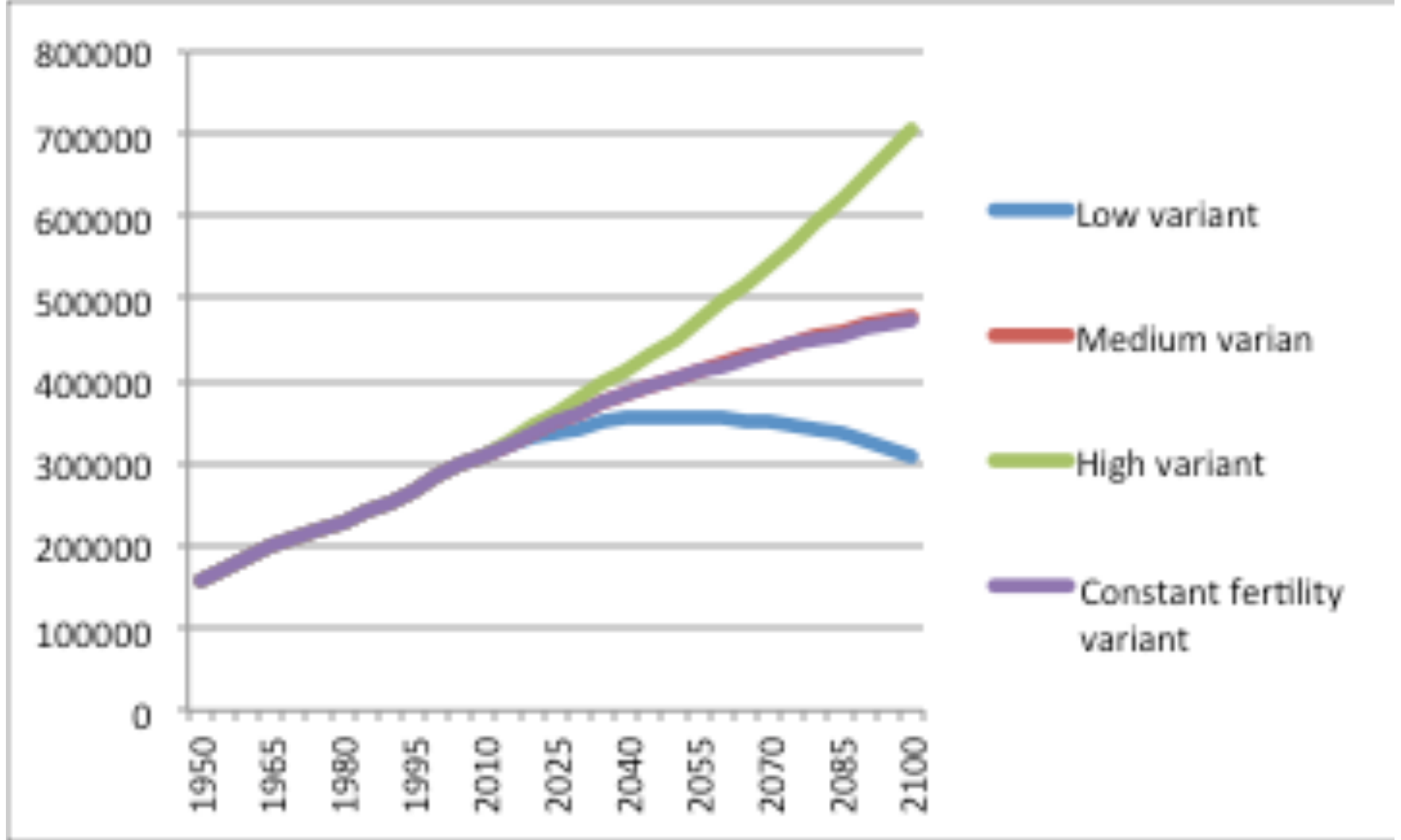
Canadian Population, by Variant
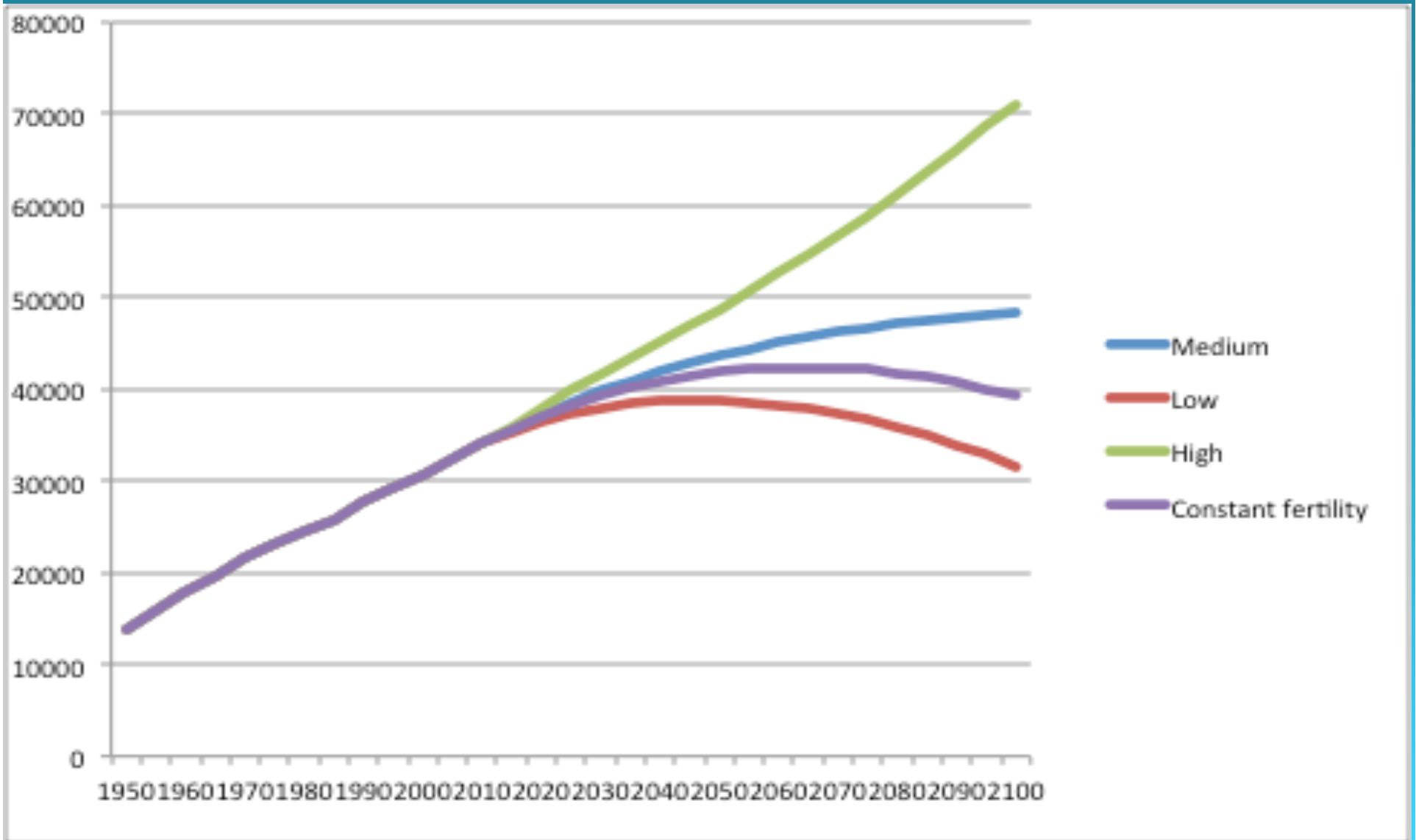
Continued Population Growth Sets the United States Apart From Other Developed Countries Around the World

**Percent Change in Population, Selected Countries: 2008-2050**

Country	Percent Change
United States	44
Canada	26
United Kingdom	26
France	13
Sweden	12
Italy	3
Spain	-6
Germany	-13
Russia	-22
Japan	-25

Source: Carl Haub and Mary Mederios Kent, *2008 World Population Data Sheet*.
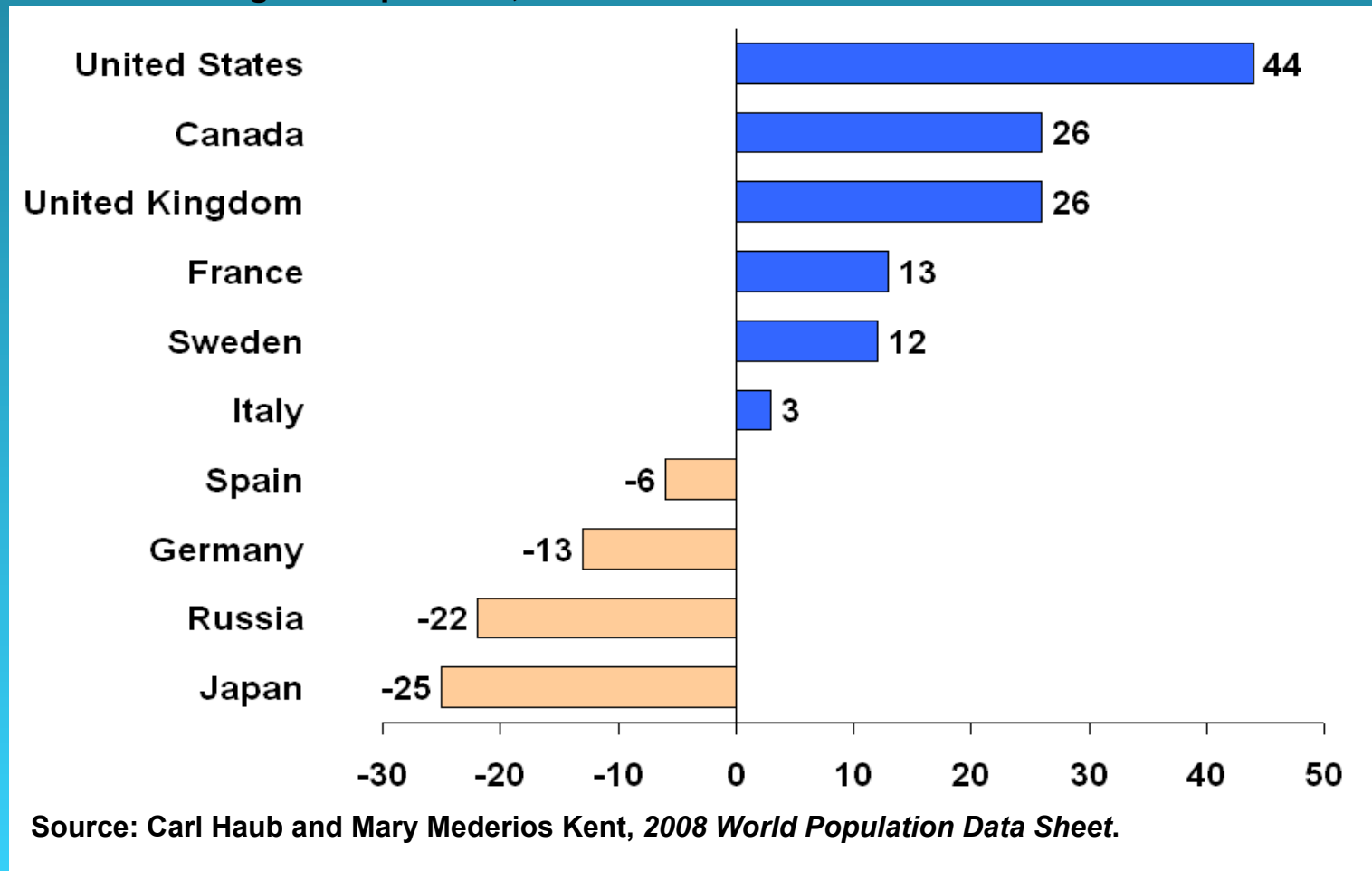
Problems with Simplified Projections

- Does not account for ageing populations
  - Mortality rates may vary in time (increasing life expectancy)
  - Mortality rates increase with age
  - High infant mortality rates can dramatically reduce populations
  - Mortality in childbearing also an important factor

- Changing fertility rates
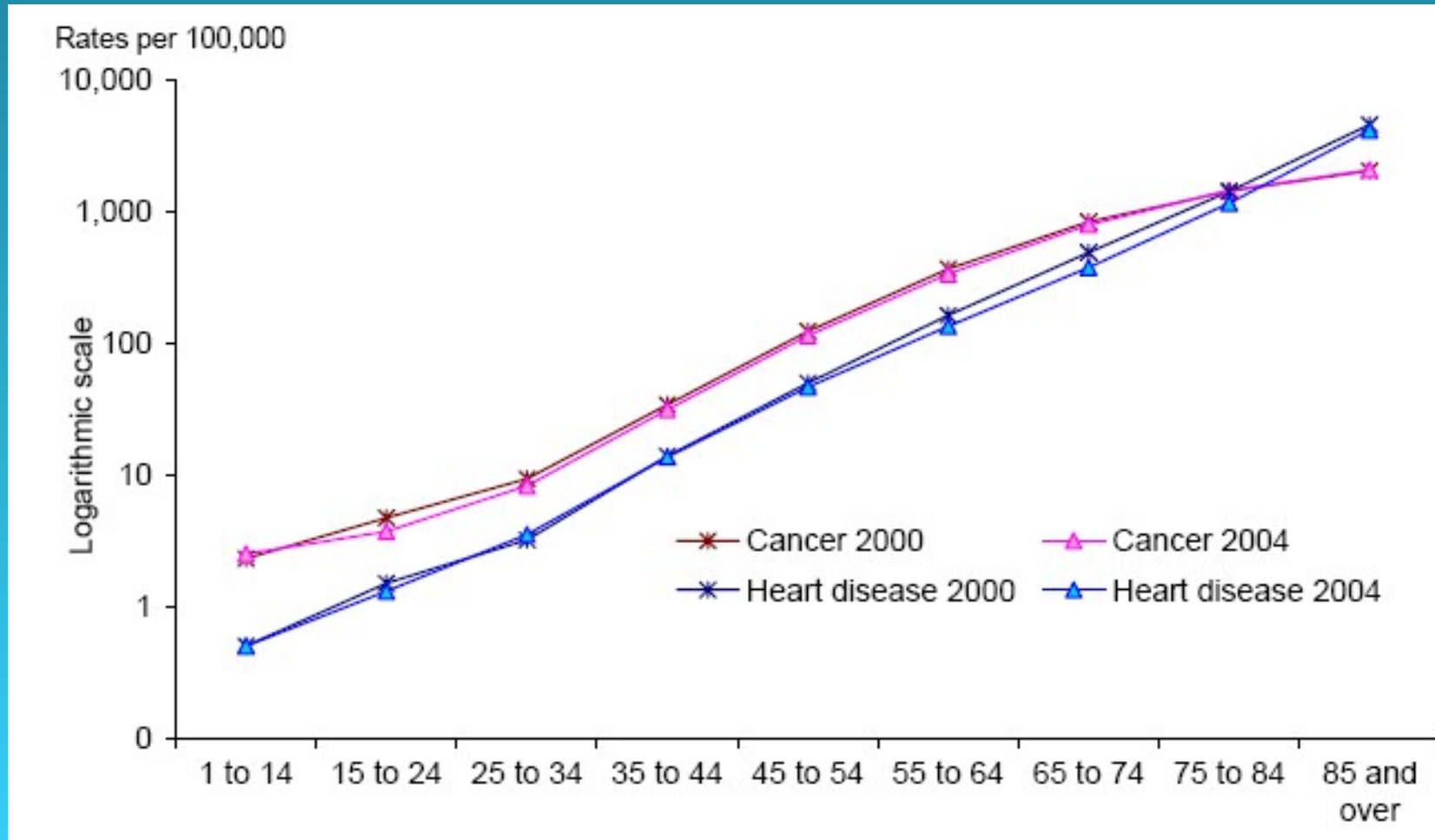
- Changing net immigration rates

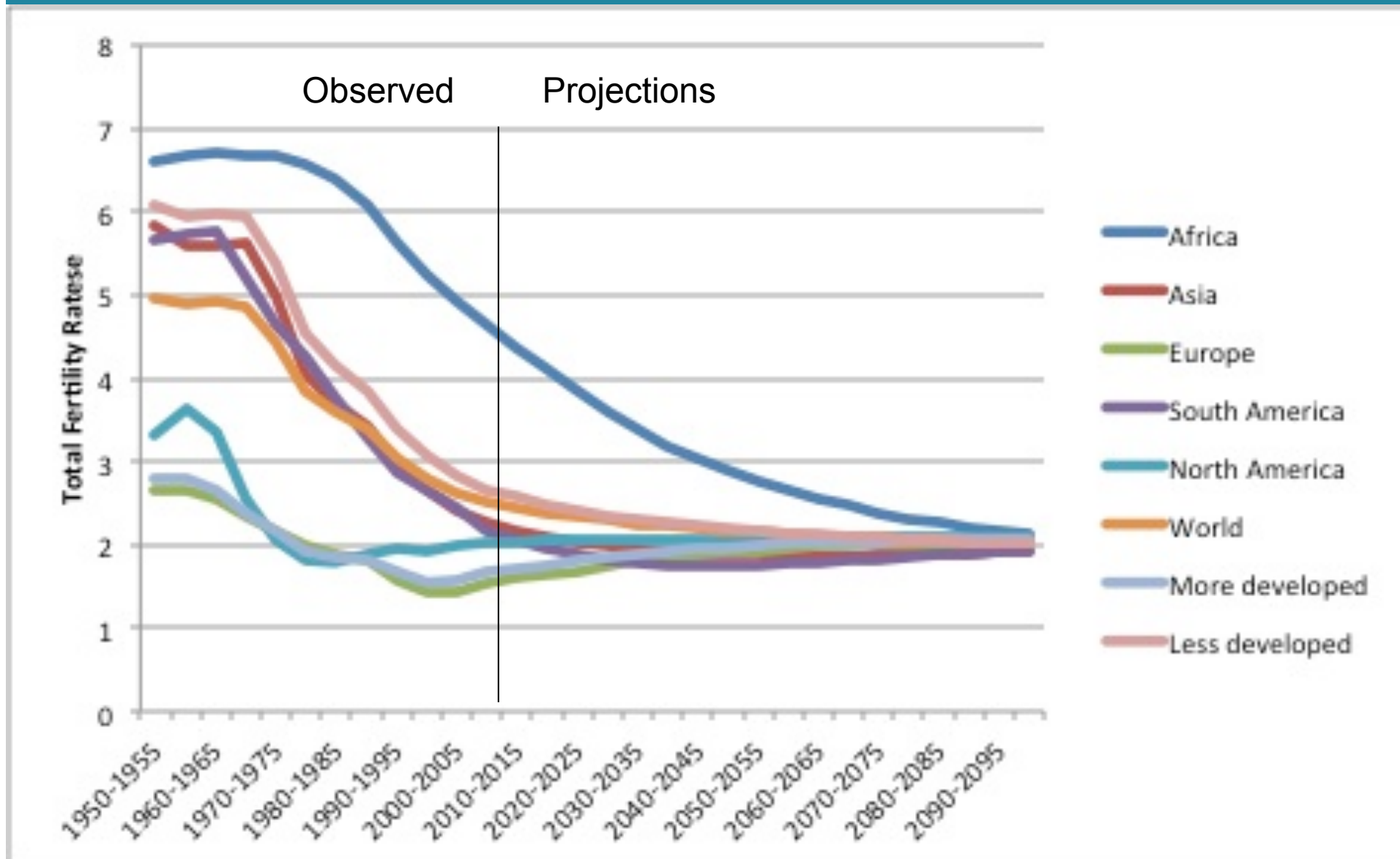# Slightly more realistic estimates: Factors considered by the UN and in other estimates

Dynamics

Number of
new births

Migration

Number of
deaths
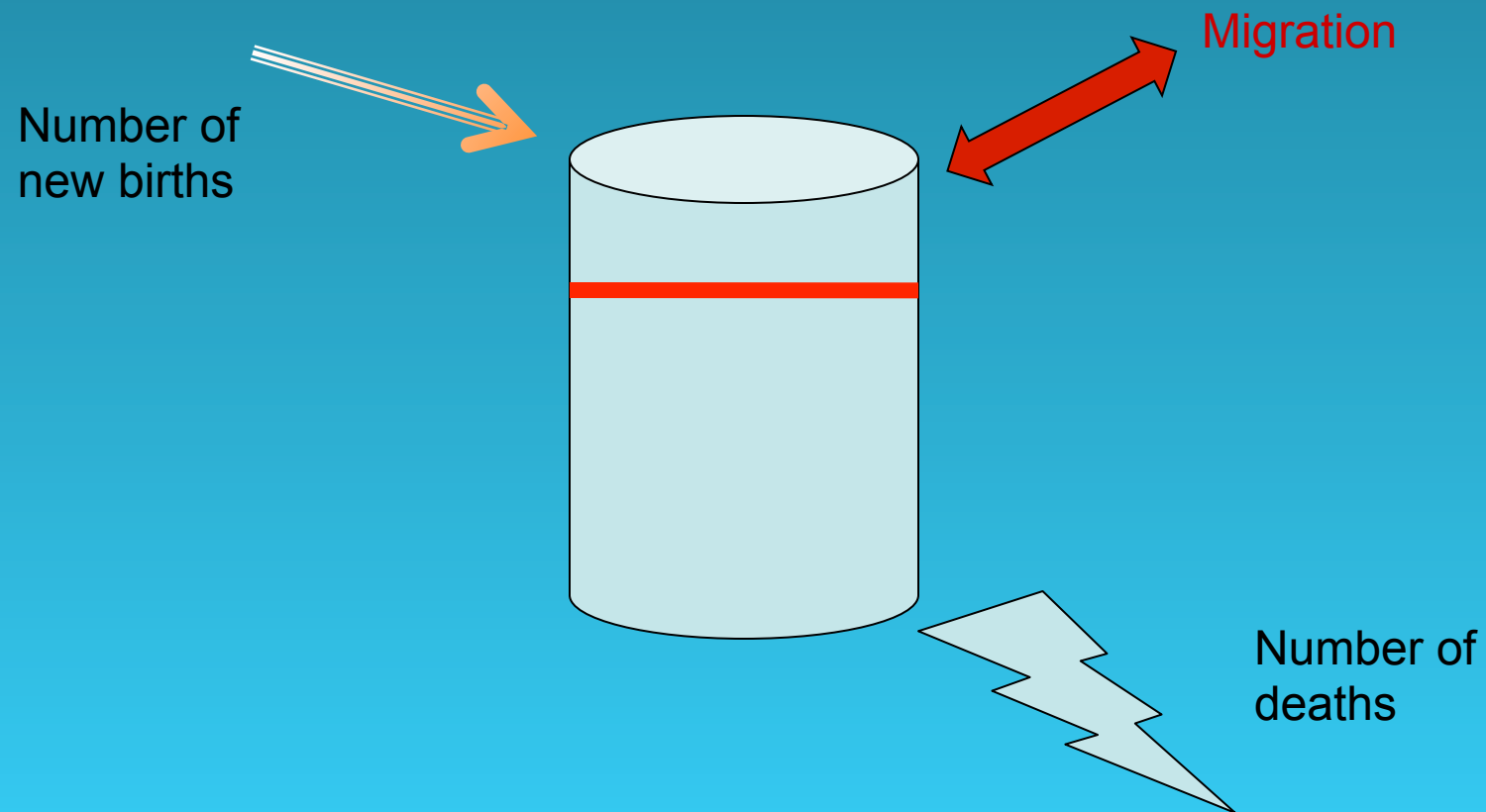
Canadian Age-specific Mortality Rates

Comparison of Total Fertility Rates: Medium Variant

Maternal Mortality

**A Woman's Lifetime Risk of Dying from a Pregnancy-Related Cause: 2005**

Developed Countries [1]	**1 in 7,300**
Eastern Asia	**1 in 1,200**
Latin America and the Caribbean	**1 in 290**
North Africa [2]	**1 in 210**
WORLD TOTAL	**1 in 92**
South Asia	**1 in 61**
Sub-Saharan Africa	**1 in 22**

[1] Excludes non-Baltic republics of the former Soviet Union.
[2] Excludes Sudan.

Source: WHO, UNICEF, UNFPA, and the World Bank, *Maternal Mortality in 2005: Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank.*
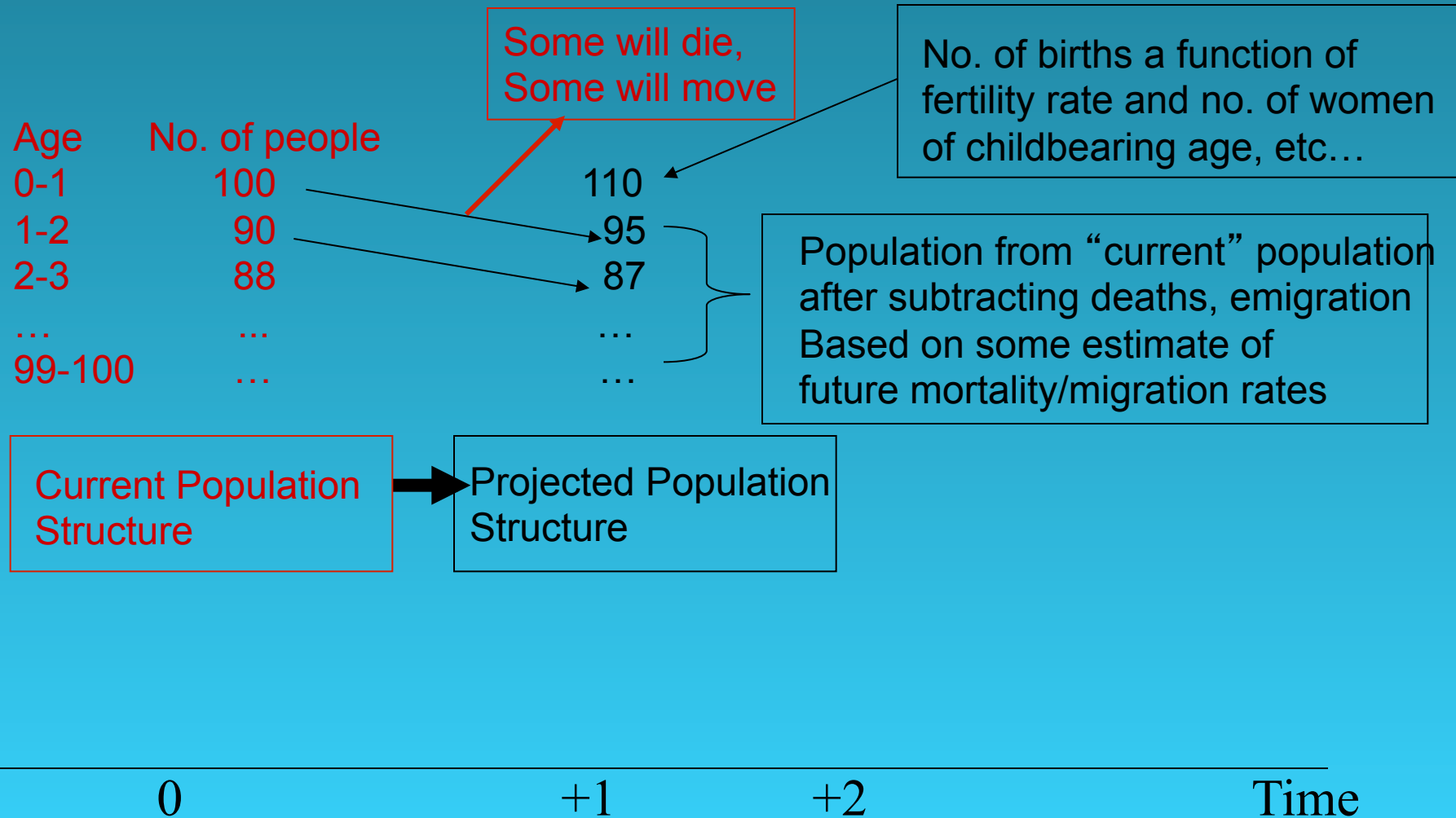
Infant Mortality Rates

Number of deaths per 1,000 live births
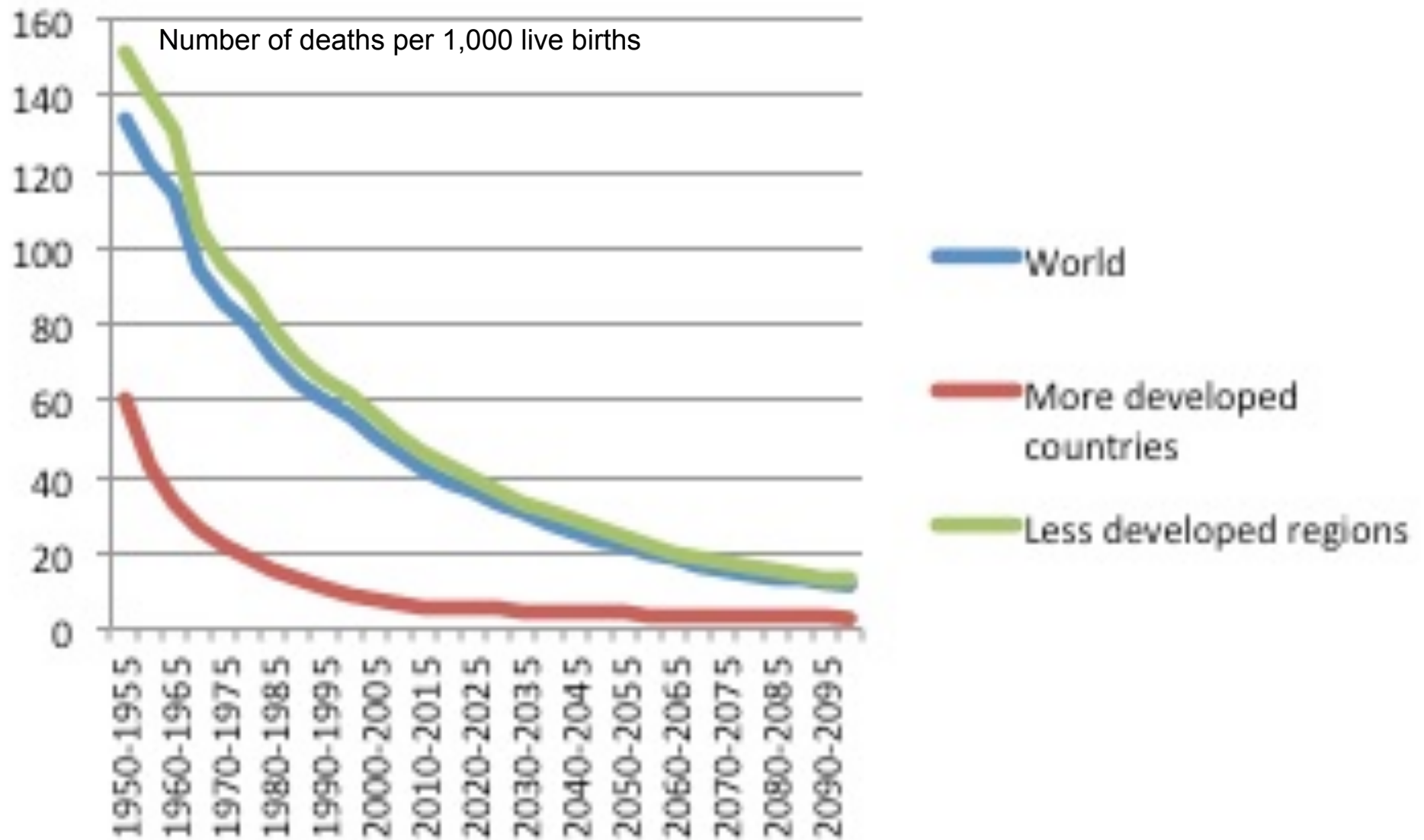
Infant Mortality Rates

- 1 Monaco 1.80
- 2 Japan 2.21
- 3 Bermuda 2.47
- 4 Singapore 2.31
- 5 Sweden 2.74
- 6 Hong Kong 2.90
- 7 Macau 3.17
- 8 Iceland 3.18
- 9 Italy, Spain, France 3.36
- 23 Switzerland 4.03
- 34 Australia 4.55
- 35 UK 4.56
- 41 Canada 4.85
- 44 Taiwan 5.10
- 45 Hungary 5.24
- 46 New Caledonia 5.62
- 48 Faroe Islands 5.94
- 49 United States 5.98

Conceptualization of Population Projection Models

Some will die,
Some will move

No. of births a function of fertility rate and no. of women of childbearing age, etc…

Age	No. of people
0-1	100
1-2	90
2-3	88
…	…
99-100	…

110
95
87
…
…

Population from "current" population after subtracting deaths, emigration
Based on some estimate of future mortality/migration rates

Current Population Structure

Projected Population Structure

0   +1   +2   Time

Factors Used in the Projections

- Start with:
  - Current population (by country, age, sex)
- Project:
  - Current fertility rate, by country
  - Age-, sex-specific mortality rates, by country
  - Age-specific migration rates

Assumptions in UN Projections

- Mortality rate and lifespan
  - UN mortality assumption: increasing life expectancy except when affected by HIV/ AIDS

Fertility

- UN "medium variant model" is assumed to converge by 2045-2050 to slightly above 2 children per woman (from 2.6 today; ~5 in 1950)

Assumptions in Fertility Transition

Figure 1: Schematic phases of the fertility transition
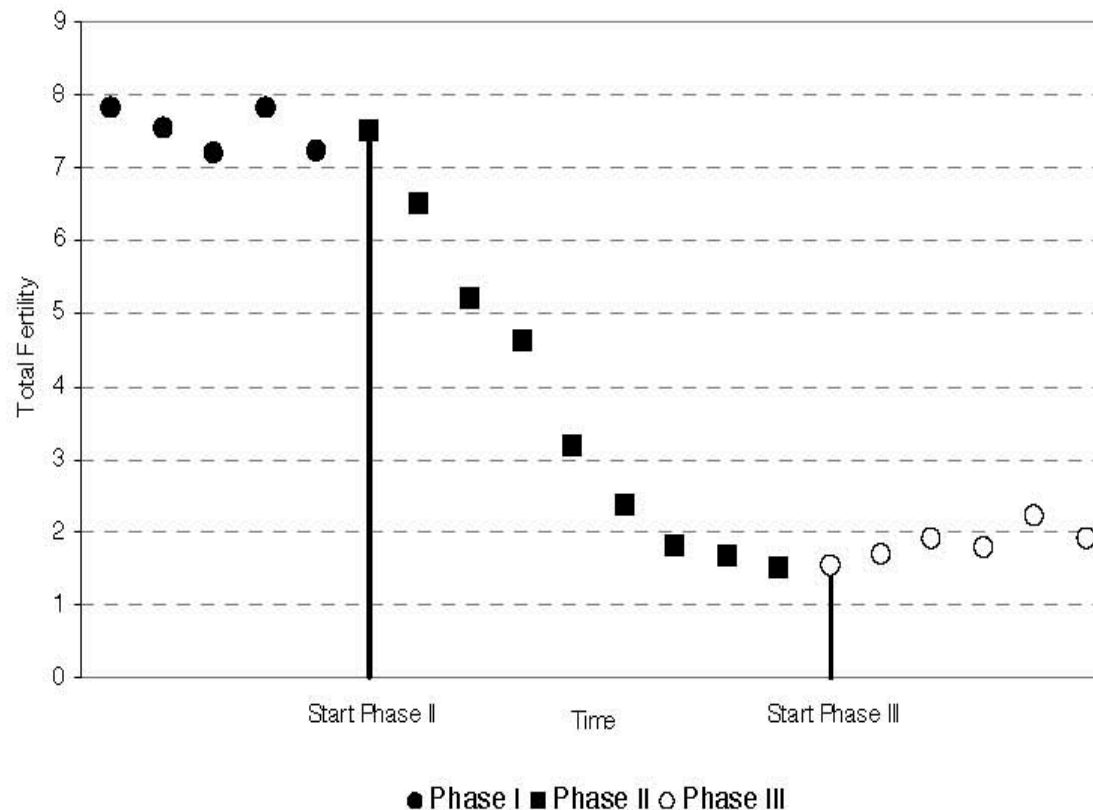
Phase I: Fertility is high and the fertility transition has not yet started. **Not modeled.**

Phase II. Fertility transition, modelled by double-logistic function using a Bayesian Hierarchical Model (BHM).

Phase III. Sub-replacement recovery, **modelled with a first order auto-regressive time series model (AR(1)).**

● Phase I ■ Phase II ○ Phase III

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2011). World Population Prospects: *The 2010 Revision*. New York: United Nations

Factors Used in the Projections

- International migration
  - *UN "normal-migration assumption*"
    - Future international migration based on past
    - Accounts for "national policies"
    - Net migration constant overtime
  - Key point: Mortality rates of immigrants approach mortality rates of the host country

Statistical Projections

- Assumes:
  - that countries will go through the "demographic transition" in a similar way
  - that countries close-by will "inform" the projections
  - that all countries in a region are in essence interchangeable
- Implication: if a country in a region is discrepant, the estimates for it will be made closer to the other countries

Factors Excluded (Joel Cohen)

- Excludes catastrophes
  - E.g., pandemic flu, tsunamis, tropical storms, catastrophic climate change

- "Holding capacity" of the land
  - E.g., world population density in 2007 is 48 persons/km^2
    - 2050: estimate will be 66 persons/km^2, and this will vary widely
      - Poor countries 93 persons/km^2 ; rich countries: 23 persons/km^2

Factors Excluded

- War and political instablity
- Food, water
- Housing
- Education
- Health
- Physical infrastructure
- Religion
- Laws
- Family structure
- Domestic and international order
- Environment and global warming

What Do Global Population Projections *Assume*?

"**Realization of the medium variant projections contained in the *2006 Revision* is also contingent on ensuring that fertility continues to decline in developing countries…To achieve such reductions, it is essential that access to family planning expands in the poorest countries of the world.**"

Source: United Nations Population Division, *World Population Prospects: The 2006 Revision.*

Total Fertility

1950-1955 estimate
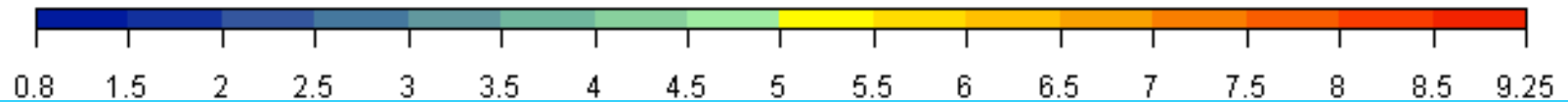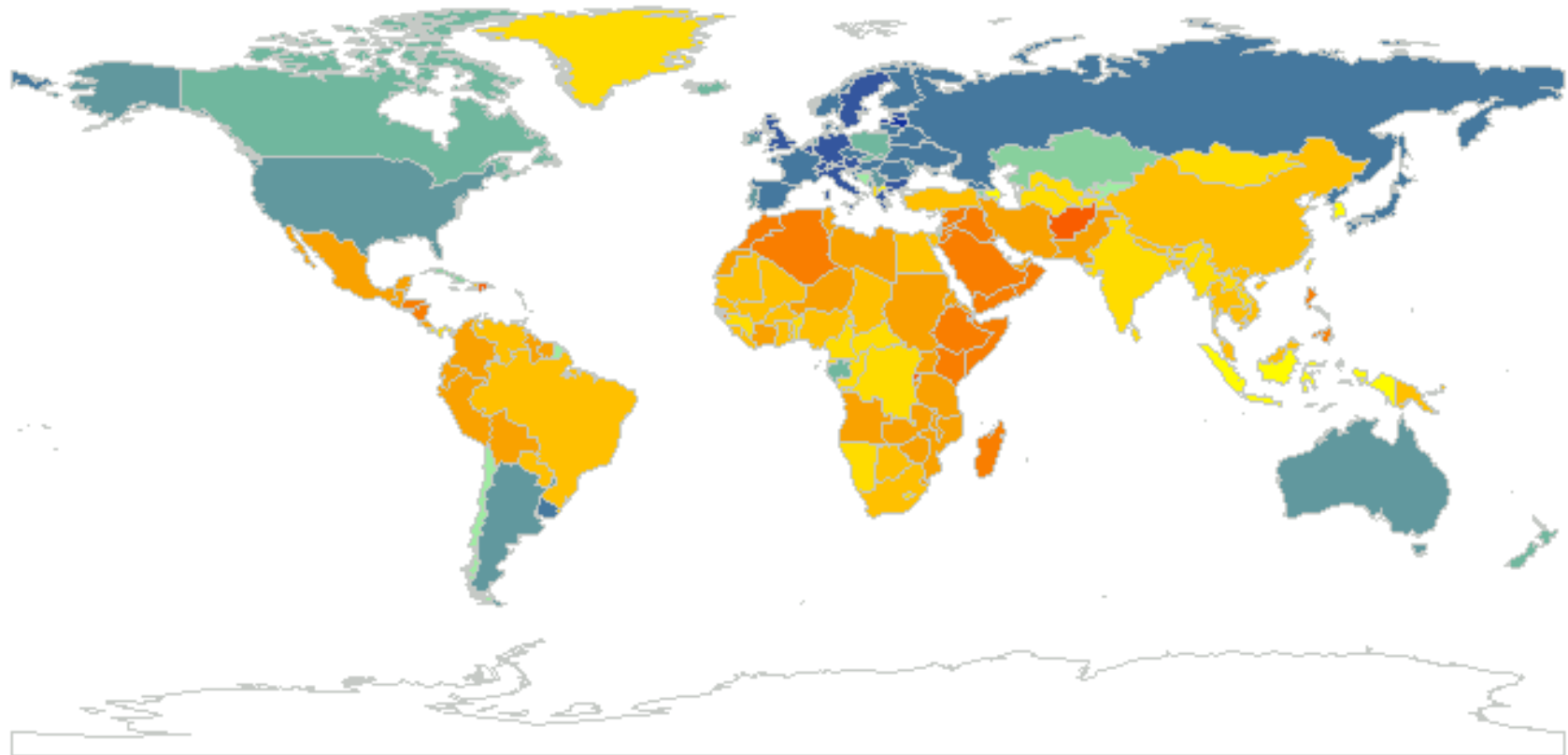
Total Fertility

2010-2015 median projection
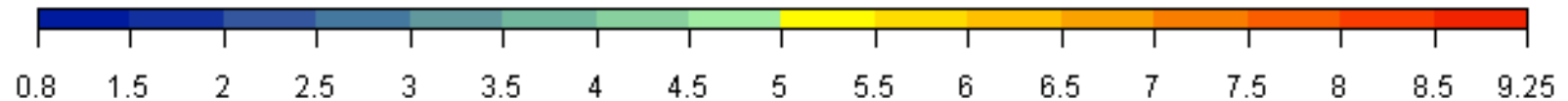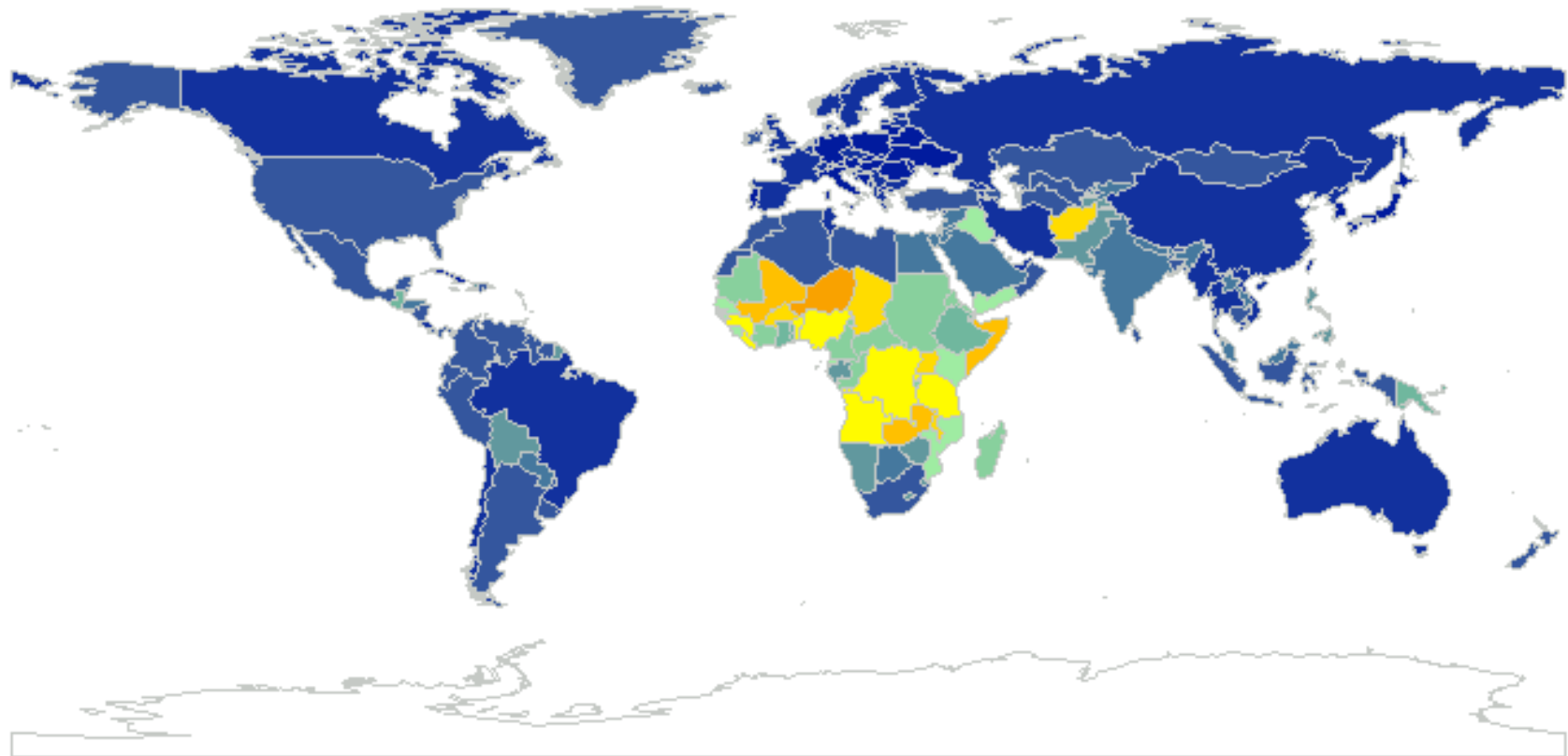
Total Fertility

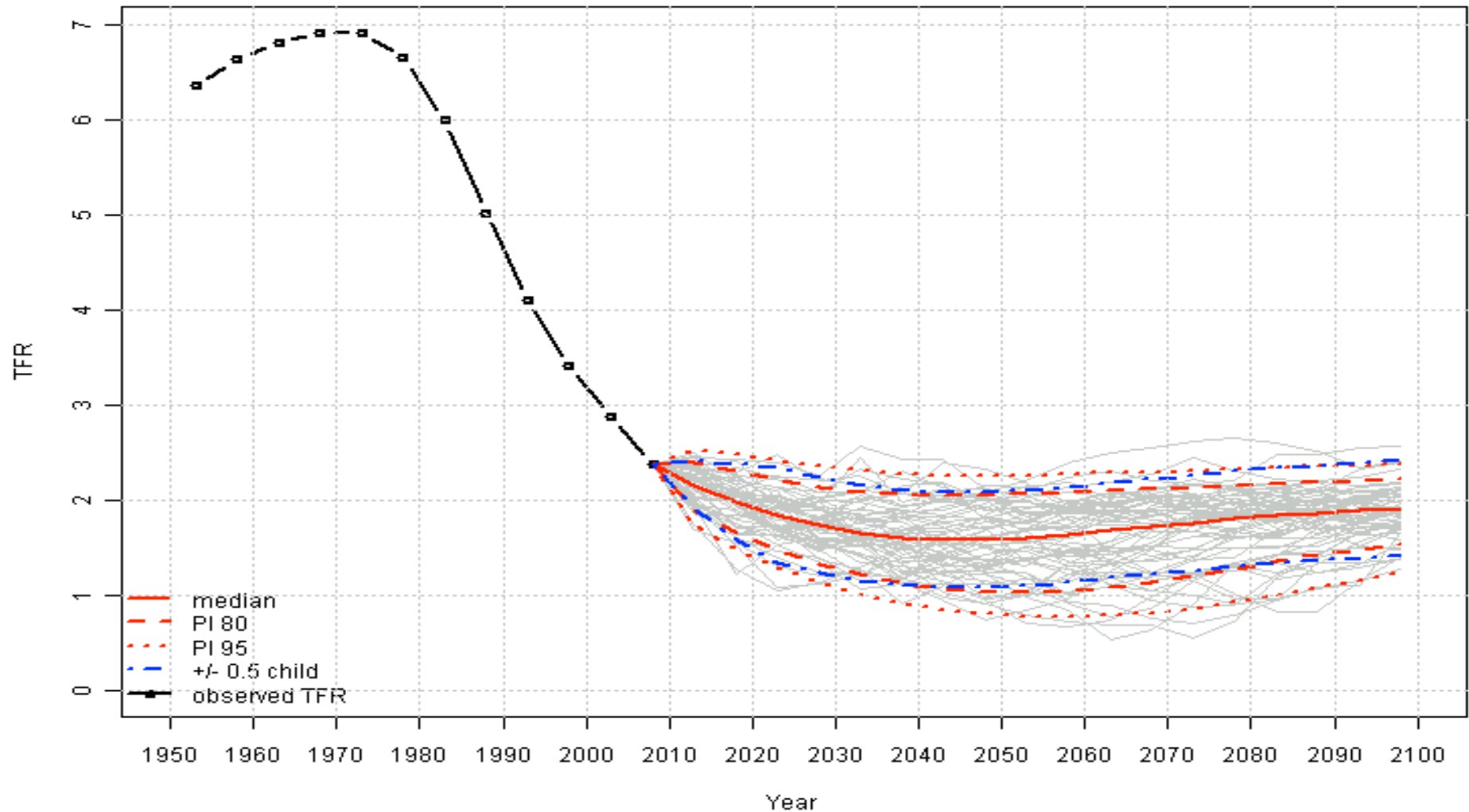
2045-2050 median projection
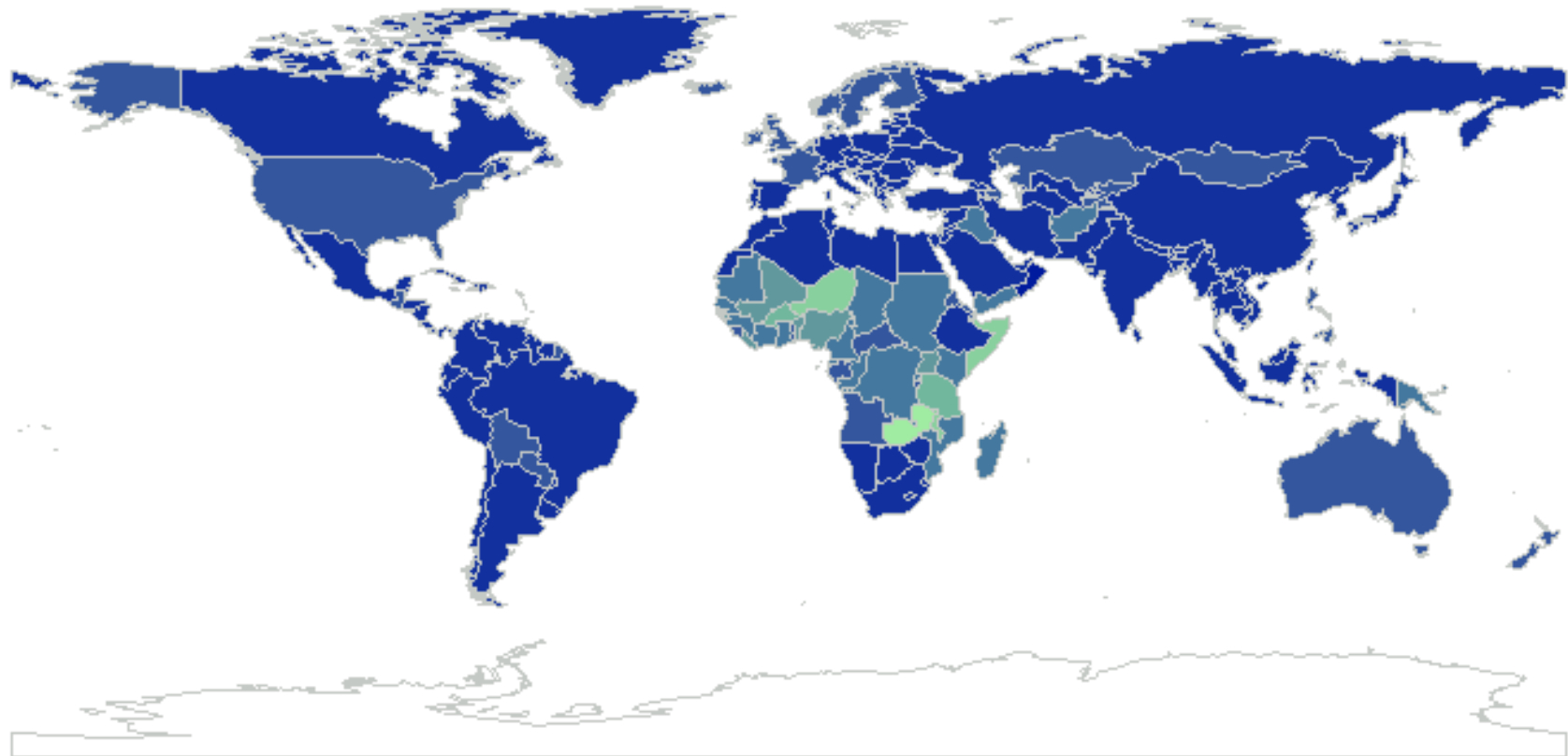
UN Probabilistic Projections of Fertility Rates in the US
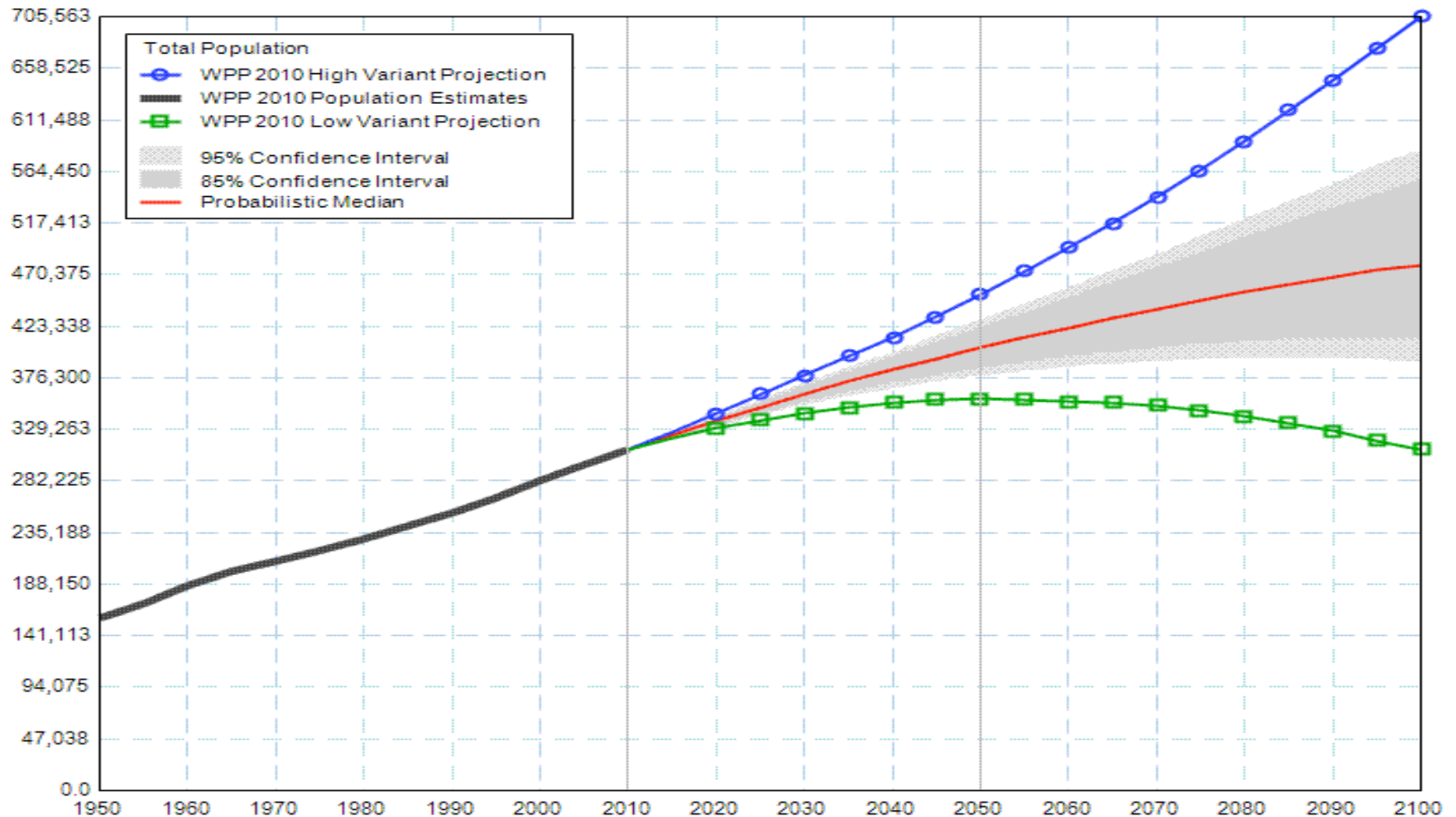

United States of America
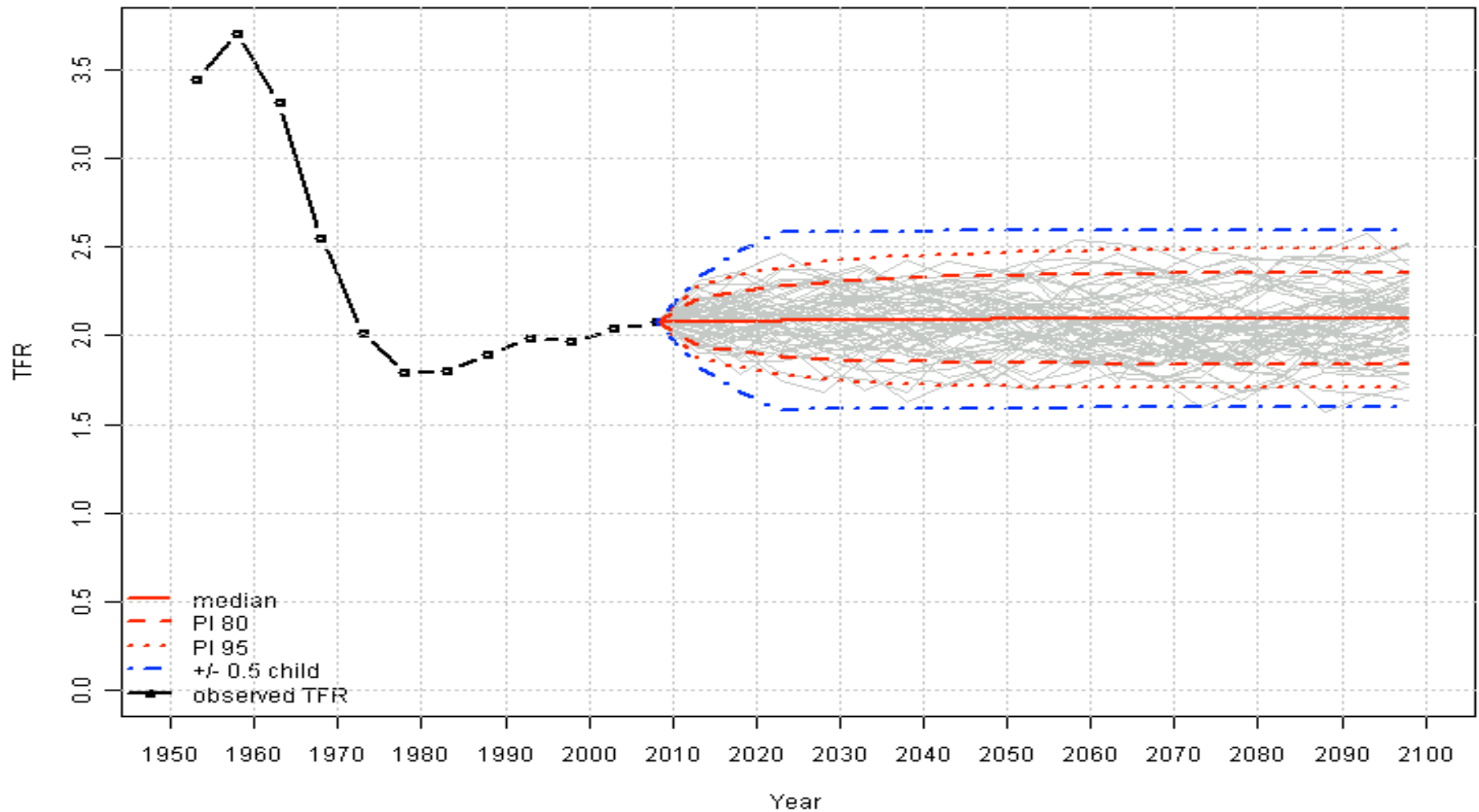
UN Probabilistic Projections of Fertility Rates in Bangladesh
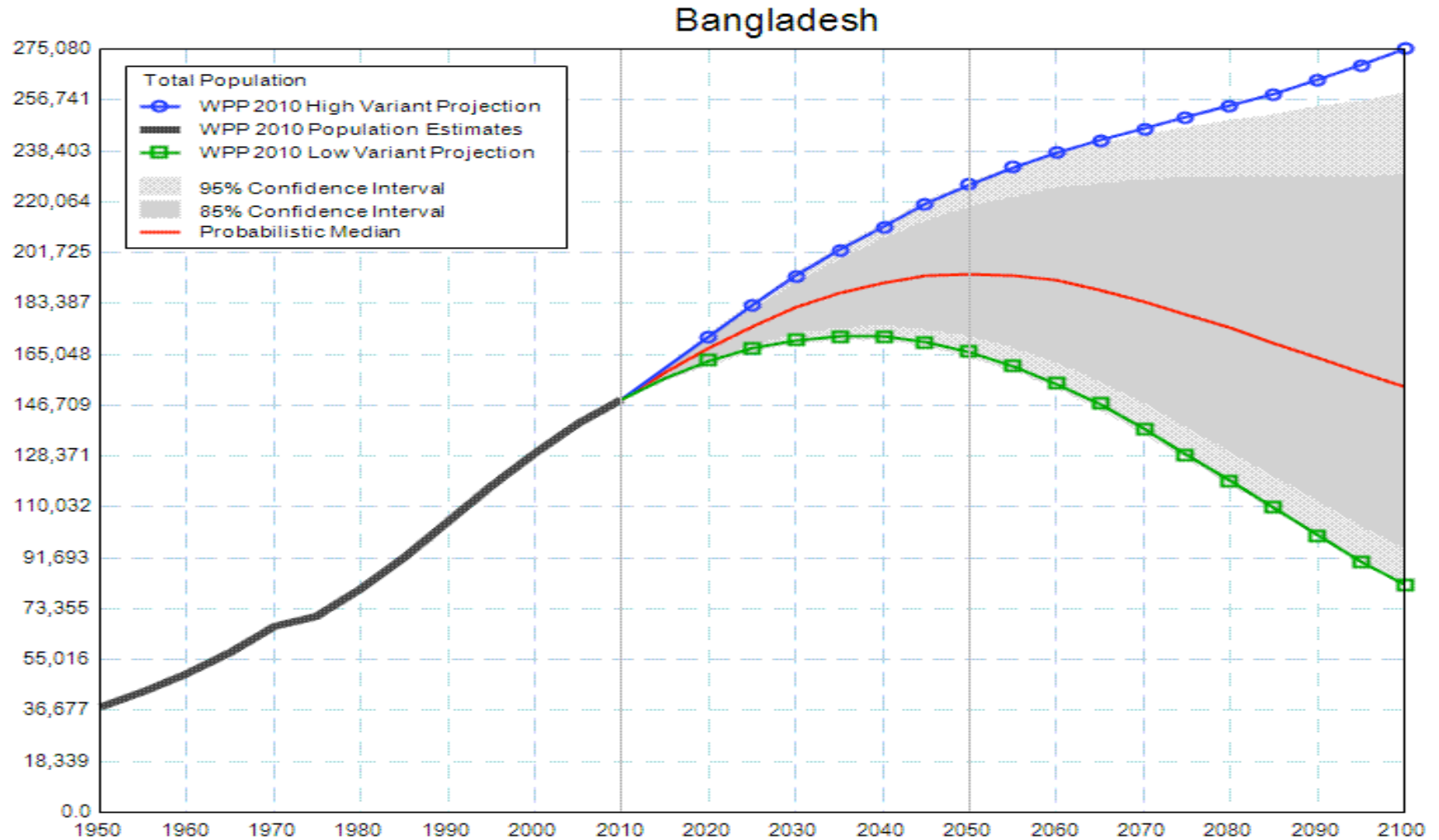

Bangladesh

# Probabilistic Population Projections for the US

United States of America

Probabilistic Population Projections for Bangladesh

Bangladesh

Total Population
- WPP 2010 High Variant Projection
- WPP 2010 Population Estimates
- WPP 2010 Low Variant Projection
- 95% Confidence Interval
- 85% Confidence Interval
- Probabilistic Median

United Nations Population Division. Chart created: 04/10/2011

Medium Variant Population Projections for the USA and Bangladesh
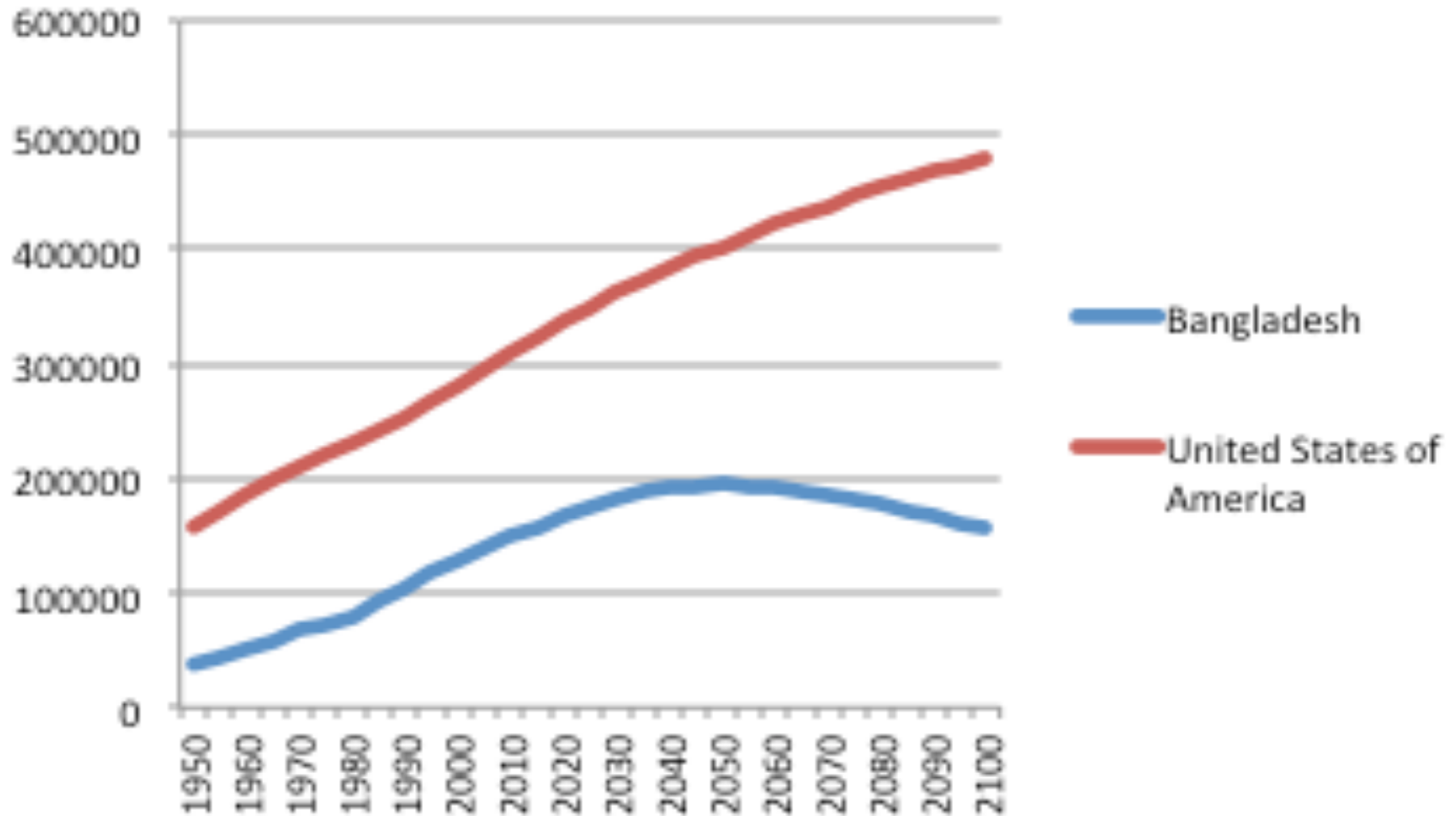
Comparison of Results from the Different Methods of Projections (billions)

| Projection Model	2050	2100
Constant 1.09% growth rate from 2010	10.7	18.4
Constant increment of births-deaths, using 1999 data	9.94	13.8
Regression model using historical trends	7.88	12.3
2010 UN estimates 　　Low 　　Medium 　　High 　　Constant fertility	 8.10 9.31 10.61 10.94	 6.18 10.12 15.80 26.84
Current population 7.0 billion		

Demographic Divide between Developed and Developing Countries
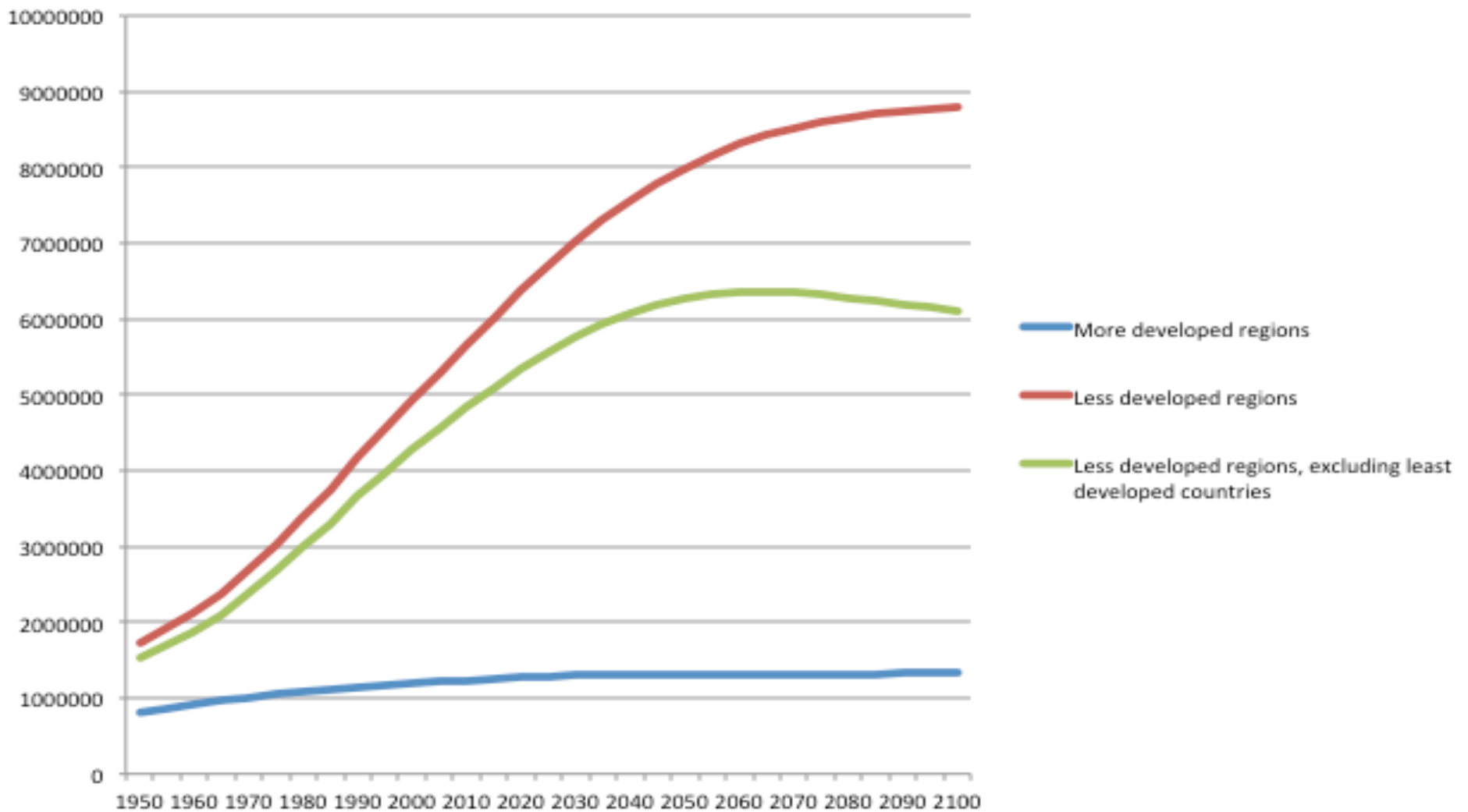
# Italy and the Democratic Republic of the Congo (formerly Zaire) Illustrate the "Demographic Divide"

	ITALY	DEM. REP. OF THE CONGO
2008 Population	**59.9 million**	**66.5 million**
2025 Population	**65.1 million**	**195.4 million**
Population below Age 15	**8.4 million**	**31.3 million**
Population Age 65 and Older	**11.9 million**	**1.7 million**
Annual Births	**568,000**	**2.9 million**
Annual Deaths	**575,000**	**843,000**
Annual Natural Increase *(births minus deaths)*	**- 7,000**	**2.1 million**
Annual Infant Deaths	**2,300**	**270,000**
Life Expectancy at Birth	**81 years**	**53 years**
Percent of Population Undernourished	**< 2.5%**	**74%**

Comparison of Population Projections between Italy and the Democratic Republic of the Congo
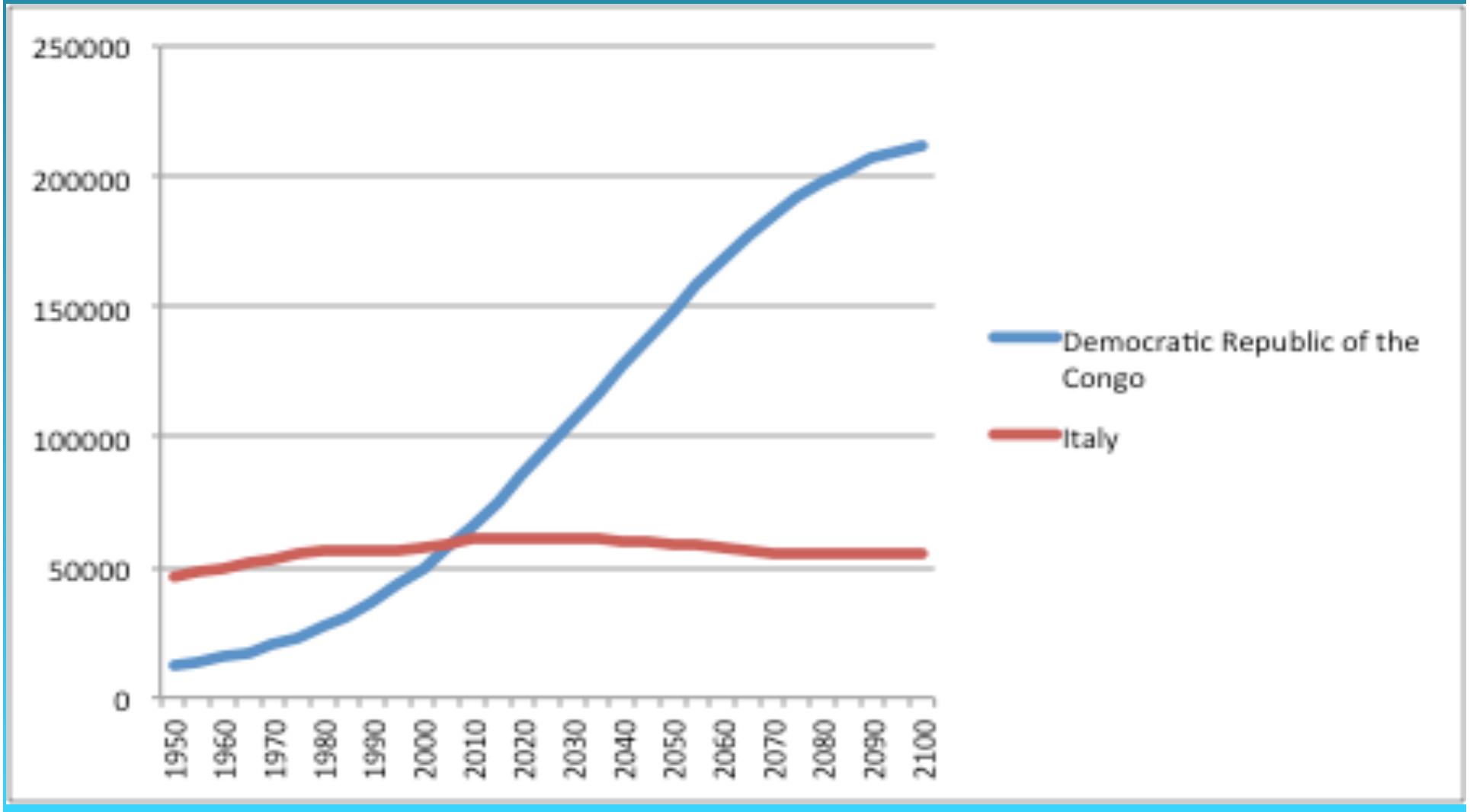
# Comparison of Italy and the Congo on Selected Indicators
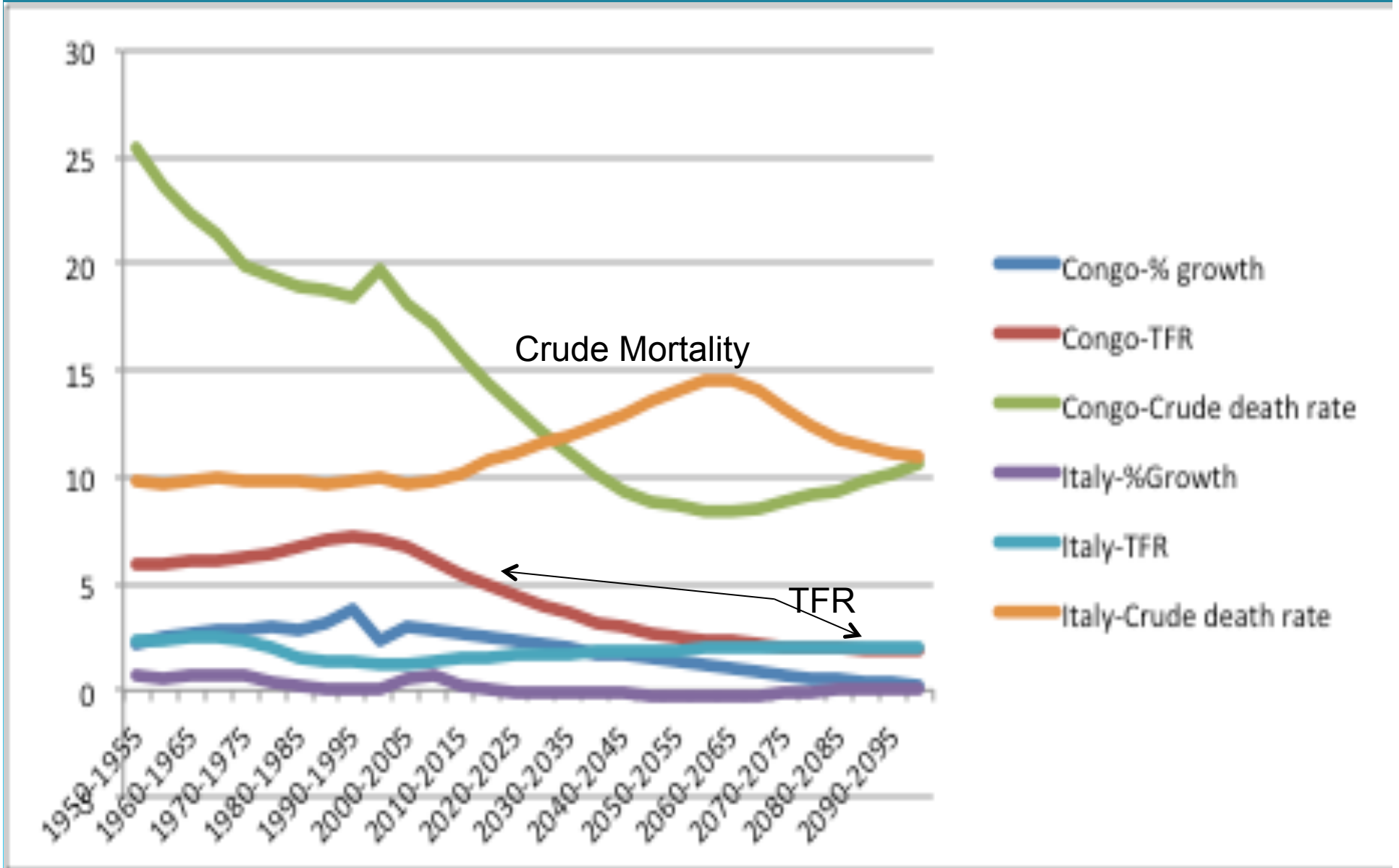
Other Essential Factors Affecting the Structure and Trends in Population

Essential Factors Related to Survival (Mortality Rates)

- Reduced infant/childhood mortality, maternal mortality
  - Pre-natal care, nutrition, environment, etc.

**Figure 6. Under-five mortality for the world and selected regions, 1950-2050**
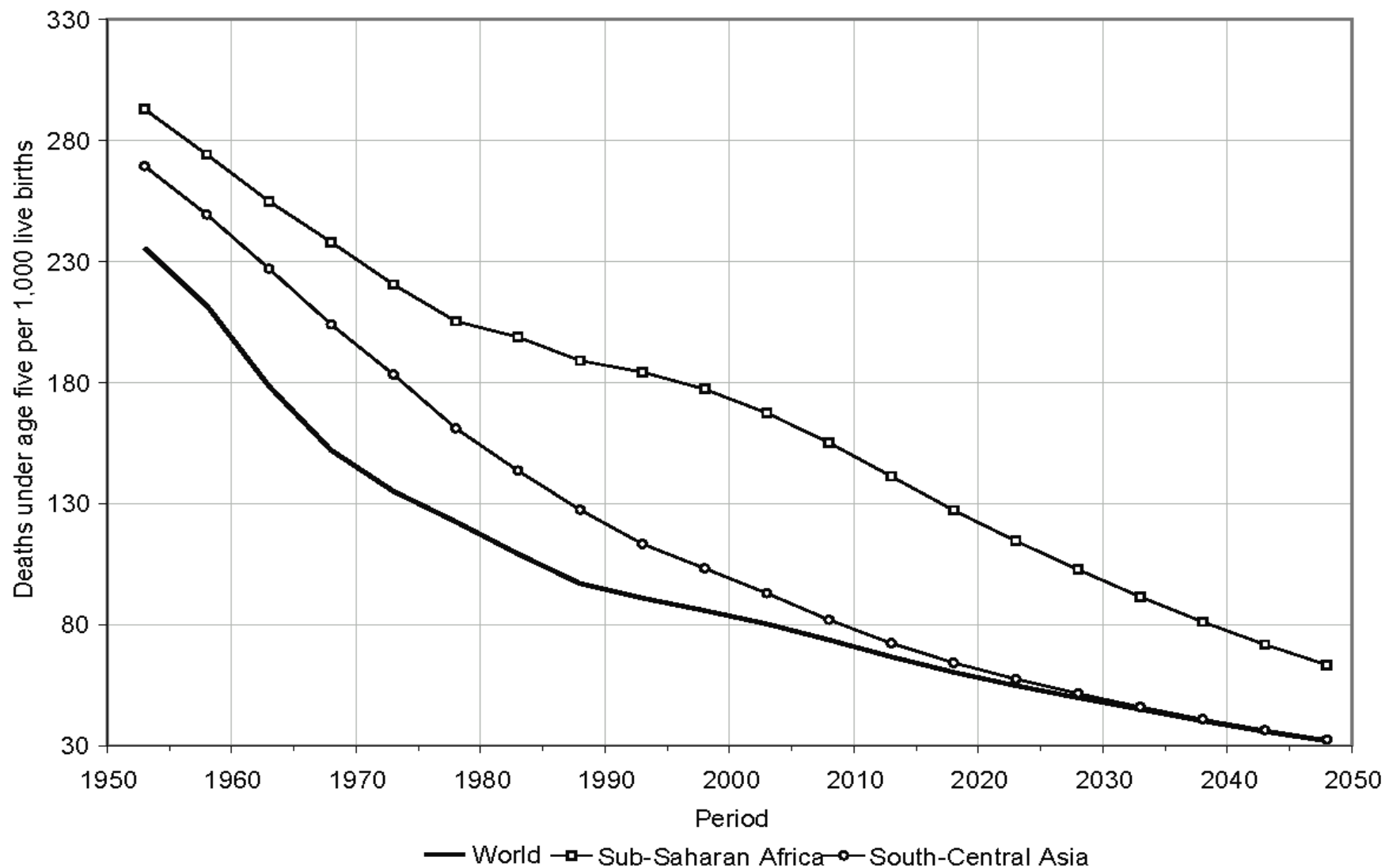
Essential Factors Related to Lifespan (Mortality Rates)

- Longer lifespans
  - Antibiotics and medical care
  - Hygiene
  - The war on infectious diseases
  - Nutrition/exercise/lowering obesity
  - Reduced alcohol and tobacco consumption
  - Reduced occupational demanding work and work hours

# Figure 4. Life expectancy at birth for the world and the major development groups, 1950-2050
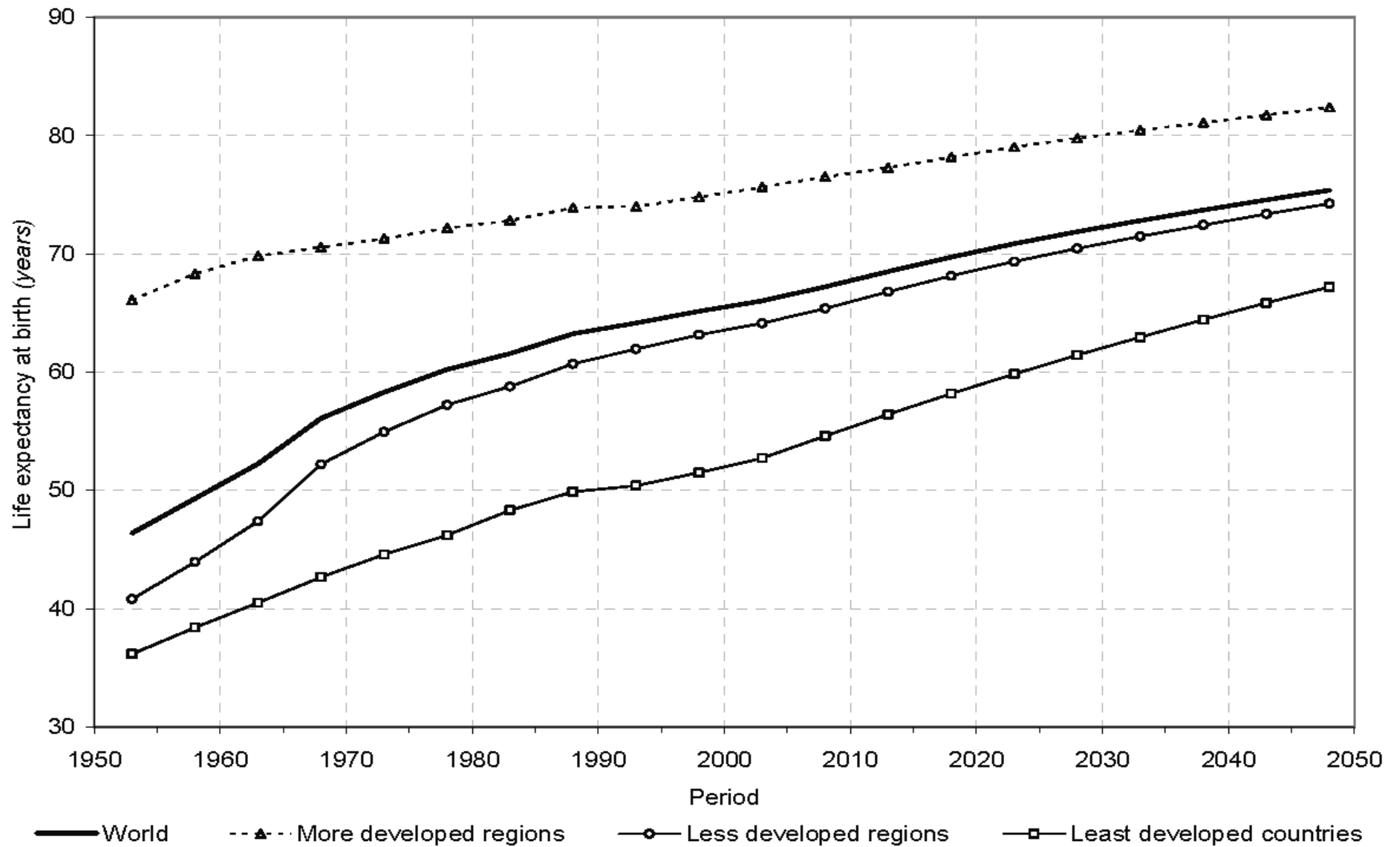
Infectious Diseases as an Example of Changing Mortality Patterns

- Infectious diseases are the second leading cause of death

- Third leading cause of death in the US

- Include:
  - Acute lower respiratory tract infections (e.g., flu)
  - HIV/AIDS
  - Diarrheal diseases
  - Tuberculosis
  - Malaria

Reduced Death Rates in the 20th Century from Infectious Diseases

Figure 1. Crude Infectious Disease Mortality Rate in the United States From 1900 Through 1996
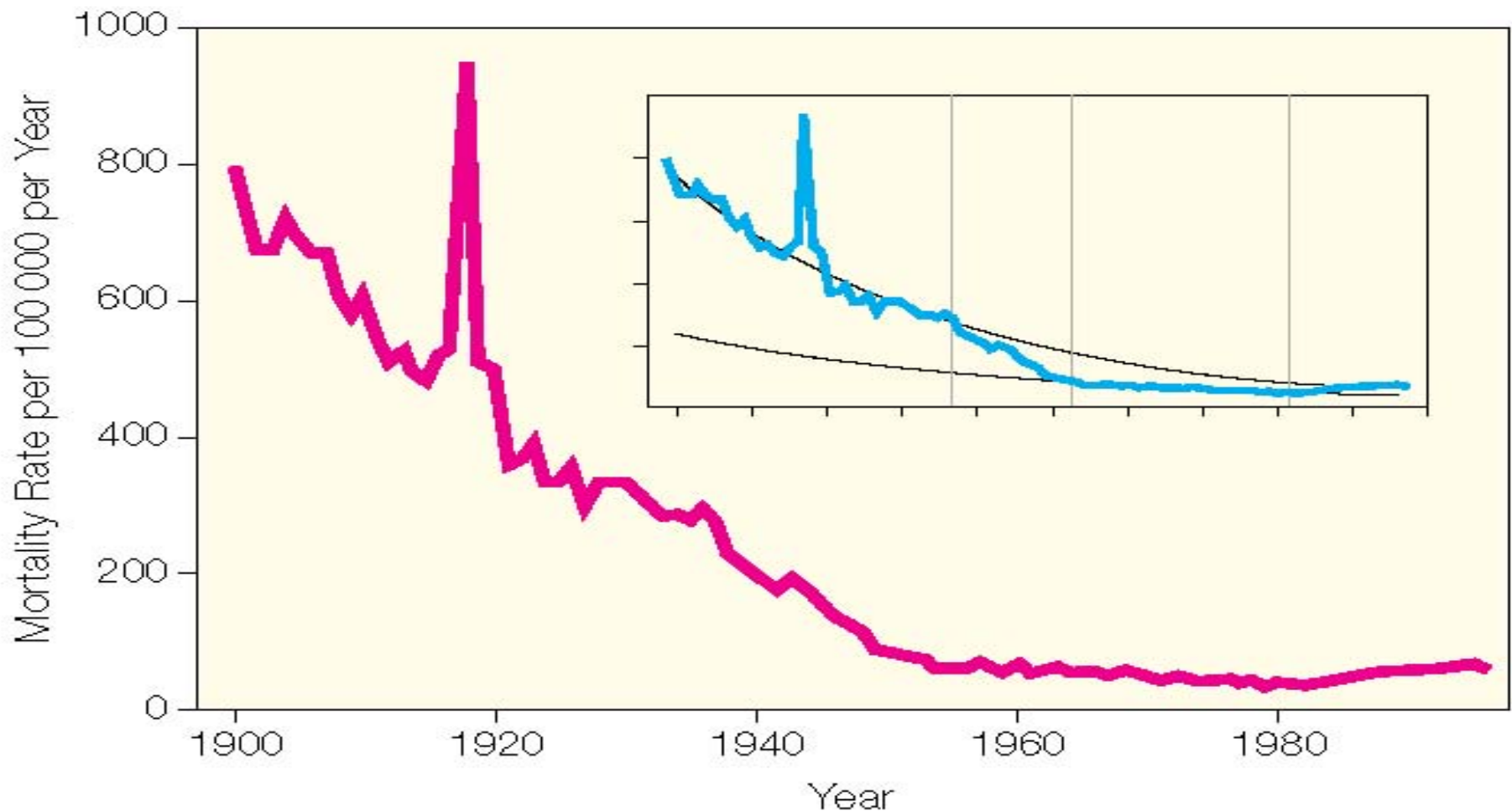
Figure 4. Crude Mortality Rates for 10 Infectious Diseases
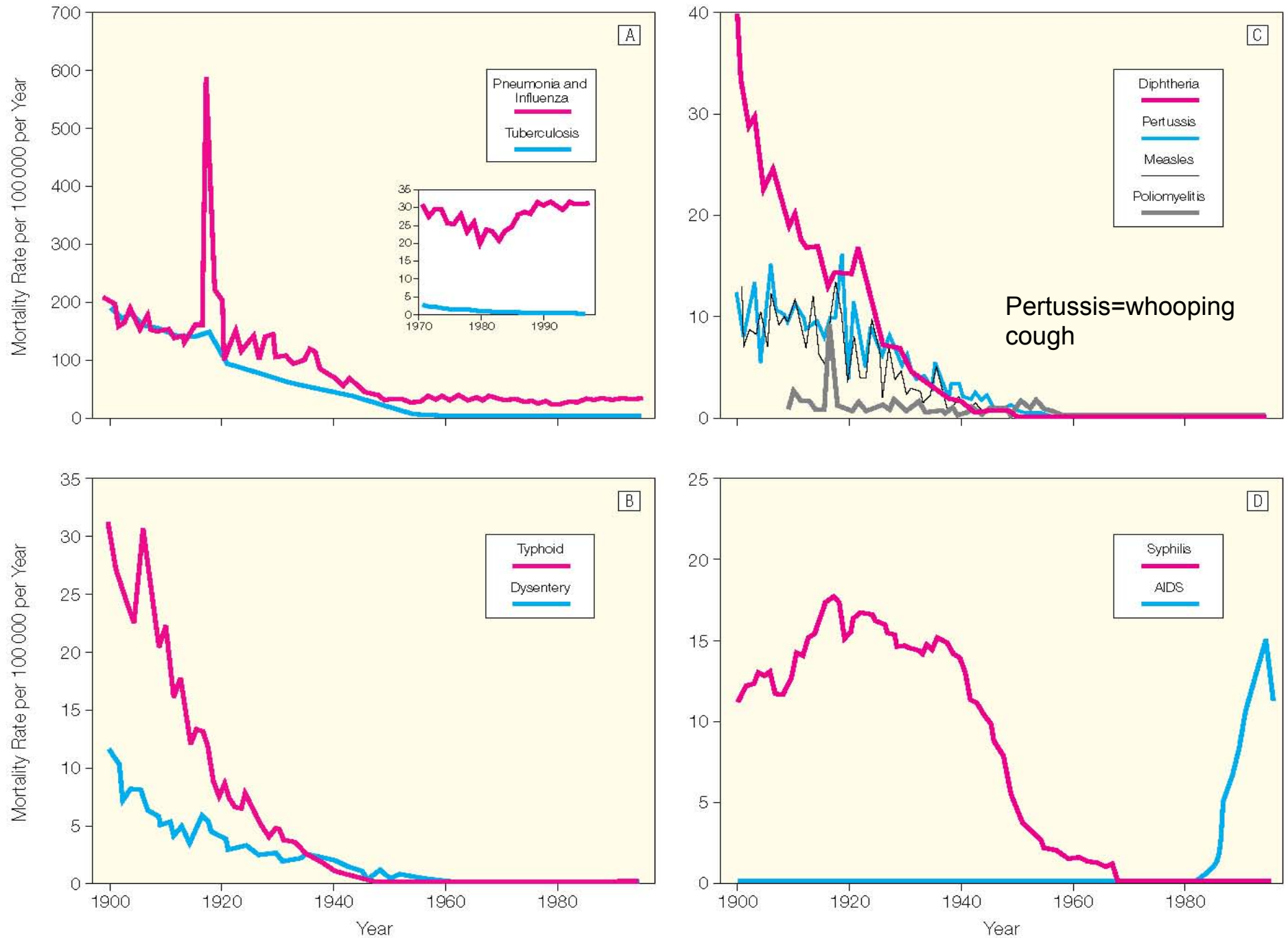
Antibiotics and Mortality

- 1938-1950: mortality from pneumonia and influenza declined dramatically
- Tuberculosis fell from 1945 to 1954 and continued to fall until the mid 1980s
  - Sulfonamides- 1935
  - Penicillin- 1941
  - Streptomycin- 1943
  - Antimycobacterials- 1944
    - Streptomycin first used against tuberculosis
  - Para-aminosalicylic acid- 1944
  - Isoniazid- 1952

Table 1.   Leading infectious causes of death worldwide, 1999.

| Cause	Rank	Estimated no. of deaths
Acute lower respiratory infections	1	3,963,000
HIV/AIDS	2	2,673,000
Diarrheal diseases	3	2,213,000
Tuberculosis	4	1,669,000
Malaria	5	1,086,000
Measles	6	875,000
Tetanus	7	377,000
Pertussis	8	295,000
Sexually transmitted diseases (excluding HIV)	9	178,000
Meningitis	10	171,000

Epidemics

- Diseases such as AIDS will increase mortality and can affect childhood health
- But this can be offset by high fertility rates

Uganda: AIDS, Fertility and Population

| Year	Prevalence of Aids (% of population)	Fertility rate	Population (millions)
1950	None(?)	6.9	5.2
1982	29%	7.1	~13.0
1991	15% (30% pregnant women)	7.1	17.8
2001	5%	6.8	24.7
2006	>5%	6.5	29.0
2050	??	2.8	94.3 (medium variant)
2100	??	---	~200 million

Population Projections for Uganda
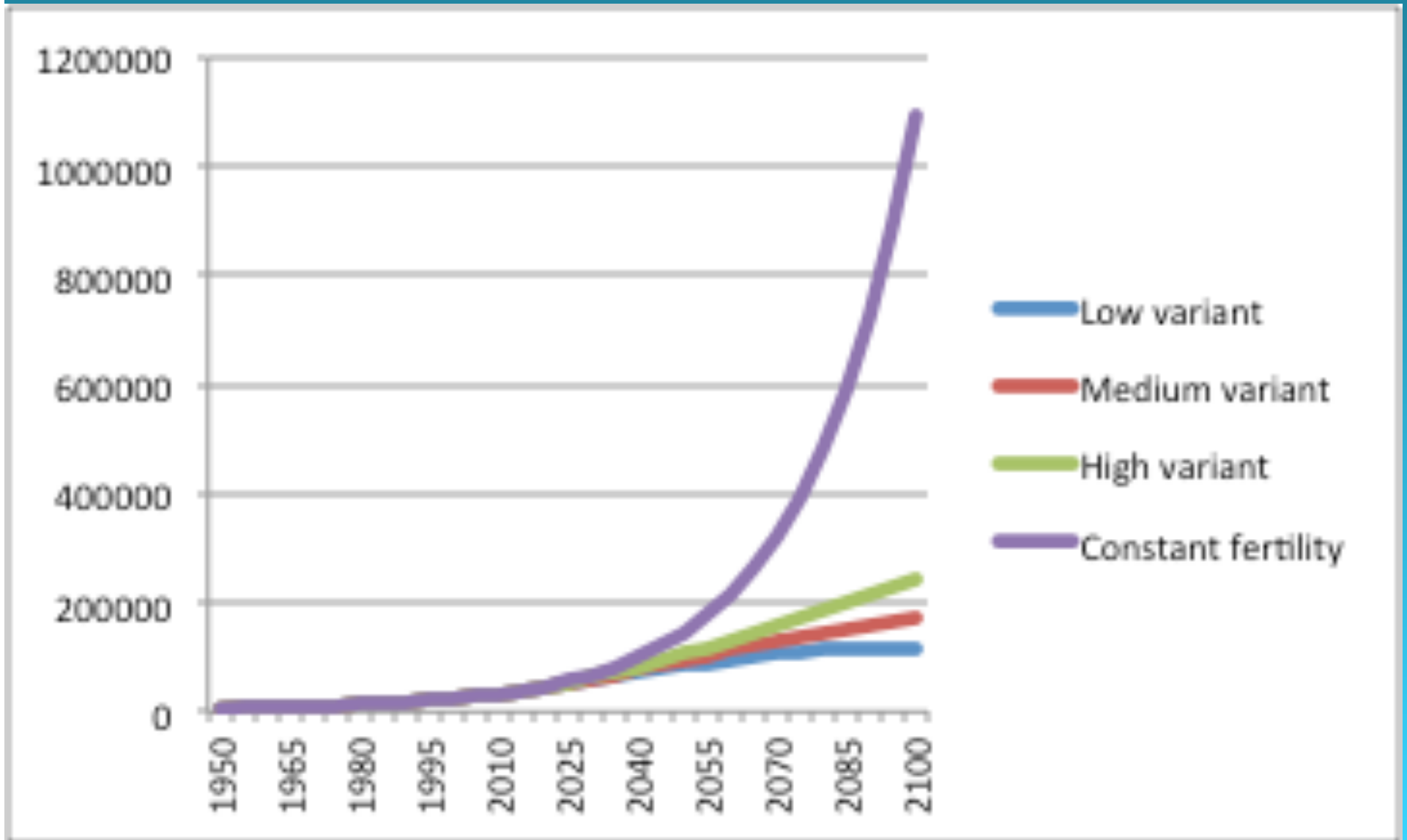
# Contraceptives, Family Planning, Fertility Rates

Essential Factors Related to Fertility

- Hard-wired into people's brains (DNA)
  - Sex
  - Need for survival of the human species and family
- Social factors
  - Cultural values and norms
  - Religion
  - Law
  - Social and economic inequity

Total fertility around 1970

Total fertility around 2000

Total fertility
- 0.8 to 1.5
- 1.5 to 2.1
- 2.1 to 4.0
- 4.0 and above
- No data
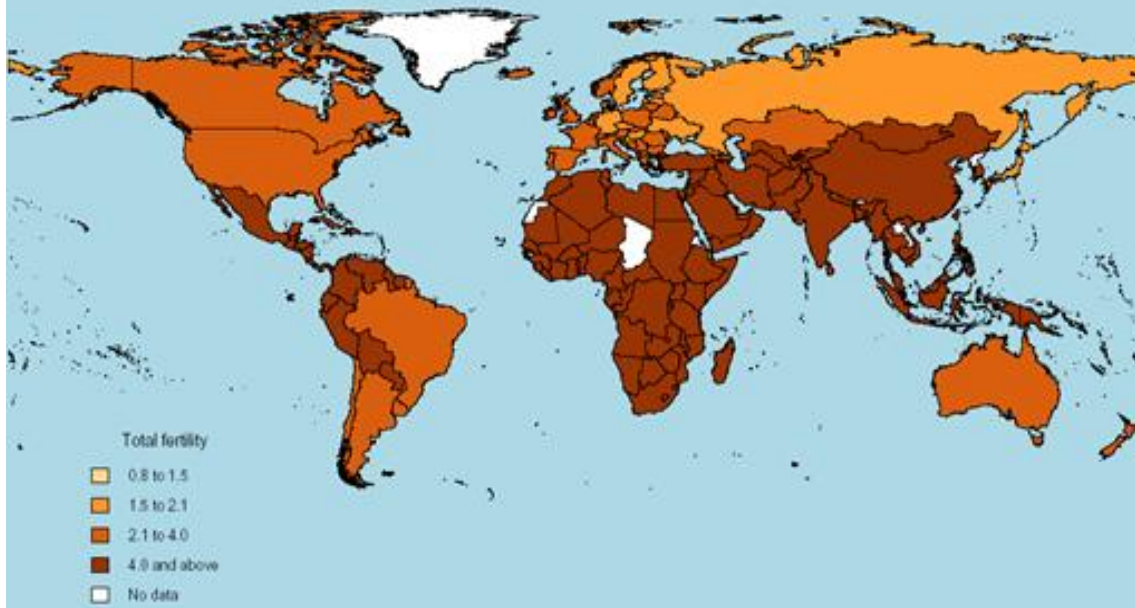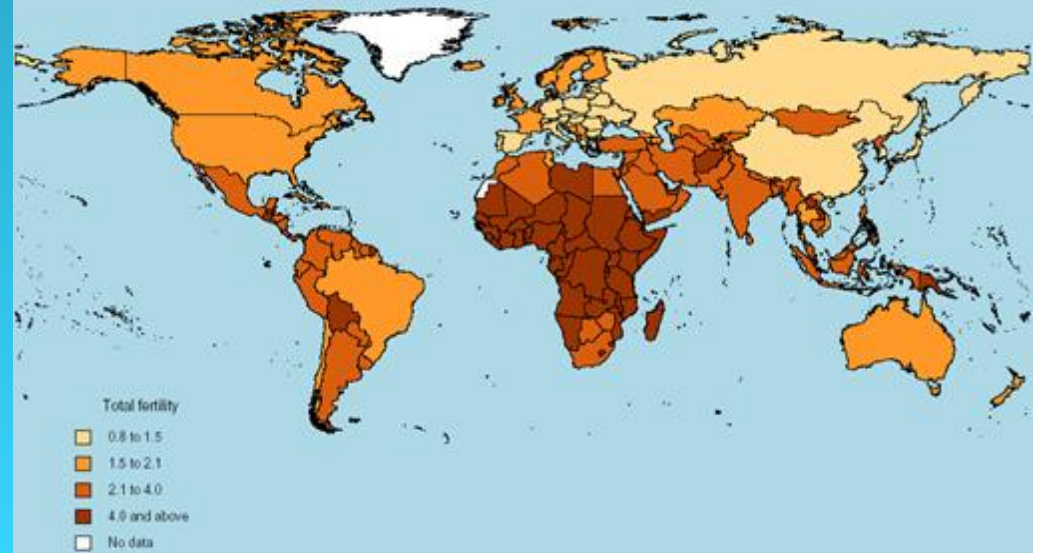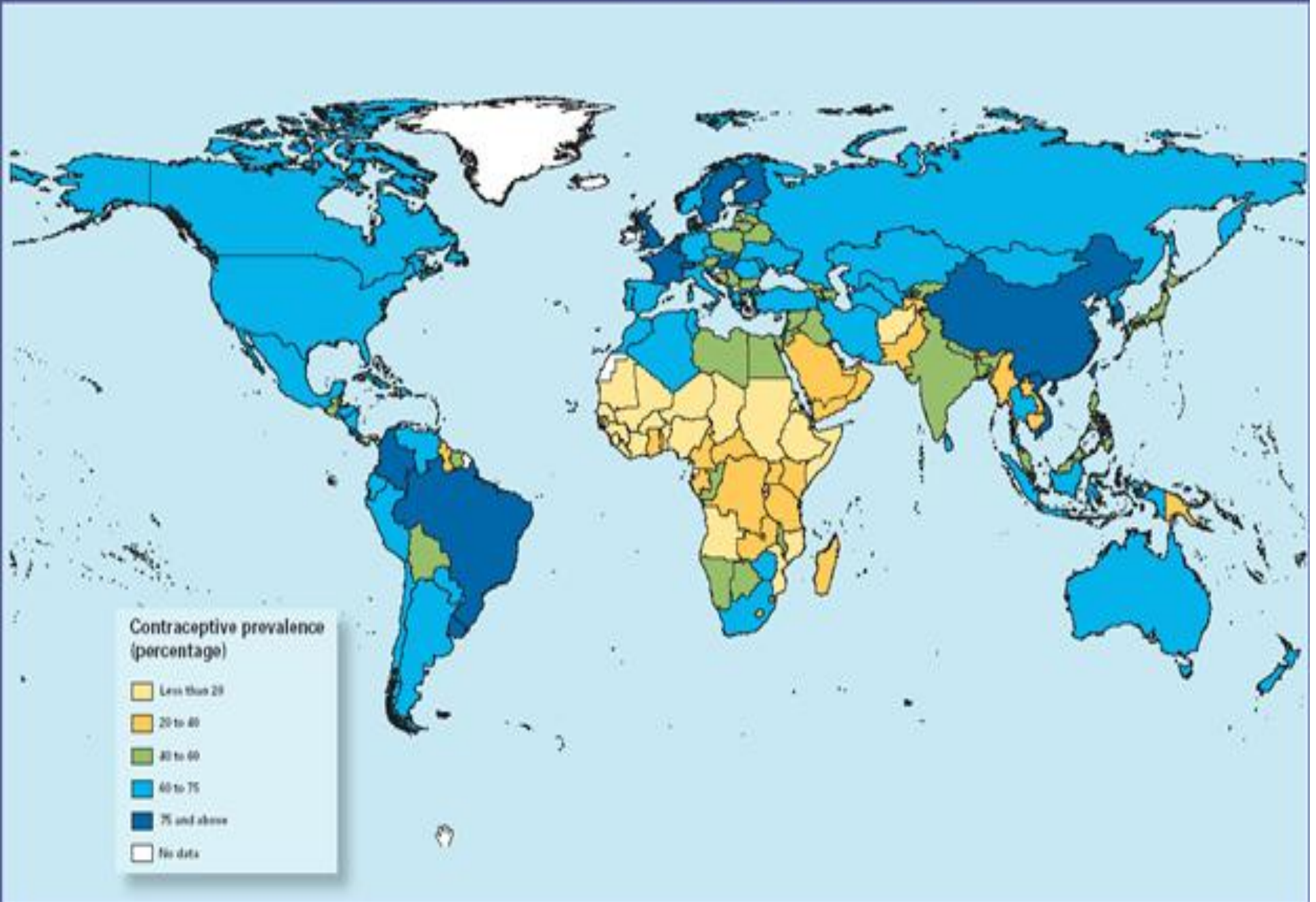
Comparison of Total Fertility Rates: Median Variant
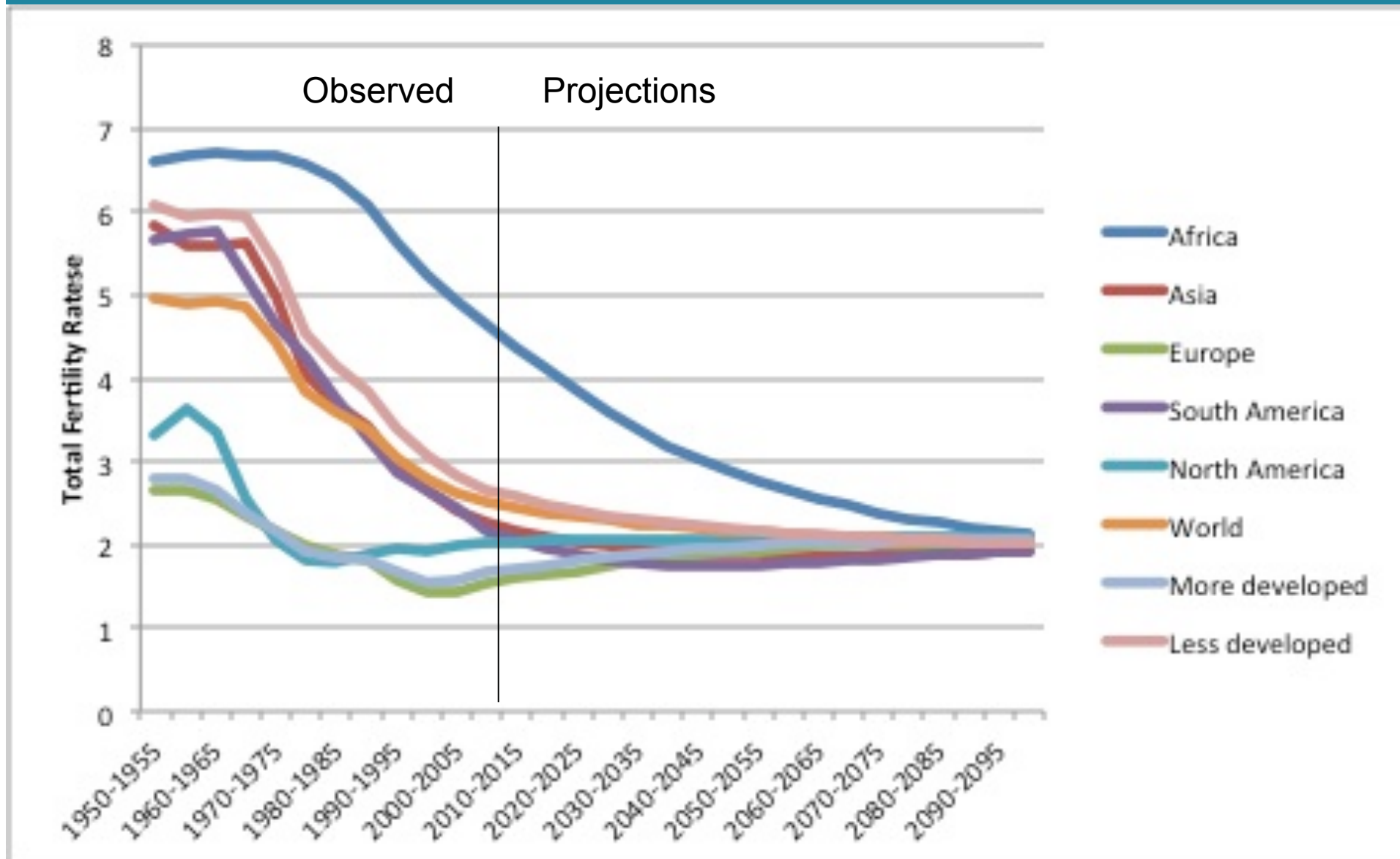
Contraceptive prevalence by country: most recent estimate

Contraceptive prevalence (percentage)

- Less than 20
- 20 to 40
- 40 to 60
- 60 to 75
- 75 and above
- No data

Contraceptives can Lower Fertility
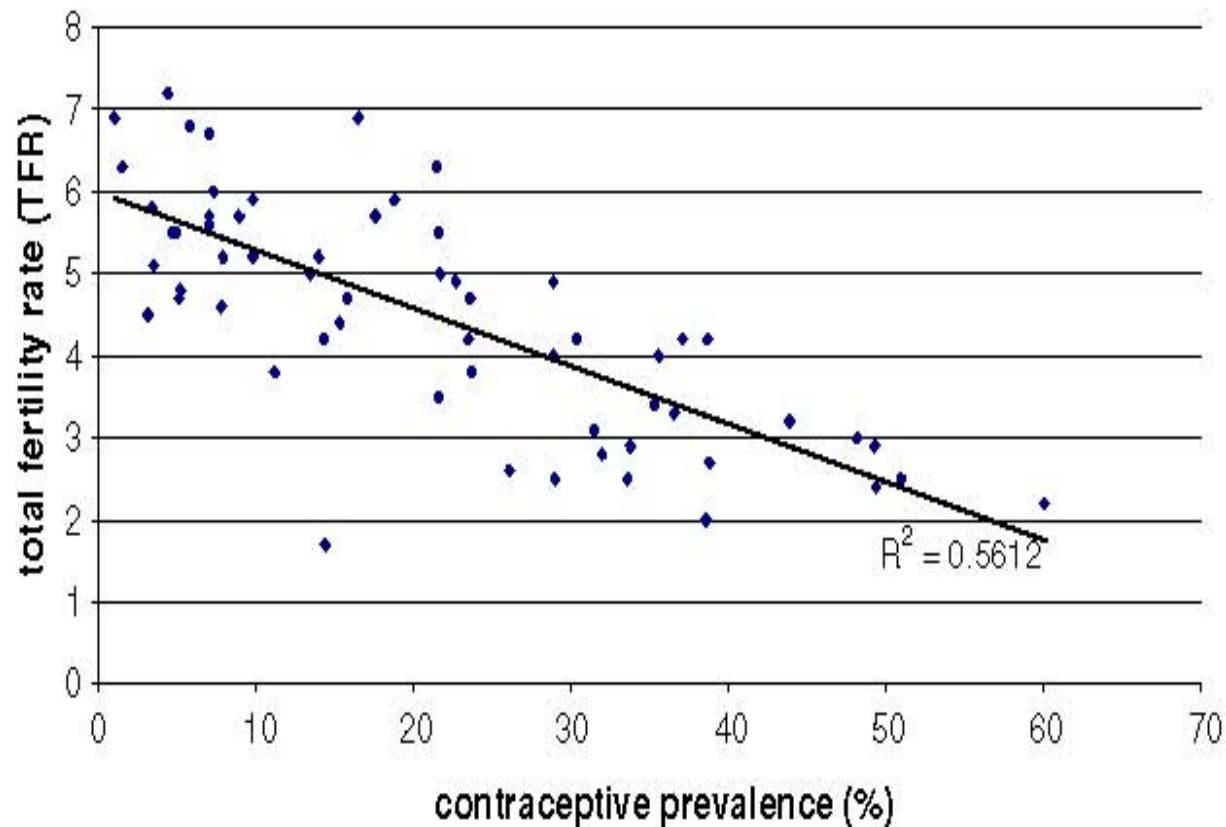
Fig. 5 Relationship between fertility and modern contraceptive use. Countries with at one (latest) DHS

Wealth is Associated with Contraception Usage
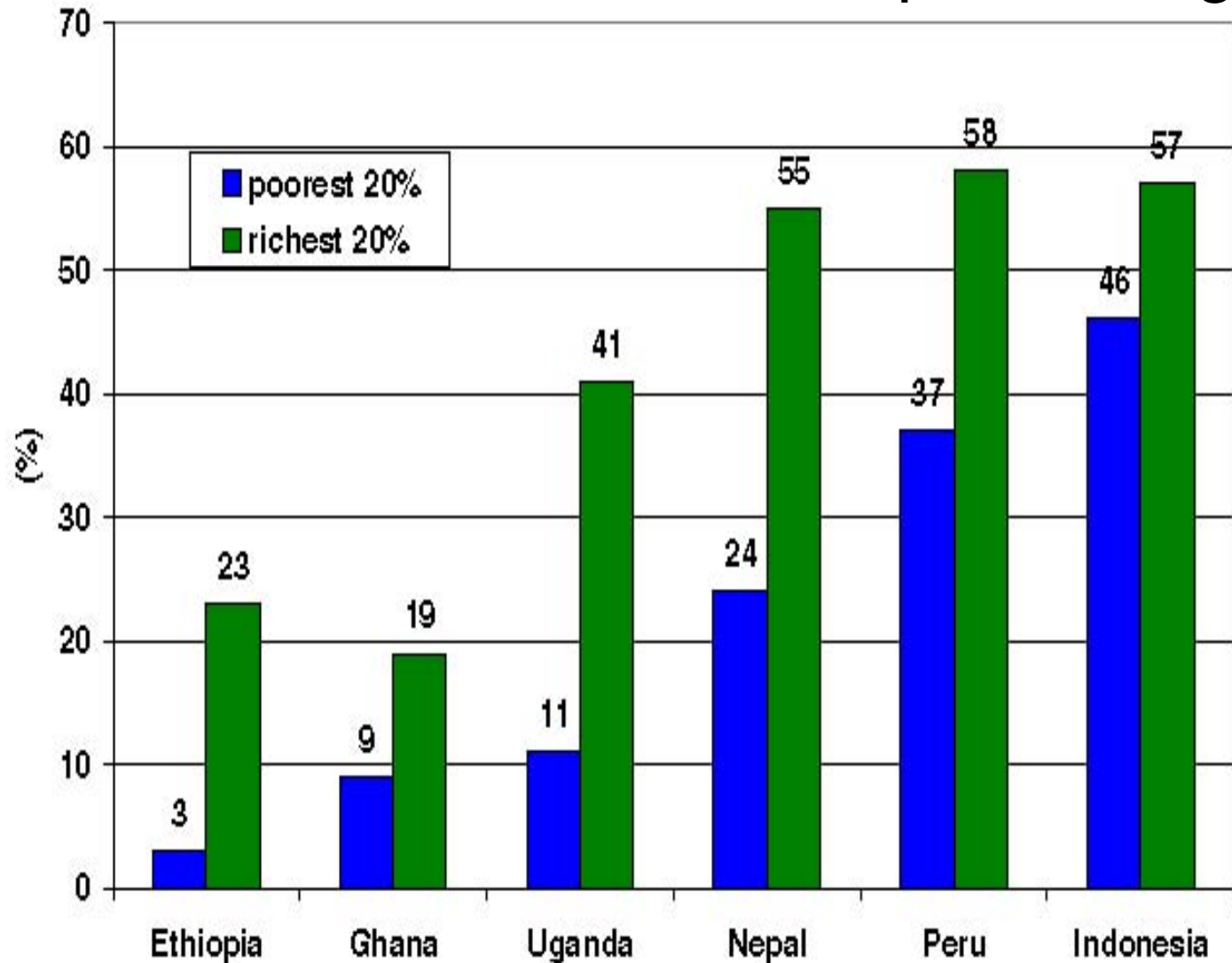
Fig. 3 Percent married women ages 15–49 using modern contraception according to wealth

From Prata The Need for Family Planning

Contraceptive Usage: Selected Countries

Percent of Married Women Using Contraception, Selected Countries
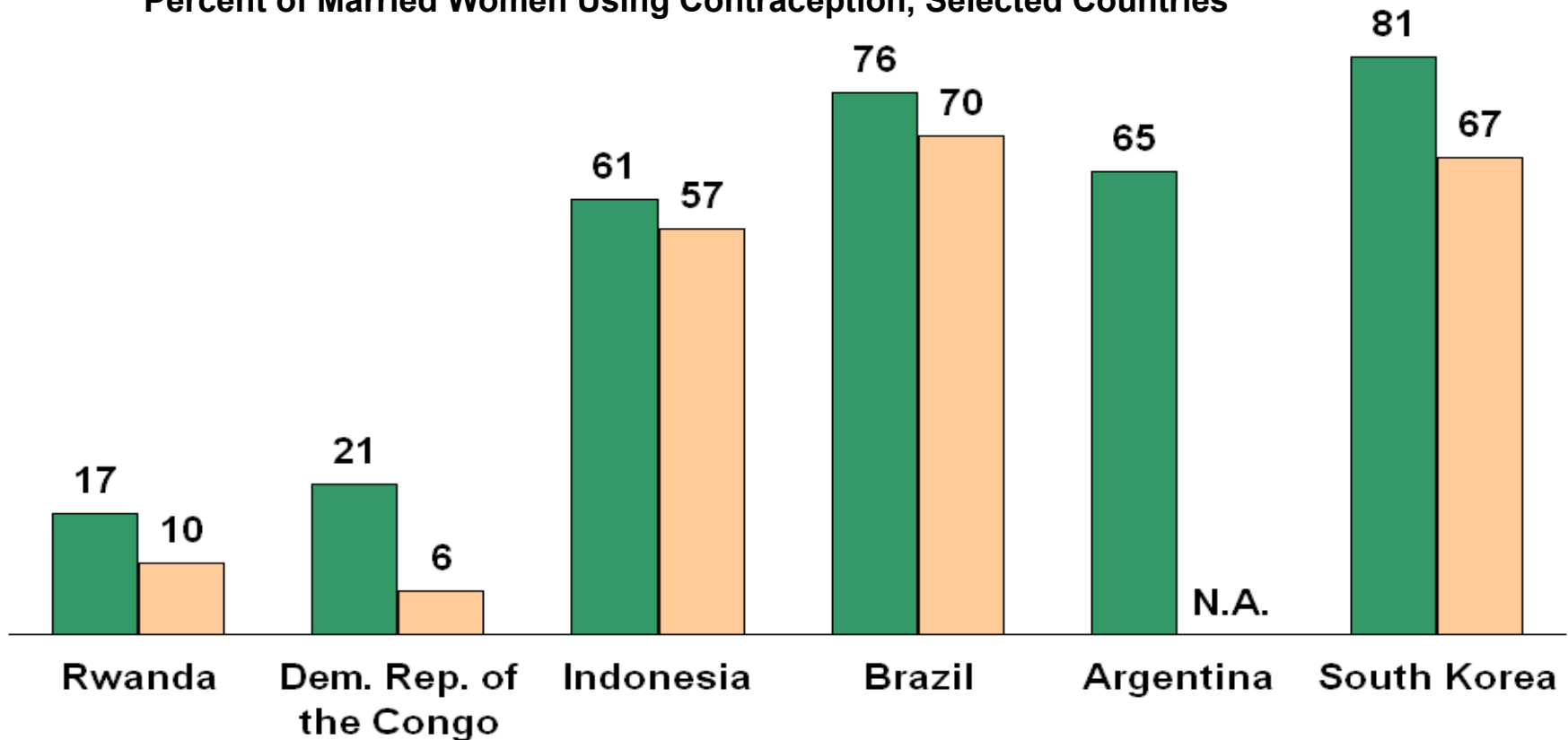
N.A. – Data not available. ■ All Methods □ Modern Methods

Sources: Demographic and Health Surveys and United Nations Population Division.

© 2008 POPULATION REFERENCE BUREAU

Wanted Fertility is Much Higher than the Rate to Replace Populations
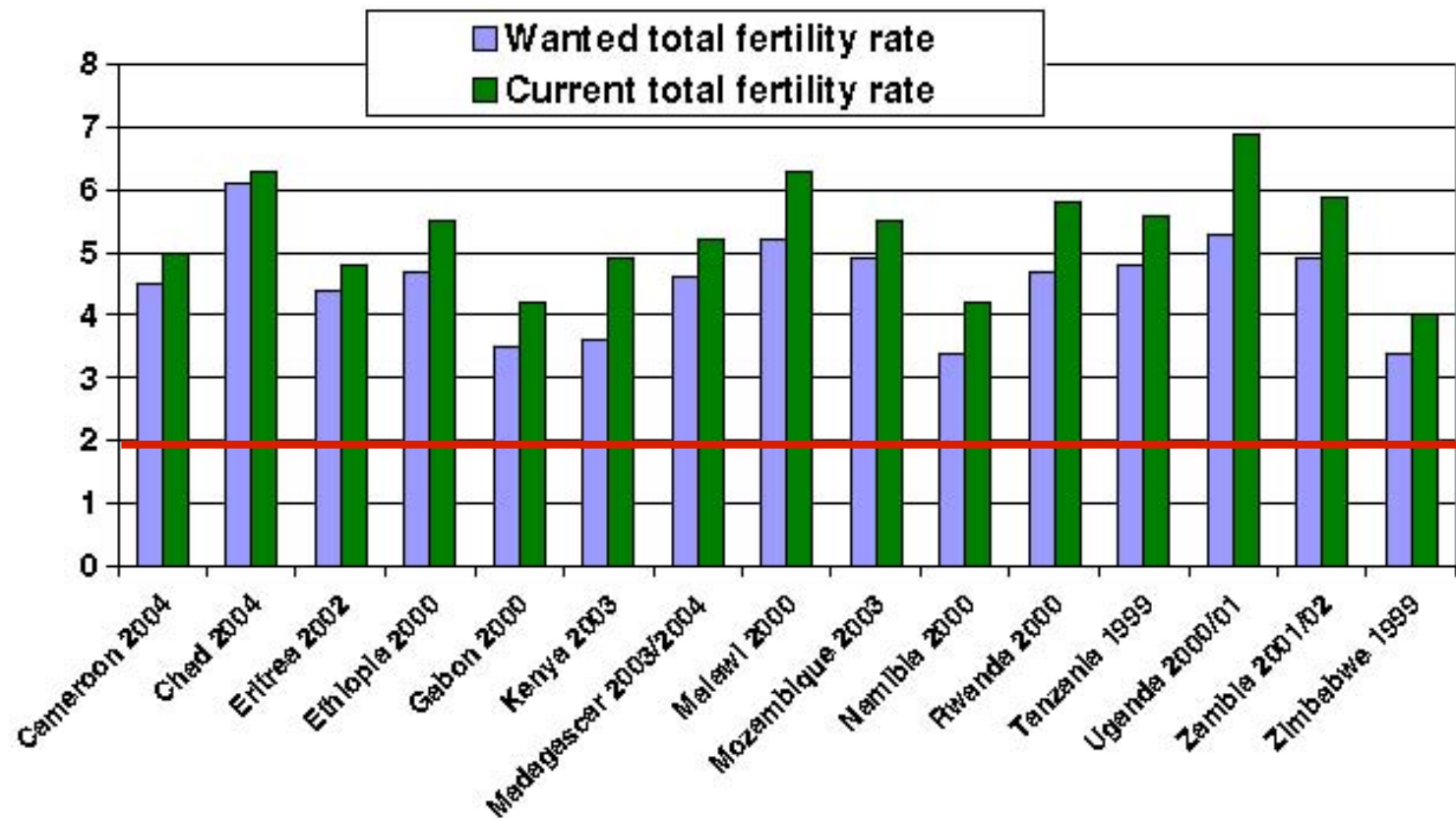
Fig. 7 Current and wanted TFR in sub-Saharan Africa

From Prata The Need for Family Planning

Family Planning to Reduce Fertility Rates

Family Planning / Birth Control

- Family Planning is about choice
- It is tied closely to:
  - Infant mortality
  - Maternal mortality
  - Health of families, including reproductive health
  - Education
  - Income
  - Religious and social values

Family Planning / Birth Control

- Types of birth control:
  - Condom
  - Vaginal barrier (diaphragm)
  - Oral contraceptive (OC) and injection (depo provera)
  - Implants
  - Intra-uterine device (IUD)
  - Other methods
    - Rhythm

Family Planning / Birth Control

- 150 million women do not want another child, but do not use contraception (Campbell)
- Technology is a means to an end, but the ends (number of children / family) will vary by many factors
- High prevalence of contraceptive usage from surveys does not mean that fertility rates will be low

Family Planning / Birth Control

- Institutional barriers to availability
  - Cultural and religious
  - Legal (rules on abortion/contraception)
  - Medical and other practices
  - Provider bias
    - Rx needed for OCs
  - Cost
  - Lack of supply

Family Planning and Birth Control

- Personal/familial barriers to availability
  - Financial
    - More children required for familial support ➔ part of the cycle of poverty
    - too expensive if >1% of income
  - Lack of knowledge, misinformation
  - Fear of side effects
  - Family and social disapproval
  - Ambivalence to future childbearing
  - Method of choice

Unmet need for family planning: most recent estimate

Unmet need
(percentage)

- Less than 10
- 10 to 20
- 20 to 30
- 30 and above
- No data
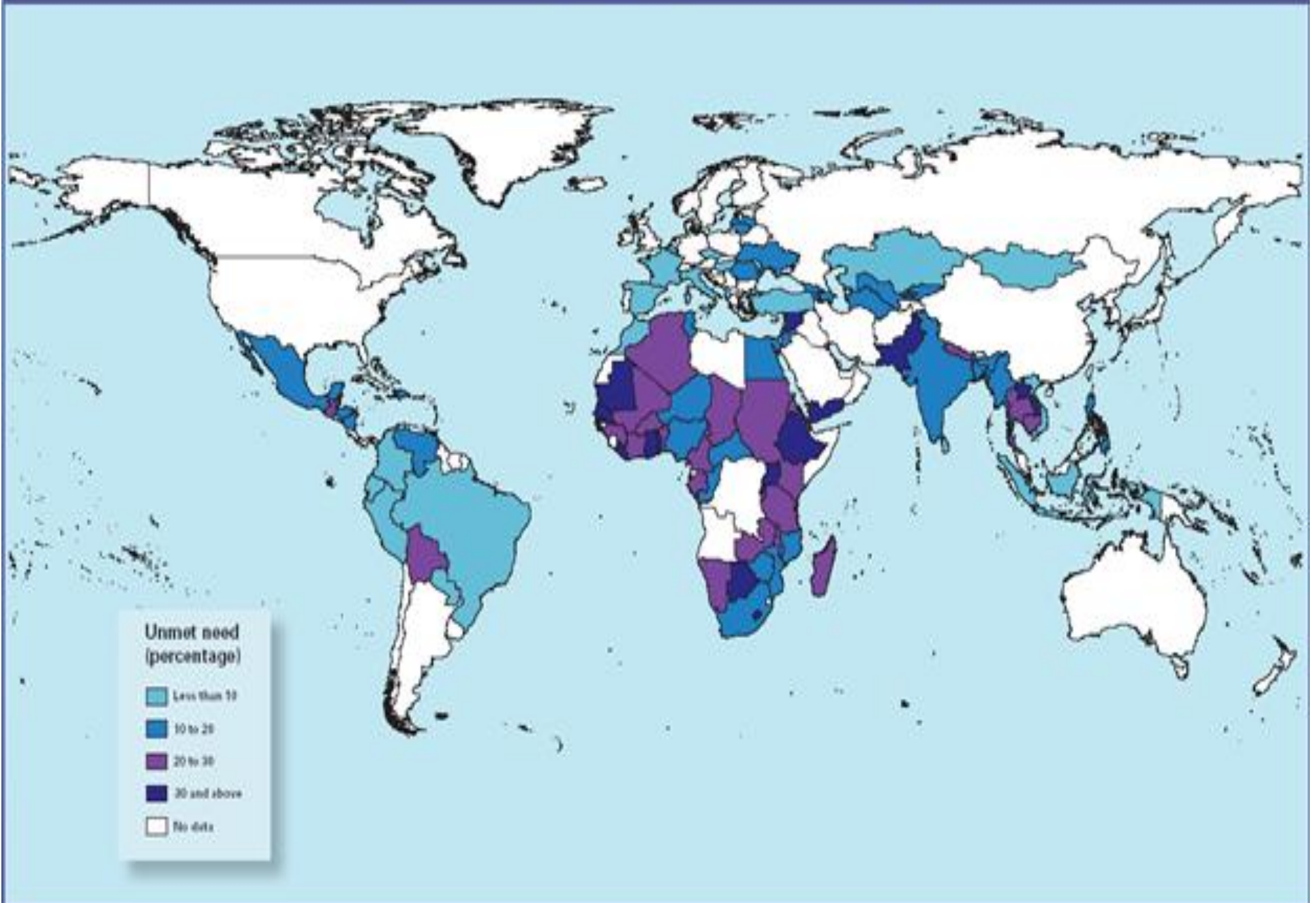
Approximate Relationship between Prevalence of Usage of Methods of Contraception

	Women (1,000s)	Year	Preval ence- any method	Fertility rates 1970-75	Fertility rates 2000-5	% change in population 1970-2000
World	1,134,650	2003	63.1	4.1	2.6	62.6
More developed	154,469	1999	67.4	2.1	1.6	N/A
Less developed	980,181	2004	62.4	5.2	2.6	N/A
China	260,743	2004	90.2	5.7	1.4	46.9
Bangladesh	32,074	2004	58.1	6.1	3.0	96.7
India	223,179	2005-6	56.3	4.9	2.8	87.5
Europe	96,762	1997	67.5	2.2	1.4	9.5
Canada	4,239	1995	74.7	2.3	1.5	40.4
USA	35,491	2002	72.8	2.5	2.0	35.9

Lack of Support for Family Planning

- 1994 International Conference on Population and Development

- Estimated costs for family planning, safe childbirth, HIV/AIDS: $25 billion / annum (2005)

Lack of International Assistance

Table 1 2005 ICPD funding targets adjusted for inflation, broadened HIV/AIDS and reproductive health services compared to projected 2005 population assistance and domestic expenditures (in $ billions and percents)

	2005 Original ICPD target (1993$)	Revised 2005 target adjusted for inflation, HIV/AIDS and reproductive health (2005$)	2005 Projected expenditures	% of revised target
Donor share (one-third)	$6.1	$20.2	$6.1	30
Developing country share	$12.4	$25.6	$14.9	58
Total	$18.5	$45.8	$21.0	46

Notes and Sources:

Donor targets were assumed to be one-third of totals needed except for adjusted STI/HIV/AIDS targets, where donor share is assumed to be two-thirds.

Adapted from: Speidel (2005).

Not Meeting Priorities

Table 2 2005 ICPD funding targets for donors adjusted for inflation, broadened HIV/AIDS and reproductive health services compared to estimated 2004 donor population assistance by category targets (in $ billions and percents)

Expenditure category	2004	2005		2005	
	Donor expenditures estimated	Original ICPD donor target (1993$)	% of target	Revised donor target adjusted for inflation, HIV/AIDS, & reproductive health (2005$)	% of target
Family planning	$0.453	$3.8	12	$5.2	9
Reproductive health	$1.368	$1.8	76	$5.0	27
STI/HIV/AIDS	$2.695	$0.5	539	$9.9	27
Basic research	$0.752	$0.1	752	$0.1	752
Total	$5.268	$6.2	85	$20.2	26

Additional Slides

Computing Number of People Alive Each Year, for One Specific Year

Age group	Total population at begining of year	No. of births in year	No. deaths during year	Net migration	Total population at end of year
0	-----	10,000	------	------	10,000
>0-1	95,000	0	2,000	+100	92,900
1-2	99,000	0	1,750	-1,500	95,750
2-3	.....	0	....	....	....
3-4	....	0	....	....	....