The Components of Demographic Change: When Does Each Matter Most?

Select Topics in International Population and Health[1]

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Released May 2024

BACKGROUND

Shifts in population size and structure are driven by three components of change: births, deaths, and migration. The dynamics among these components interact through a basic accounting system called the demographic balancing equation (Swanson and Siegel, 2004). Although these basic features of population change are readily understood (Eatwell et al., 1989), one of the most basic questions one might ask—which of the three demographic components most affects population change for a given area—often lacks simple answers.

Although one might expect fertility to matter most given that fertility rates drive population change by adding people, there may be exceptions. This document seeks to illuminate those circumstances under which each component can have an unusually large influence on population change. After a brief review of basic demographic dynamics, the potential role of each component is highlighted through case studies.

THE FOUNDATION OF DEMOGRAPHIC ANALYSIS AND POPULATION PROJECTIONS

Components of the Demographic Balancing Equation

The following demographic balancing equation shows how population change results from the interplay of births (or population additions), deaths (or population subtractions), and net migration, which can either add or subtract from a population when there are differences between inflows and outflows. As an accounting system that requires its parts to fit together in a specific way, it provides the foundation for both estimating and projecting the population of any country or area. Note that the balancing equation can be expressed either in numbers or in rates, the latter typically being population change (between time 1 and time 2) per 1,000 population.

Population (time 2) = population (time 1) + births – deaths + net migration (inflows minus outflows)

Although the balancing equation typically refers to a total population, it also holds for specific age and sex groups. For instance, a population of 10-year-olds at time 1 would be 20-year-olds 10 years later. If populations at these ages were estimated perfectly at these two distinct points in time, the difference in the counts would be due to deaths and net migration among 10-year-olds as they traversed the next decade of their lives.

Population age 20 (time 1 + 10 years) = population age 10 (time 1) – deaths + net migration

Shifts in each component of change typically affect different age groups. For instance, fertility changes in a given year only impact age 0 (an impact that cascades annually as the cohort ages), whereas changes to mortality tend to affect all age groups, especially among infants and at older ages where death rates are highest. In contrast, changes in migration tend to affect younger adults, given that migration is most prevalent at those age groups.

[1] This technical note is part of a series on *Select Topics in International Population and Health* that explores matters of interest to the international statistical community. The U.S. Census Bureau helps countries improve their national statistical systems by engaging in capacity building to enhance statistical competencies in sustainable ways.

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Demographic Analysis and Population Projections as New Data Become Available

Demographic analysis is a process through which one attempts to fit the various elements of the balancing equation together from past to present, like the pieces of a puzzle, to reflect actual changes in the population. One of the challenges in doing so is that these elements never fit together perfectly based on available data, even in areas with strong statistical systems allowing reliable estimates for each individual piece.

One reason for this situation is that the most reliable estimates of these elements come from different sources. Population estimates are often derived from a census, births and deaths come from civil registration and vital statistics (CRVS) systems and other sources, and net migration comes from whatever reliable source is available. Each of these sources is subject to different kinds of error. Demographers must use their judgement as to which parameter(s) needs to be adjusted to bring the elements into balance, and different demographers may have different judgements about the best methods for adjusting given the latest available data. New census data, for instance, can be compared to population estimates and projections from a prior census using estimated components of change.

As to population projections into the future, trends are naturally uncertain. Yet the common feature of any cohort projection based on the balancing equation (often referred to as "cohort component" projections) is that the elements of the balancing equation are perfectly balanced by design. In the absence of new information on the population, projections of future populations must focus attention on demographic change parameters. The efforts by demographers projecting populations are thus devoted to assessing the most influential parameter(s) given the situational context.

WHEN FERTILITY MATTERS

Background

Fertility is often assumed to be the primary engine of population growth (Coale, 2003; Lee and Zhou, 2017). From a global perspective, this assumption is readily understood since the Earth's human population cannot grow without births. Yet there are also times and places where fertility powers population growth much more than others. For example, demographic transition theory is built upon historical observations that declines in mortality typically precede more gradual declines in fertility (Chesnais, 1992; Eatwell et al., 1989). Thus, in the initial stage of the transition when mortality falls, yet fertility remains relatively high, the excess between birth rates and death rates (also known as natural growth rates) is at its largest, making fertility the primary determinant of population change. Fertility is often measured with the total fertility rate (TFR), which is the expected number of births per women through her lifetime if she were to experience all of the current fertility rates by age.

Case Study: Uganda

Uganda provides an illustrative example of this context of high fertility, in which births drive population change. Table 1 shows key demographic indicators for Uganda and selected countries. Among them, Uganda, as well as Nigeria, stand out for their very high fertility rate as well as the high rate of natural increase (crude birth rate minus crude death rate).[2, 3] Uganda, where women typically bear more than five children in their lifetimes (TFR of 5.3 in 2023), stands out even among other countries in Africa and Asia for its high fertility. As illustrated in Figure 1, even as Uganda's CBR falls, the rate is expected to remain high compared to other countries and areas, even projected to 2043. Due to high fertility, the age-sex structure of Uganda's population resembles a traditional pyramid shape and implies a high rate of natural increase (Figure 2). Migration aside, when there is a high rate of natural increase there will also be high population growth, driven by fertility.

Case Study: South Korea

Although very high fertility drives population growth in the early stages of the demographic transition, sustained very low fertility can have the opposite effect on population. In South Korea, which is featured in Table 1 and Figures 1 and 2, the TFR has hovered at or just below 1.0 births per woman for several years, reaching an

[2] Crude birth rate (CBR) is defined as the number of births during a year per 1,000 population at midyear.
[3] Crude death rate (CDR) is defined as the number of deaths during a year per 1,000 population at midyear.

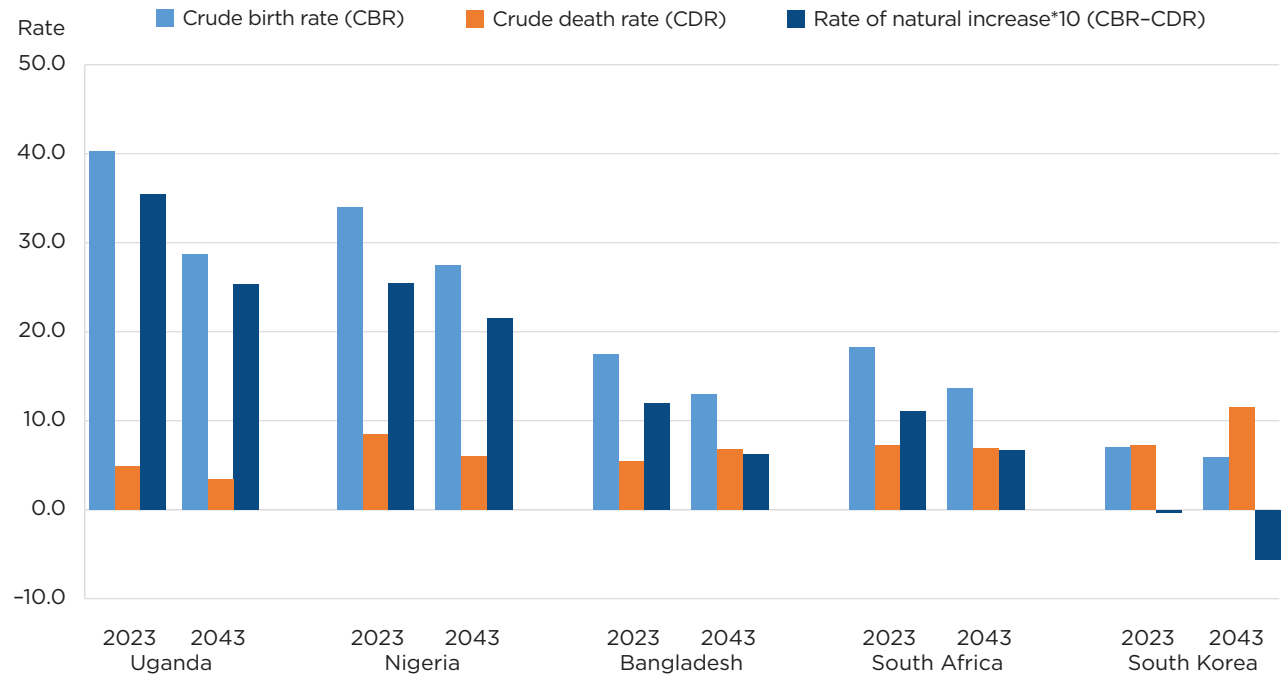
Table 1.
Key Demographic Indicators for Selected Countries: 2023

Country/ area name	Year	Population	Annual growth rate (percent)	Rate of natural increase (per 100)	Crude birth rate	Crude death rate	Total fertility rate	Life expectancy at birth: both sexes
Uganda	2023	47,729,952	3.22	3.54	40.3	4.9	5.3	69.3
Nigeria	2023	230,842,743	2.53	2.55	34.0	8.5	4.6	61.8
Bangladesh	2023	167,184,465	0.91	1.20	17.5	5.5	2.1	75.0
South Africa	2023	59,795,503	1.08	1.11	18.3	7.2	2.3	71.0
South Korea	2023	51,966,948	0.23	–0.03	7.0	7.3	1.1	83.2

Source: U.S. Census Bureau, International Database, 2023.

Figure 1.

Projected Crude Birth Rate, Crude Death Rate, and Rate of Natural Increase*10 (CBR–CDR) for Selected Countries: 2023 and 2043



Source: U.S. Census Bureau, International Database, 2023.

all-time low of 0.78 in 2022 (Lee, 2023). With only one child succeeding each generation of couples, the base of the population pyramid has already started to shrink and is destined to shrink further due to a phenomenon called the "fertility trap" (Lutz, 2006). Even if birth rates increase somewhat, the dramatic shrinkage of cohorts of mothers caused by very low fertility in the past (Figure 2) will cause an ongoing shrinkage of births—a cycle of decline that may cascade for decades to come.

By 2060, the most populous age groups will not be at young ages, but rather at 60 and over. This means that consistently low fertility has been a driving factor for the population decline, making way for an older population age structure. As we mentioned, older age structures are particularly susceptible to mortality as a demographic component, but it's important to note that fertility mattered greatly as the driving demographic component that led to the older age structure and now declining population. Mortality may be starting to matter more in South Korea due to the older age structure, making this case study a good transition into focusing on mortality.

WHEN MORTALITY MATTERS

Background

Throughout much of human history, population growth and change have been driven by the excess of fertility over mortality. However, in recent decades, the number of places where death rates exceed birth rates is increasing. In addition, mortality can have an outsized influence during social upheavals, pandemics, or other contexts in which death rates spike temporarily. Illustrative cases of each of these scenarios appear in the following case studies of Romania, Mexico, and Venezuela.

Case Study: Romania

As noted earlier, fertility decline tends to lag mortality decline over the course of the demographic transition, a difference that causes the population to grow rapidly for some time. However, at the end of the demographic transition, fertility rates may continue to decline, leading to a decline in the rate of natural increase and meaning mortality rates matter more in population projections.

Romania provides an excellent example of such a scenario. Along with other parts of Eastern Europe, Romania has one of the lowest rates of natural increase in the world of –6.3 (difference between the crude death rate of 14.9 and crude birth rate of 8.6, both measured per 1,000 in population). In contrast to South Korea, where natural increase has only recently become negative, natural growth has been negative in Romania for more than 30 years. That negative rate of natural increase has been compounded by excess outmigration that results in a

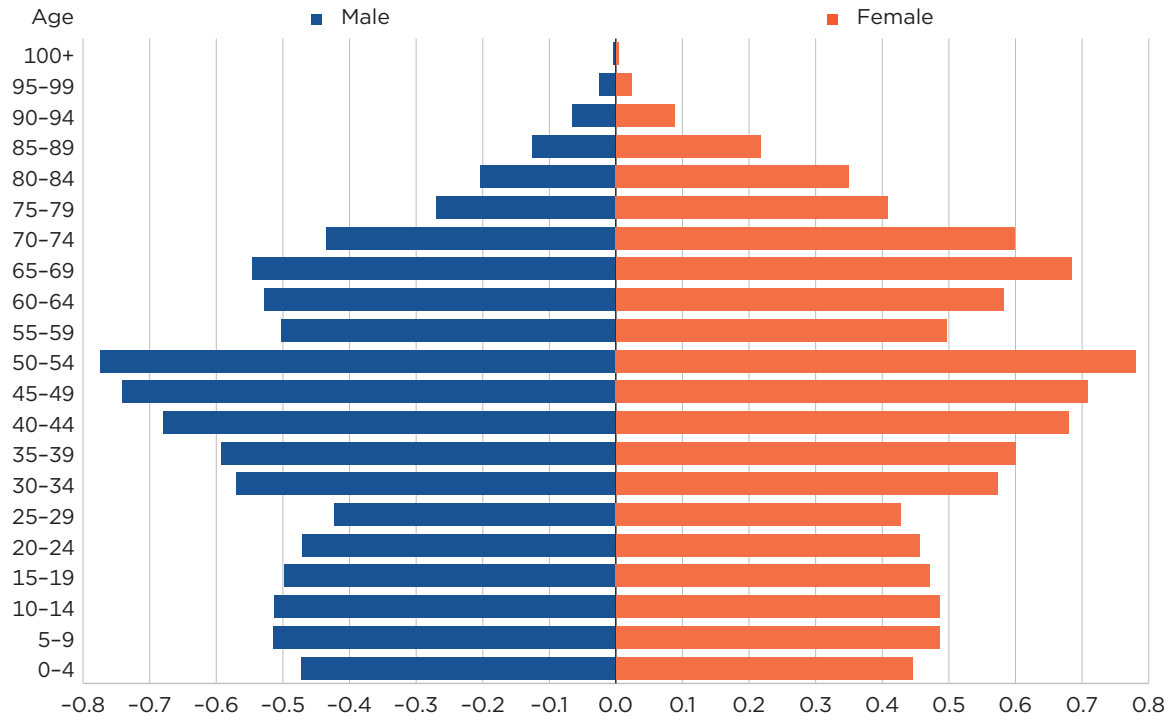
Figure 2.

Projected Population Structures of Uganda, Bangladesh, and South Korea: 2020 and to 2040 and 2060

(In millions)

Source: U.S. Census Bureau, International Database, 2023.

Figure 3.
Population Structure of Romania: 2022
(In millions)



Source: U.S. Census Bureau, International Database, 2023.

population shrinking by more than 1 percent per year (U.S. Census Bureau, 2023).

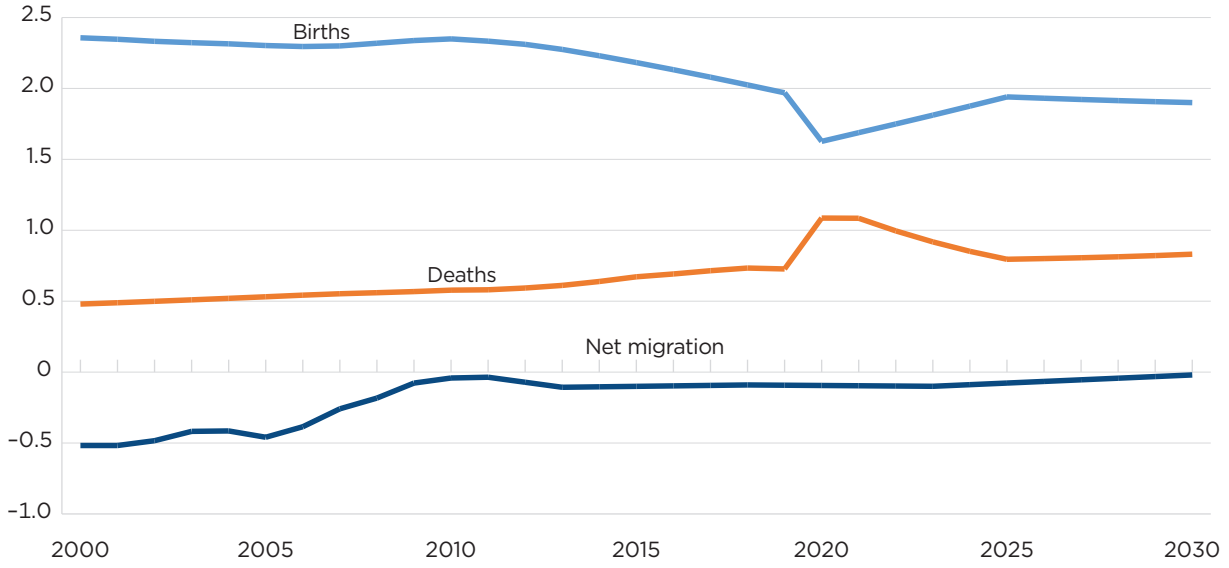
Romania's high CDRs are not driven by poor health conditions. Indeed, life expectancy at birth in Romania as of 2019 (just before the COVID-19 pandemic) was quite high at nearly 80 years for females and 73 years for males. Instead, CDRs are inflated because of its population structure; specifically, persistent low fertility over several decades and an unusually large portion of Romania's population being at the older ages where death rates are highest. The population concentration at older ages might be even greater now had there not been a restriction on abortion along with other prenatal policies in 1966, after which fertility increased notably for almost 2 decades (Berelson, 1979). The impact of these variables is indicated on the age pyramid at around the age of 55 in 2022 (Figure 3). Yet mortality can also be of outsize significance in demographic change regardless of age structure, as illustrated by the following case study of Mexico.

Case Study: Mexico

Mortality can also be of great significance in countries that experience shocks to public health owing to social upheavals, natural disasters, wars, or pandemics. The COVID-19 pandemic is a prime example of such a shock. We examine these effects in the case of Mexico, which also has declining fertility and a growing percent of older adults. We can observe in Figure 4 that the number of deaths in Mexico increased from 727,000 in 2019 to 1.086 million in 2020 and 1.084 million in 2021, an increase of 357,000 between 2019 and 2021. The corresponding decline in life expectancy at the time of birth was more than 5.4 years for males and 3.6 years for females (U.S. Census Bureau, 2023).

Although not applicable for all countries during the pandemic, Mexican fertility, which was already in decline prior to the pandemic, fell further. Coincidentally, the number of Mexican births fell by roughly the same amount as the increase in deaths by 218,000, down from 1.97 million in 2019 to an average of 1.68 million in 2021 (U.S. Census Bureau, 2023). Both births and deaths contributed to one of the sharpest declines in the Mexican population's rate of natural increase in modern history (Silverio-Murillo et al., 2023). We cannot say that mortality matters the most for Mexico, but we can be sure that mortality has a significant effect on the population estimates and projections of Mexico.

Figure 4.
Births, Deaths, and Net International Migration in Mexico: 2000–2030
(In millions)



Note: Estimates for 2022–2030 are projected from 2021.
Source: U.S. Census Bureau, International Database, 2023.

WHEN MIGRATION MATTERS

Background

Although world population growth is driven by the rate of natural increase, migration can have profound impacts on population change in certain countries and areas. The relative impact of migration is typically related to the overall population size of the area under consideration and the overall context of push-pull forces in which it occurs. Migration rates in small populations require particular care and attention. Migration is less dependent on population age-structure than mortality or fertility and it is, therefore, more susceptible to fluctuations. Figure 5 and the Venezuela case studies illustrate these contexts, as well as those situations where migration can have a profound impact on future projected population change.

Case Studies: Smaller Populations and Migration

This case study is of a group of areas presumed to have the highest and lowest net migration rates. These areas tend to be located predominately in the Pacific Islands, the Caribbean, and other less populous countries and areas. For these areas with substantial migration in the recent past, the assumption that migration numbers remain at similar levels in the future can have outsized implications on population projections—either quickly depopulating the outflowing countries or overwhelming receiving areas. One way to reduce that impact is to project using constant migration rates or to assume future long declines in net migration, sometimes requiring an iterative process.

Case Study: Venezuela Crisis Situation and Migration

Sudden waves of mass emigration can occur after (or in anticipation of) political, economic, or social upheavals. The resulting volume of crisis migration is typically difficult to measure, particularly when monitoring mechanisms—such as those provided by the United Nations High Commissioner for Refugees (UNHCR)—are unavailable or may not fully cover the true extent of population movements (United Nations High Commissioner for Refugees, 2021).

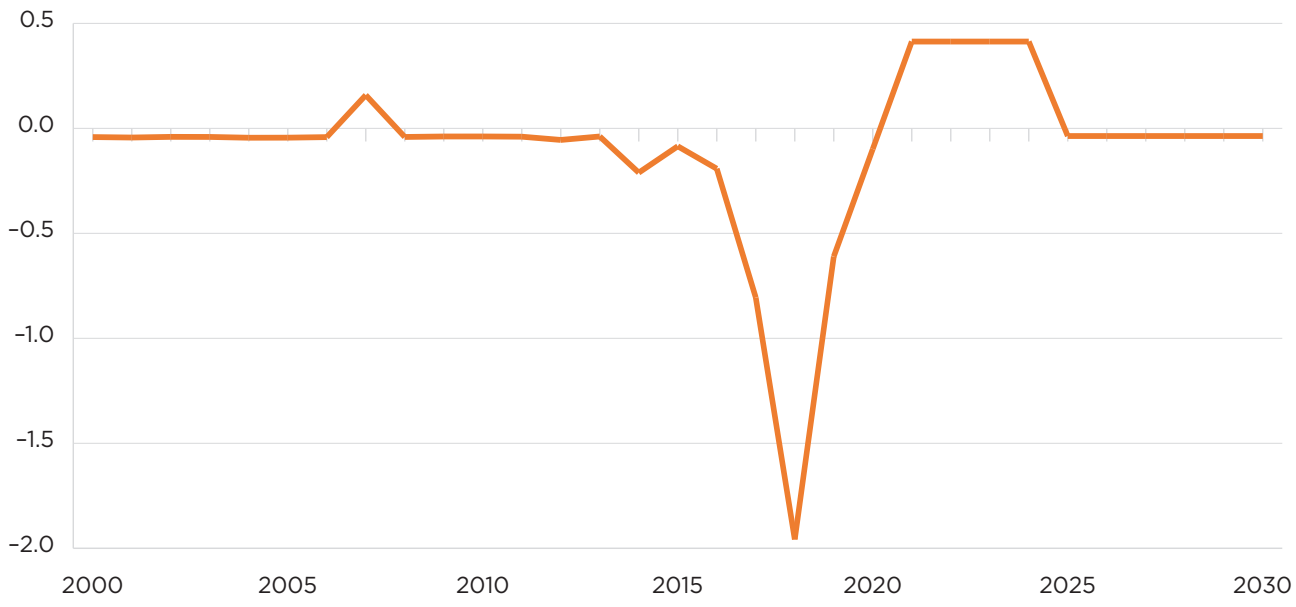
Another challenge concerns anticipating post-crisis return migration to the place of origin. If all emigrants eventually return, then migration would have no effect on long-term population growth. (Migration would still, however, affect year-to-year population change). Demographers producing population projections in crisis areas cannot bypass these uncertainties. They must make assumptions of post-crisis migration patterns, which are often built on nondemographic assumptions such as the likelihood of a crisis abating.

Figure 5.
When Migration Matters Most

When Population Numbers Are Relatively Small...	**A given numerical flow of migrants has a larger impact when the sending or receiving population is smaller.**
When Economic Push-Pull Factors Predominate...	**The number of laborers needed may be too many or too few depending on the nature of the economy.**
When There Are Social, Political, or Military Upheavals...	**Upheavals can lead to substantial migratory flows (even in large populations).**

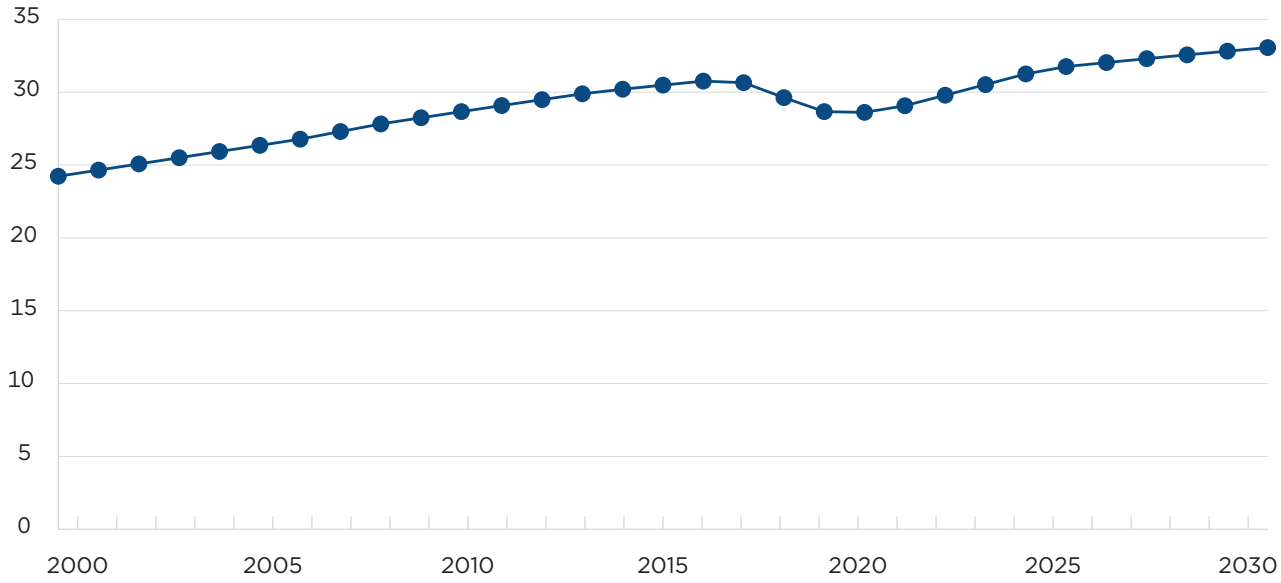
Source: U.S. Census Bureau.

Figure 6.
Net International Migration in Venezuela: 2000–2030
(In millions)



Note: Estimates for 2020–2030 are projected from 2019.
Source: U.S. Census Bureau, International Database, 2023.

Figure 7.
Mid-Year Population in Venezuala: 2000–2030
(In millions)



Note: Estimates for 2020–2030 are projected from 2019.
Source: U.S. Census Bureau, International Database, 2023.

During several years of social instability after a close election in 2013, Venezuela experienced what the UNHCR called "the largest exodus in Latin America's recent history" (United Nations High Commissioner for Refugees, 2023). As of 2023, the number of people who had departed the country remained in the millions, according to governments in receiving countries (United Nations High Commissioner for Refugees, 2023). The pivotal impact of such migration is illustrated in Figure 6 through a sharp increase in outmigration as well as a visible dip in Venezuela's total population size (Figure 7). Given the lack of formal reporting systems for monitoring refugee flows or other formal categories, the bulk of the exodus was described by the UNHCR as "other persons of concern."

SUMMARY

Among the three components of demographic change, fertility is usually the primary driver of population growth and, in some areas, decline. Mortality usually has a secondary impact on population change, most easily inferred at specific age groups. However, in times of exceptional social upheaval, war, or pandemic, the role of mortality can be greatly elevated. Net migration tends to have a relatively larger influence in small populations and crisis areas and requires deeper understanding of socioeconomic and other contextual push-pull factors. It is also important to consider that the three components are interrelated and can impact each other.

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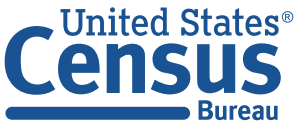

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