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Population Projections for Israel

2017–2040

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Introduction

In 2012, researchers at the Israeli Central Bureau of Statistics (CBS) published long-term population projections for five-year intervals to 2059 (Paltiel, Sepulchre, Kornilenko & Maldonado, 2012). Updated projections are also published annually in the CBS *Statistical Abstract of Israel* (see Table 2.10, various years), and by other branches of government (Shvadron & Avramson, 2017).

Why, then, is the Taub Center producing its own projections? There are two main reasons. The first is instrumental. Both Paltiel and colleagues, the CBS in general, and Shvadron and Avramson publish projections in 5-year intervals covering 5-year age groups. For various public policy questions under investigation at the Taub Center, these two types of aggregations are not specific enough. For example, in forthcoming Taub research on the education system (Weinreb, Shavit & Blass, 2021), it is important for us to know how many children will be entering 1st grade over the next decade — including children not yet born — or reaching university age. Likewise, in forthcoming Taub research on elderly health and welfare, it is important to know how many adults are likely to reach the age of retirement over the next couple of decades. In both of these cases, we could generate single-year estimates from the published CBS projections by interpolating both 5-year values and 5-year age groups (into single years and single ages). However, that interpolation would result in a loss of information by, for example, smoothing over year-on-year fluctuations in birth cohort size.

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The second reason for producing our own projections is more substantive. We do not agree with some of the assumptions that Paltiel et al. (2012) used to shape the inputs in its own projections. And the fact that more recent annual report projections differ so dramatically from the Paltiel et al. estimates suggests that the CBS has markedly changed those assumptions.

For example, the projected population in 2040 according to the medium variant is 11.95 million people in Paltiel et al. (interpolated from the pace of change between the 2039 and 2044 projections) and 13.22 million in the most recent *Statistical Abstract of Israel* (CBS, 2019a).

In prior work (Weinreb & Blass, 2018), we described the ways in which Paltiel et al. follow standard — and recommended — demographic procedures. Examples include the use of improved Lee-Carter methods to project mortality, and expert opinion regarding the range of future fertility rates. However, we also pointed to two problems with Paltiel et al.'s approach.

The problem stems from the decision to estimate a discrete series of projections for Haredim (ultra-Orthodox Jews) and "Jewish/Other" while assuming zero net movement between these streams of Judaism. In the same research, we argued that there is 10–20 percent net loss to Haredim, which suggests that Paltiel et al. overestimate the percentage of the population that will be Haredi, and, therefore, overestimate the growth rate of the population as a whole.[1] The second problem is existing projections' approach to migration and fertility. We will discuss these in more detail below, but for now, suffice to say that in the last 15 years, there has been a significant increase in net in-migration to Israel. At the same time, fertility has also increased somewhat in the non-Haredi Jewish sector, fallen moderately among Haredim and fallen quite sharply in the Arab Israeli sector. There is, therefore, a need to update the migration and fertility assumptions underlying the population projections.

These considerations give rise to the central goal of this paper: to project the number of people in Israel by single age for each year up to 2040. Our projections, using a standard "cohort component" model, are based on anticipated trends in fertility, mortality and migration. In all cases, the estimates are disaggregated by sex and ethnicity: Jewish, including "other," and Arab Israeli.

1 Since fertility is much higher in the Haredi sector, and is the main factor underlying population growth in Israel as a whole, assuming a higher percentage of Haredim in 2030 raises the mean fertility of the whole population.

We have chosen to limit the projections to 2040 for a few reasons. First, although the arithmetics of extending them is not complicated, we feel that with every additional year, our loss of confidence in the accuracy of those projections outweighs the potential benefits of a longer time horizon.[2] Additionally, limiting ourselves to 2040 years also simplifies projection methods, especially, as discussed below, for mortality. Finally, the longer-term timeline is less relevant for Taub research, making it less important for us to push the projection beyond 20 years.

A final difference between these projections and those of the CBS is that we do not estimate discrete demographic trajectories for the Haredi and non-Haredi Jewish populations. As implied thus far, we think there is too much movement across levels of religiosity — and too many shared demographic attributes — to justify this separation. We think it best to make this first run of projections disaggregating only by Jewish/Other and Arab Israelis — there is very little movement between these two groups, and group-specific measures of fertility and mortality are easily available for both — and only then divide the Jewish/Other category by levels of religiosity. We will leave the latter for a later elaboration.[3]

In terms of total population in Israel, the central finding of our projections is that they fall on the high side relative to Paltiel's estimates — somewhere between their median and high scenarios, though closer to the latter. However, they fall on the low side relative to the most recent projections in the *Statistical Abstract of Israel* (CBS, 2019a), somewhere between the low and median scenarios.

The main body of this paper is divided into two sections. In the first, we describe the underlying assumptions regarding the three parameters that affect the projected population: future age-specific mortality, fertility, and

2 Barring unforeseen crises (medical, military, environmental) that would suddenly increase mortality or stimulate significant in- or out-migration, the main problem confronting demographic projections in the longer-term is what to assume about future fertility. The fertility patterns of Jewish Israelis, in particular, are quite unusual — and therefore puzzling — in demography (see Weinreb, Chernichovsky & Brill, 2018), making it more difficult to forecast with any real confidence. We return to this below.

3 A first version of this will appear in a forthcoming Taub publication projecting the number of Israelis entering higher education between now and 2040 (Weinreb et al., 2021).

migration rates. We end this section by outlining six projection scenarios, based on variability in those parameters. In the second section, we discuss the projections themselves, presenting basic results for all six scenarios and detailed results — focusing on specific age groups — based on what, in our view, is the most likely scenario.

1. Assumptions

Mortality

Age-specific mortality rates (ASMRs) are one of the core components of demographic projections. These tell us the proportion of people that die at any given age, which is almost always the principal way in which people leave a population (the other is migration).

Since ASMRs differ across major population groups, and by sex, it is standard practice in demography to identify discrete ASMRs by subpopulation and sex, then project those ASMRs into the future. For example, to identify the percentage of Jewish 30–year-old men that will survive to age 38, we subject them to the ASMR for Jewish men aged 30, 31, 32, etc, up to mortality at age 37. Yet, this also demands that we forecast what the ASMR of 31-year-olds will be in a year, ASMR of 32-year-olds in two years, and 37 year olds in seven years. The longer the time horizon of the projection, the further into the future we have to project changes in ASMRs, and the greater the likely error term in our projection.

The standard method of forecasting future mortality is to use the Lee-Carter model. Very simply, this model identifies a vector that captures up to 90 percent of a mortality trend over a long historical time series. It then projects that vector forward as a “random walk” with trend, assuming constant long-term mortality reduction.

In these projections, given that our projections are limited to little more than 20 years and, more importantly, that gains to life expectancy in most developed countries over the last few decades — including Israel — have been fairly constant year after year, we do not use the Lee-Carter model.[4] Instead, we employ a simpler method. Disaggregating the population into four subpopulations — by gender and into Jewish/Other and Arab Israeli sectors — we estimate the annualized change in age-specific mortality rates (ASMR) between 2007 and 2015 for every age group up to 89. For ages 90 to 94 and 95+, ASMRs were not available before 2012, so we estimated the annualized rate of change for the 2012 to 2015 period.

These annualized rates of change for five-year age groups are presented in Table 1.[5] They show continued reductions in ASMRs across all four subpopulations and almost all ages, pointing to ongoing gains in population health. Yet there is also some variability across the four subpopulations. Among Jews, men's ASMR fell more sharply than women's at all ages below 55 (the exception is ages 1–14) and less sharply at all ages 55 or over. Among Arab Israelis, men's ASMR fell more sharply in only seven age groups, with no distinct age pattern in this difference. Likewise, among both males and females, there were faster reductions among Jews than Arab Israelis in 13 of these 21 age-groups, and slower in seven age-groups.

4 The Lee-Carter method was designed for long-term forecasting, extrapolating future trends from a long historical series. In their comparison of the original Lee-Carter method and a few later variants, Booth et al. (2006) point to problems with random walk models (p. 305) based on long-time horizons, arguing that where "a longer fitting period is not advantageous, the heavy data demands of the Lee-Carter method can be somewhat relaxed" (p.290).

5 To clarify, we use single-year estimates for this projection input. However, our estimates of change in age-specific mortality rates use five-year age groups. This is the only way to avoid fluctuations in estimated rates of change that arise from the fact that Israel has both a small population and very low mortality, especially at young ages. Small temporary spikes in mortality can therefore significantly influence the annual mortality estimate and, therefore, estimates of change in mortality across time.

Table 1. Annualized change in age-specific mortality rates, 2007–2015

	Jews/Others		Arab Israelis	
Age	Men	Women	Men	Women
0	-0.034	-0.030	-0.024	-0.016
1–4	-0.025	-0.044	-0.039	-0.022
5–9	-0.044	-0.064	-0.017	0.019
10–14	-0.037	-0.048	0.007	-0.023
15–19	-0.042	-0.037	-0.004	0.007
20–24	-0.045	-0.031	-0.048	-0.063
25–29	-0.024	-0.022	-0.034	0.014
30–34	-0.027	-0.012	-0.009	-0.013
35–39	-0.044	-0.026	-0.002	0.005
40–44	-0.043	-0.033	-0.011	-0.015
45–49	-0.042	-0.036	-0.027	-0.020
50–54	-0.021	-0.013	-0.026	-0.036
55–59	-0.016	-0.023	-0.009	-0.033
60–64	-0.012	-0.018	-0.023	-0.035
65–69	-0.024	-0.025	-0.024	-0.029
70-74	-0.027	-0.033	-0.025	-0.022
75–79	-0.027	-0.031	-0.022	-0.031
80–84	-0.016	-0.021	-0.015	-0.025
85–89	-0.037	-0.054	-0.029	-0.047
90–94*	0.014	0.001	0.021	0.007
95+*	0.009	-0.002	-0.022	0.034

Note: Annualized change 2012–2015.
Source: Alex Weinreb, Taub Center | Data: CBS, 2019a

These reductions are consistent with those of other low-mortality/high life expectancy countries, especially in the Mediterranean region. They are also consistent with the most recent projections from the Global Burden of Disease project (Foreman et al., 2018), which also expects Israel's age-specific mortality to continue to fall over the next 20 years.[6] That said, these reductions provide a more mixed picture about convergence between women and men, and between Jews and Arab Israelis. In most ages, reductions in mortality will be greater among women than men, and among Jews than Arab Israelis.

6 Note that not all OECD countries are expected to be on this trajectory. The US is the most notable exception — life expectancy was 78.9 in 2013 and 78.8 in 2018 (Woolf & Schoomaker, 2019). There are also worrying signs in the UK, which has experienced virtually no gains in life expectancy since 2011 (Raleigh, 2019).

We apply these rates of change in ASMRs up to 2040 to each of these four subpopulations in two ways, allowing us to tap into a longstanding debate within demography about how long mortality rates can continue to fall, and how quickly. Thus far, skeptics have been repeatedly proven wrong. In the highest life expectancy countries — a “maximum life expectancy” club that includes Israel — life expectancy has continued to increase at a fairly consistent rate. The first scenario assumes that this trend will continue in Israel for the next two decades, in other words, that the ASMR will continue to change at the same pace as in the 2007 to 2015 period.

The second scenario taps into concerns that rising Israeli morbidity in younger ages — due especially to the rapid rise in obesity and diabetes — will slow the pace of mortality reduction. This scenario assumes that the ASMR will change at only half the pace of the 2007 to 2015 period.

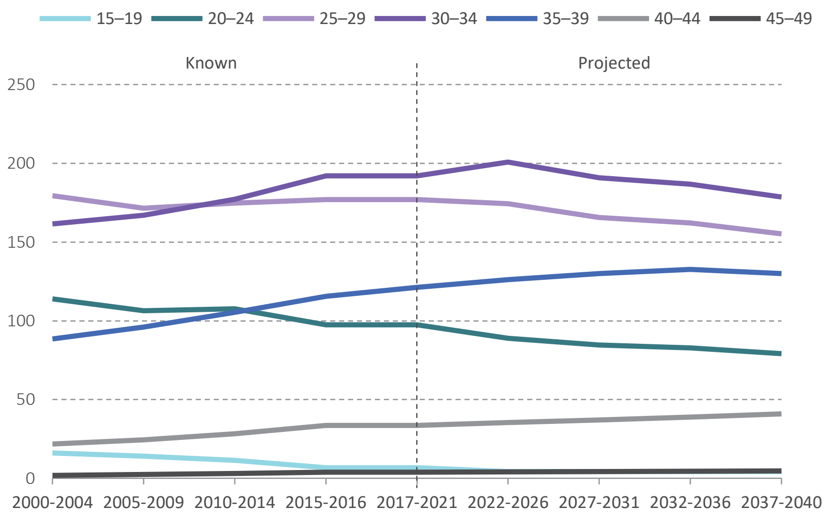
Fertility

Age-specific fertility rates (ASFRs) are a second core component of demographic projections. Multiplied by the number of women in each age group, they tell us the number of births in any given year. Births are almost always the principal way in which populations grow (the other is migration). In Israel, unlike in most developed countries, there is a substantial excess of births over deaths that accounts for about 80 percent of annual population growth.

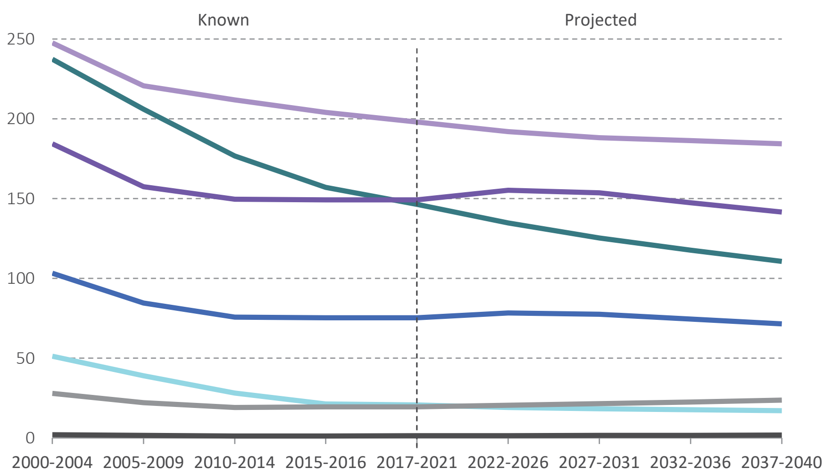
Figure 1 presents the ASFR for the Jewish/Other women (Figure 1a) and Arab Israeli women (Figure 1b). In each panel, the lines on the left side of the vertical line are the known ASFRs for each population from 2000 to 2016, aggregated into the 5-year rates with the exception of 2015 to 2016. Lines on the right side of the vertical line are the ASFRs used in our main projection (Scenario 1).

Figure 1. Age specific fertility rates, births per 1,000 women

a. Jews/Others



b. Arab Israelis



Source: Alex Weinreb, Taub Center | Data: CBS, *Statistical Abstract of Israel 2017*, Table 3.13

Among Jewish women since 2000, there have been significant reductions in ASFR in the under-25 age range, stability in the 25–29 age range, and substantial increases in ASFR in the 30–44 age range. The main projection (Scenario 1, described below) assumes that these trends will continue — albeit with a reduction in the rate of increase — for the next 10 years or so, and then start to fall (25–34), or stabilize (40–44). The only exception to this is the 35–39 age group, where we expect continued slow increase, reflecting increasing delays in childbearing and single parenthood. These trends are documented and discussed in prior Taub research (Weinreb, Chernichovsky & Brill, 2018).[7]

Among Arab Israeli women, the reductions in ASFR since 2000 have extended across all age groups, though they have been particularly sharp among women under age 30. Given the ongoing increases in Arab Israeli women's education and employment, we expect these trends to continue, though at a slower pace. We also expect to see increases in delayed childbearing — hence the projected stability, and even moderate increase, in fertility rates in the age 30–44 age groups.

To generate lower and upper bounds for fertility, projections were replicated with two additional scenarios (in addition to the one just discussed). One assumes a sharper reduction in ASFRs in women's 20s, and the second completely stable ASFRs.[8] The ASFRs of these three scenarios are used to generate the Total Fertility Rates presented in Table 2. In the main Scenario 1, there is relative stability in TFR in the Jewish population for the next decade, then a slight reduction, falling below 3.0 by the late 2030s. In the Israeli Arab Israeli population, in the meantime, there is a deceleration in the pace of fertility decline, though continued reductions, with TFR falling to 3.0 in the next decade, and to 2.75 by the late 2030s. These declines are in line with those in neighboring Arab states.

7 Note that these projected reductions in fertility take into account the increasing percentage of women in the Israeli population that are Haredi or very religious. In other work, we have shown that Haredi women's fertility has fallen somewhat over the last 10 years. Given ongoing increases in Haredi women's education and employment, limitations on their husband's employment, in addition to changes in consumption patterns and cost of living, we expect a continued downward trend in Haredi TFR.

8 The assumption of stable age-specific fertility rates is not a reasonable one. We use it to highlight how fluctuations in the number of women of reproductive age can influence the number of births.

Table 2. Actual and projected total fertility rates, by year, sector, and scenario

Given the assumed trends in age-specific fertility rates

Scenario		2010–2014	2015–2016	2017–2021	2022–2026	2027–2031	2032–2036	2037–2040
1 Slow fertility reduction	Jews/Others	3.04	3.13	3.16	3.17	3.08	3.06	2.96
	Arab Israelis	3.31	3.14	3.05	3.01	2.93	2.84	2.75
2 Fast fertility reduction	Jews/Others	3.04	3.13	3.13	3.14	2.95	2.83	2.74
	Arab Israelis	3.31	3.14	3.05	2.97	2.85	2.73	2.63
3 Stable fertility	Jews/Others	3.04	3.13	3.13	3.13	3.13	3.13	3.13
	Arab Israelis	3.31	3.14	3.14	3.14	3.14	3.14	3.14

Source: Alex Weinreb, Taub Center | Data: Calculated from specific population tables

As noted above, the number of actual births is the sum of age-specific fertility rates multiplied by the number of women in the associated age group. This means that even if the ASFR were to remain constant over the next 20 years (Scenario 3, Table 2), differences in age-structure of women's Jewish and Arab Israeli populations up to age 50 — mainly reflecting prior fertility in these populations — would themselves lead to fluctuations in the number of births. Evidence of these fluctuations in age structure can be seen in Figures 2a and 2b, which graph, respectively, the number of Jewish and Arab Israeli women by single years of age in 2017, from age 0 to 50. By comparing the relative size of cohorts we see that in 2037 there will be roughly the same number of women aged 20 in the Arab Israeli sector as there were in 2017 — when the latter were aged 0. In the Jewish sector, in contrast, there will be far more women aged 20 in 2037 than there were in 2017. Differences in the number of births will follow from this difference in cohort size. We describe these age structure effects in greater detail below.

Figure 2. Age structure, females, ages 0–50, 2017

a. Jews/Others

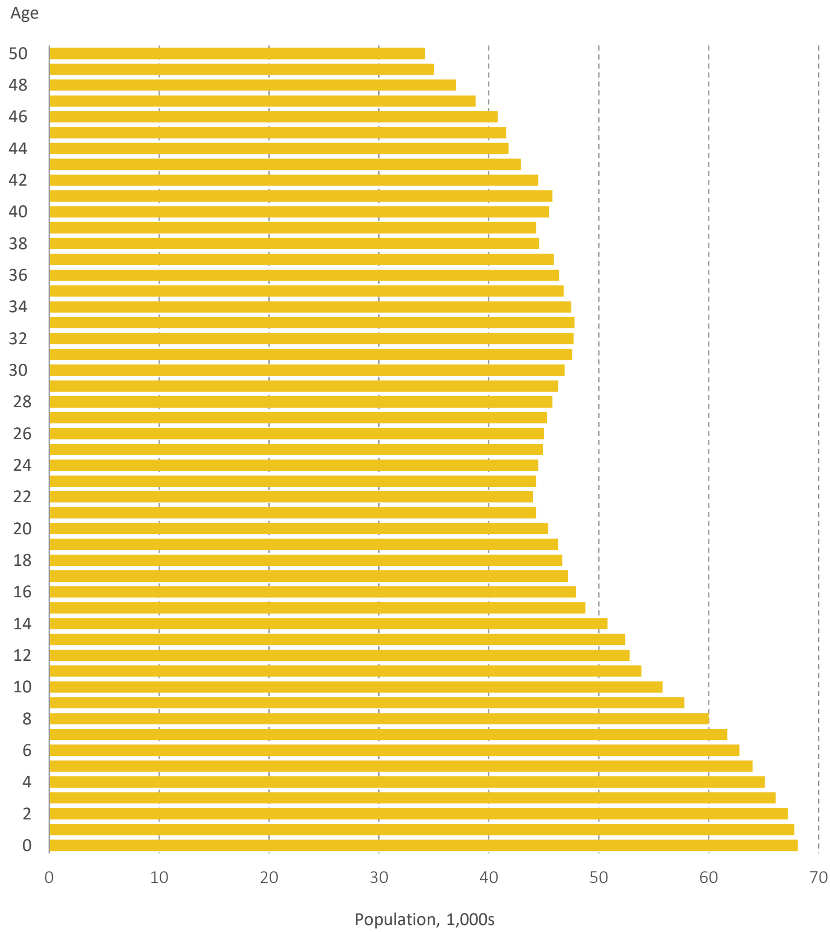
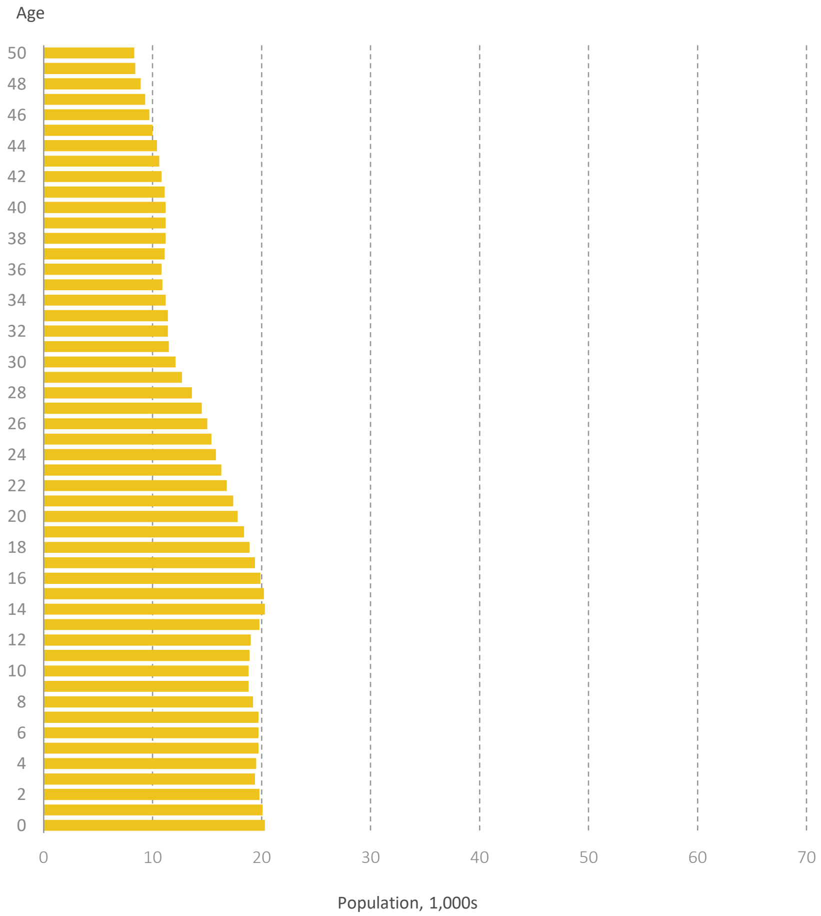


Figure 2 (continued). Age structure, females, ages 0–50, 2017

b. Arab Israelis



Source: Alex Weinreb, Taub Center | Data: CBS, *Statistical Abstract of Israel 2018*

Migration

Migration is typically the worst measured component of demographic change (Preston, Heuveline & Guillot, 2000, p. 133). Whereas births and deaths are singular events that can occur only once to each person, and are, in most cases, easily recorded in modern states' vital registration systems, migration can occur once or multiple times, at any (or many) points in a life-course, can be in a single direction to a single country or to multiple countries, and it can also involve "circular migration" with returns to one's country of origin. Variation in legal and administrative definitions of different types of movement further complicate measurement. For example, migration can be legal or "undocumented," or involve changes in status associated with transitions between labor migration, marriage migration, tourism, or refugee movements. Likewise, at the population level, migration is difficult to forecast because it is so easily affected by historical events that are largely unforeseen and unforeseeable. For example, no demographic projection in the 1980s or 2000s included, respectively, the large-scale movements of Russian Jews into Israel in the early 1990s, or Middle Eastern refugees into Europe in the 2014 to 2016 period.

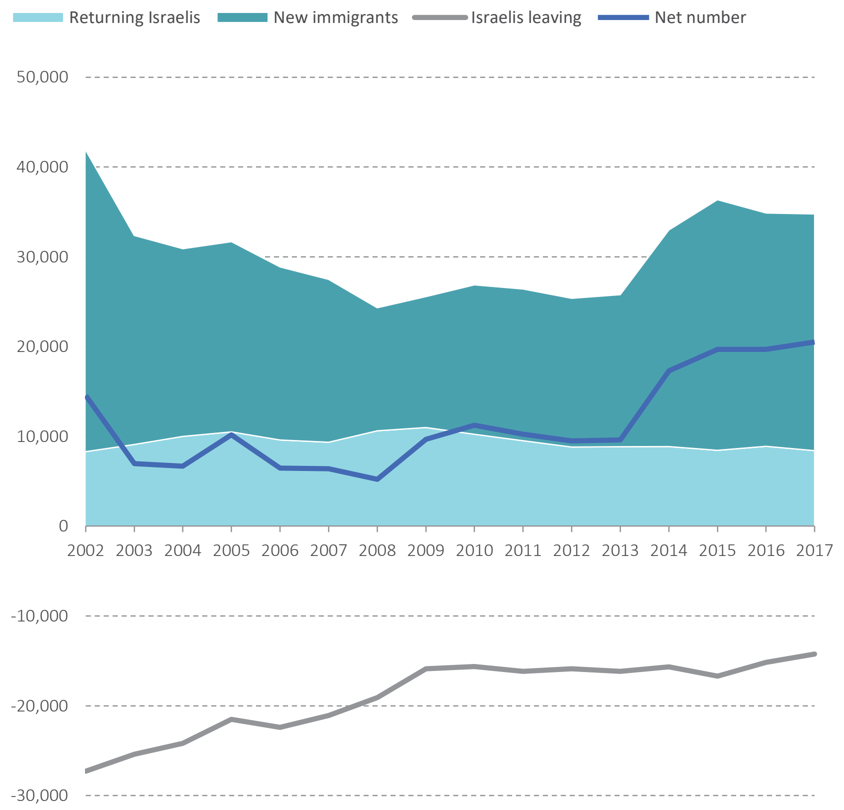
Paltiel et al.'s (2012) projections assume a "closed population." This means that they ignore migration, preferring "a clean estimate of the influence of natural growth (births minus deaths)" (p.8). This means that they implicitly assume net zero migration, with the same number of people leaving Israel as moving to it. Our projections take a different approach, closer to that of Shvadron and Avramson (2017), for two reasons.

First, as shown in Figure 3, which graphs the number of new immigrants coming into Israel, in addition to returning Israelis and Israelis leaving Israel (defined as being outside Israel for at least one year), the net number of in-migrants to Israel is positive and increasing. In the first decade of this century, that net number hovered around 6,000–7,000 in most years, dropping to 5,225 in 2008. In most of those years, more than 20,000 Israelis left the country every year, even if a substantial portion of these were former immigrants — five times more likely to leave than veteran Israelis in the early 2000s (Hason, 2006), and accounting for 55 percent of all leavers 2017 (CBS, 2019b). By the 2010 to 2013 period, however, the net number of in-migrants had increased to the 9,000–11,000 range, and since 2015 it has exceeded 19,000 per year. Across the total 2002 to 2017 period, that is a net gain of 184,000 people. Yet that number in itself understates the full demographic impact of this in-migration, since migrants are disproportionately young or prime-age adults, meaning that a substantial number of these 184,000 migrants will give/have given birth to children in Israel. Nor is it likely that this net number will change dramatically in the near future: a combination of economic stagnation, political instability, or antisemitism in many other countries with significant Jewish populations — Argentina, Ukraine, France, the UK — will drive continued migration to Israel, especially as Israel's economic growth continues to outpace the OECD average. Indeed, over the first 10 months of 2019, there was a 20 percent increase in in-migration rates over the same period in 2018, pointing to an ongoing increase in this trend (CBS, 2019c).

This last point touches on the second reason for incorporating migration into the current projections. Israel has become increasingly appealing to other groups of migrants. As of 2017, there were around 67,000 workers in Israel who had entered the country as tourists, around 99,000 labor migrants with temporary residential status in Israel, and around 37,000 people who claimed asylum (CBS, 2018). Even if only a small portion of these 200,000 people stay in Israel — a tiny percentage of asylum seekers given official authorization, a larger number of the tourists and workers marrying Israelis — that would also act as a net contributor to Israeli population growth. Moreover, the increasing use of bilateral labor migration agreements for care of the elderly, construction and agricultural sectors, in addition to more recent calls to allow for skilled migrants in high tech fields, alongside ongoing increases in tourism — including Israelis traveling to other countries — will inevitably lead to more interpersonal connections that, in turn, lead to romantic relationships and marriage.[9] Given Israel's economic status relative to most of these migrants' countries of origin, that will result in at least some permanent movement into Israel as opposed to out of Israel.

9 Between 2014 and 2018, the number of international visitors to Israel increased from 3.251 to 4.389 million (CBS, 2019d).

Figure 3. Number of new immigrants, returning Israelis, and Israelis leaving Israel, by year



Source: Alex Weinreb, Taub Center | Data: (top) CBS, Publication 242/2019, Tables 1 and 4; (bottom) CBS, *Statistical Abstract of Israel 2018*, Table 206

Our projections use two migration scenarios. The main projection (Scenario 1) assumes the following:

1. A net gain of 20,000 migrants and returning Israelis each year, divided equally by sex, with 19,000 assigned to the Jewish population, and 1,000 to the Arab Israeli population, in each case distributed proportionately across the 0–90 age group. This number approximates the minimum net number

of migrants entering Israel since 2015, alongside the assumption that the increasing geographic mobility of young Arab Israelis — there have been a sharp rise in the number of Arab Israelis studying outside Israel (Waked, 2018) — will generate some in-migration of spouses.

2. A gain of 1,400 others each year. These include labor migrants, tourists, and asylum seekers, divided 60:40 women:men, 90 percent assigned to the Jewish/Other population, and distributed proportionately across the population aged 20–44.[10]

In terms of overall impact on the projections, the first of these items is clearly the most important, having both direct and indirect (through fertility) effects on the future population. But at least conceptually it is important to try to capture some of the other lesser movements into Israel, too.

A second projection model was run without any migration. Comparing this model to others allows us to evaluate how much migration contributes over time to the Israeli population, including through indirect effects of migrants' fertility.

10 The contribution of these 1400 individuals to the overall projection is so small that whether they are assigned in a 50:50 female:male ratio or a 60:40 ratio, makes absolutely no difference to the gist of the projections. We assume a 60:40 ratio based on two main ideas. First, gender differences in labor in-migration patterns into Israel vary significantly by industry. Over the last few years, most labor migrants have entered Israel officially through bilateral agreements regulating their employment in three key industries: construction, agriculture, and care of the elderly. The last of these groups, by far the largest, is disproportionately female — in 2016, 80 percent of migrant workers from Sri Lanka, a major sending country of carers, were women (Kushnirovitch & Raijman, 2017), which makes sense given that most elderly in need of care are women, and women are much more likely to be cared for by female carers. We therefore assume that even if the rates of remaining are the same for migrant men and women, there are simply more women migrants, so more will stay. The second factor underlying the 60:40 ratio is that post-marital international migration patterns also tend to be patrilocal — i.e., women moving toward the husband's family instead of the wife's. In other words, if Israelis meet people overseas, Israeli men will be more likely to bring non-Israeli female partners back to Israel than is the case among their Israeli women counterparts.

2. Six projection scenarios

The range of assumed values of future levels of mortality, fertility and migration are combined in six discrete projection models:

Scenario 1 — The main model: Assumes mortality change in accordance with data in Table 1, fertility reduction in line with first two rows in Table 2, and migration parameters described in the prior section.

Scenario 2 — Slower pace of mortality change: Fertility and migration assumptions are the same as in Scenario 1, but we assume mortality change is at half the speed of Table 1.

Scenario 3 — Zero net migration model: Mortality and fertility assumptions are the same in Scenario 1, but we assume zero net migration.

Scenario 4 — Slow mortality change and no migration: Combines the assumption of slow mortality change in Scenario 2 with zero net migration of Scenario 3, and fertility reduction in accordance Scenario 1.

Scenario 5 — Faster fertility reduction: Assumes ASFRs associated with the third and fourth rows in Table 2, and mortality and migration in line with Scenario 1.

Scenario 6 — No fertility reduction: Assumes ASFRs associated with the final two rows in Table 2, and mortality and migration in line with Scenario 1.

3. Projections

Current age structure

Before describing the mechanics of the projection, it is helpful to point to a key insight of demography as a discipline: the age structure of a population — that is, the relative size of different age cohorts — reflects that population's past, and that this in turn shapes its future. We have already touched on this in relation to fertility. Before proceeding to the actual projections, we expand on this, since "echo" effects associated with bulges and depressions in the current age structure will have important effects on Israel's population in the future.

Figure 4 presents the age structure of Israel's male and female population, by Jewish and Arab sectors, using data from mid-year 2017. We see that both sectors have characteristic age structures of growing populations, with much larger cohorts at younger than older ages. There are, for example, about

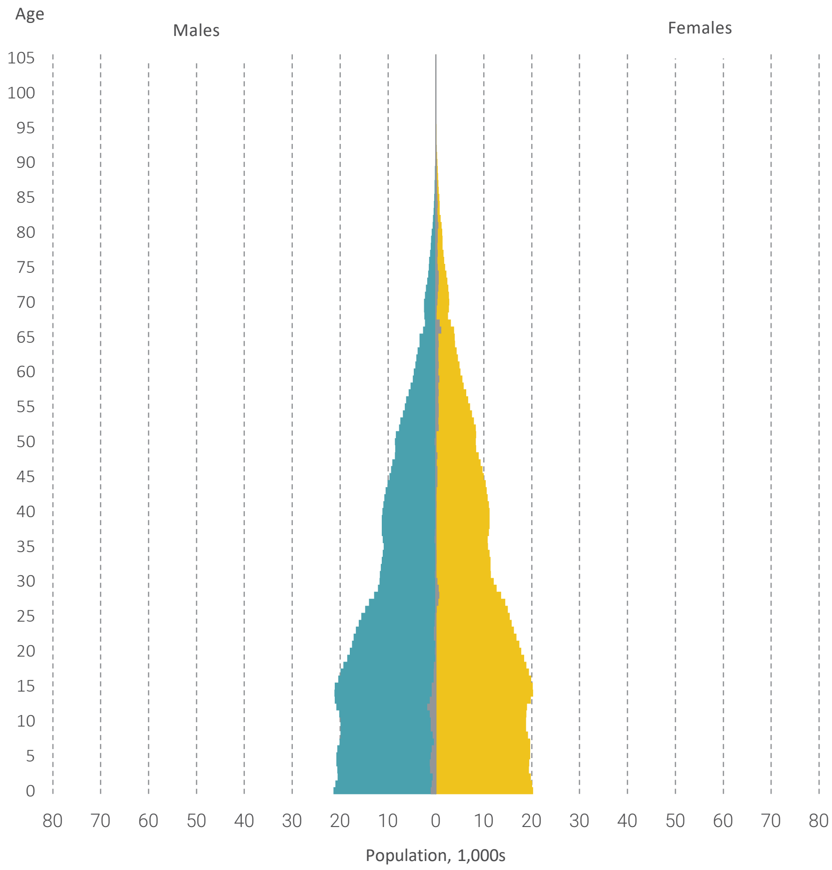
140,000 infants in the Jewish sector (age less than 1), relative to about 94,000 people aged 35, and 60,000 people aged 70. The equivalent numbers in the Arab sector are 42,000, 22,000, and 5,300, pointing to an even younger population.

Figure 4. Age structure, mid-year 2017

a. Jews/Others

Figure 4 (continued). **Age structure, mid-year 2017**

b. Arab Israelis



Source: Alex Weinreb, Taub Center | Data: CBS, *Statistical Abstract of Israel 2018*

Likewise, in both populations we see the expected excess in males at younger ages — reflecting the standard sex ratio at birth of around 105 males per 100 females — before a gradual reversal in that ratio, leading to an even larger excess of elderly women, especially in the Jewish sector. This change in sex ratio across the life course reflects higher age-specific mortality rates among men than women at almost every age. The cumulative effect of these differential rates is the reason that women's life expectancy is higher than men's.

Here we point to three notable differences in age structure between the Jewish and Arab populations. Later we show how each leaves its mark on the projected future population.

First, the Jewish population has grown at a slower pace overall, but more steadily. Over the last 20 years, in particular, each successive birth cohort in the Jewish population has been larger than its predecessor. This is not the case in the Arab Israeli population. There we see a sharp reduction in the number of births, beginning in 2004, which has led to relative stability in the size of birth cohorts over the last 15 years. This means that whereas the ratio of children aged 0–4 to those aged 10–14 is 1.26 in the Jewish population, it is only 1.03 in the Arab Israeli population.

A second difference is that whereas the Jewish population has distinct waves, with “echo” effects every 30 years or so, the Arab Israeli age pyramid looks more stable, at least for people born between the 1930s and early 2000s. The differences in these patterns across these two subpopulations reflect their distinct histories. The large age bulge among 55–70-year-olds in the Jewish population are a product of a post-WWII baby boom, massive in-migration of children and youth into Israel in the early years of statehood, and the large migration of prime-age adults (25–50) from the Soviet Union in the early 1990s. The first echo of that initial bulge — people aged late 20s to early 40s — are the children of those older individuals. Likewise, the more recent echo — the bulge extending from age 3 to early teens — are the grandchildren of the initial bulge, though their higher number also partly reflects the marginally higher fertility rates of the non-Haredi Jewish population, mentioned above.

In contrast, there has been little in-migration into the Arab population, so its age structure primarily reflects fluctuations in fertility. There are small temporary reductions associated with the immediate aftermath of the War of Independence and the Six-Day War, a sharper though temporary fall in the early 1980s, and then the most recent reductions since 2004. Note that the drop in TFR in the Arab sector over the last 15 years has been sharp enough to outweigh the rapid increase in the number of women entering reproductive ages, leading to relative stability in the number of children born.

The third notable age-structure difference between the Jewish and Arab Israeli populations is the relative impact of aging in these communities. We can see more direct signs of this in Table 3. In 2017, whereas 7.7 percent of Jewish men and 10.1 percent of Jewish women were at least 70 years of age, the same was true of only 2.6 and 3.3 percent of Arab men and women.

This also affects the relative size of cohorts in both populations. Thus, for every Jewish man and women aged 55–59, there were 1.58 men and 1.38 women aged 15–19. In the Arab Israeli population, the equivalent ratios were more than double: 3.33 for men, and 3.08 for women.

Table 3. Selected statistics from the *Statistical Abstract of Israel 2017*

	Jews		Arabs	
	Men	Women	Men	Women
Percentage of population aged 70+	7.72	10.06	2.64	3.33
Ratio population aged 15–19: 55–59	1.58	1.38	3.33	3.08

Source: CBS, *Statistical Abstract of Israel 2017*

The mechanics of the projections[11]

For illustrative purposes, we first focus on Jewish males. We take the mid-year (i.e., June 30) population of Jewish males in Israel in 2017, divided into single ages. To estimate the mid-year population of Jewish males in 2018 we subject each age group of Jewish males to its age-specific mortality rate in 2017 from age 0 to 105, while also adding the expected number of (net) in-migrants at each age. We then add the number of Jewish/Other male births plus a small number of infant in-migrants, reducing the latter by expected infant mortality rates in the first six months (assuming 75 percent of infant mortality rate between birth and age 1).[12] We repeat each of these steps for each year up to 2040, generating year-on-year population estimates by age. We then replicate the whole series of steps for each of the other three subpopulations — Jewish women, Arab Israeli men, Arab Israeli women.

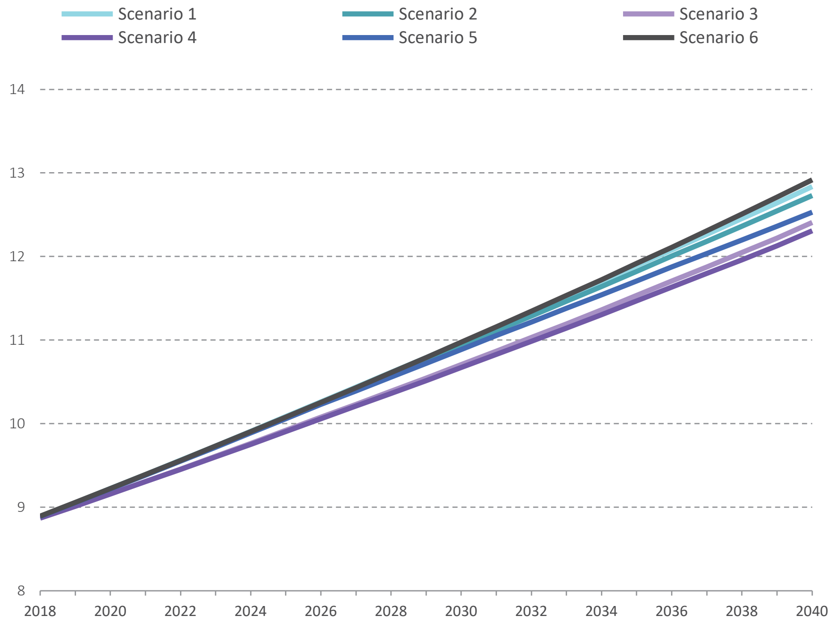
They suggest that Israel's population will increase from around 9.05 million in mid-2019 (projection from 2017) to 12.83 million in 2040, with the annual

11 The projections are described in more formal terms in Appendix 1.

12 Mortality before age 1 occurs disproportionately in the first few months. Here we assume that infant in-migrants arrive on average at age 6 months, so should be subject to only a portion of the age-specific mortality rate for age 0–1.

growth rate falling from 1.87 percent to 1.52 percent across that period.[13] This projection is graphed as the lightest blue line (Scenario 1) in Figure 5.[14]

Figure 5. Projected population of Israel, 2018–2040, by scenario



Source: Alex Weinreb, Taub Center, Population projections

Estimates based on other projection scenarios described above — allowing for a more modest reduction in mortality, assuming sharper fertility reduction or, unrealistically, setting migration to net zero and fertility as stable with no reduction at all — change the overall estimated population. Putting aside these last two (Scenarios 4 and 6), the projected overall size ranges from 12.4 to 12.8

13 The full projections by single age and year for Scenario 1 are made available in online Appendix 3.

14 In comparison, Israel's 2018 *Statistical Abstract* projects 13.22 and 12.27 million in 2040, respectively, in its medium and low variants, and Paltiel et al. (2012) projected 13.55 and 11.95 million, respectively, in its high and medium variants of 2040 (interpolated from the pace of change between the 2039 and 2044 projections).

million. In each case, this also leads to a slight reduction in the proportion of the population that is Jewish: from 79.0 percent to 77.7 percent in Scenario 1, with similar reductions in the other scenarios.

However, the different scenarios do not substantively change the compositional shifts in the population that are our central interest here. Signs of these changes can be seen in Figure 6, which graphs the projected age structure of the population in 2017, 2027 and 2037 using the Scenario 1 projections. We focus on three main findings.

Figure 6. Projected age structure of population in 10-year intervals, 2017–2037

a. Jews/Others

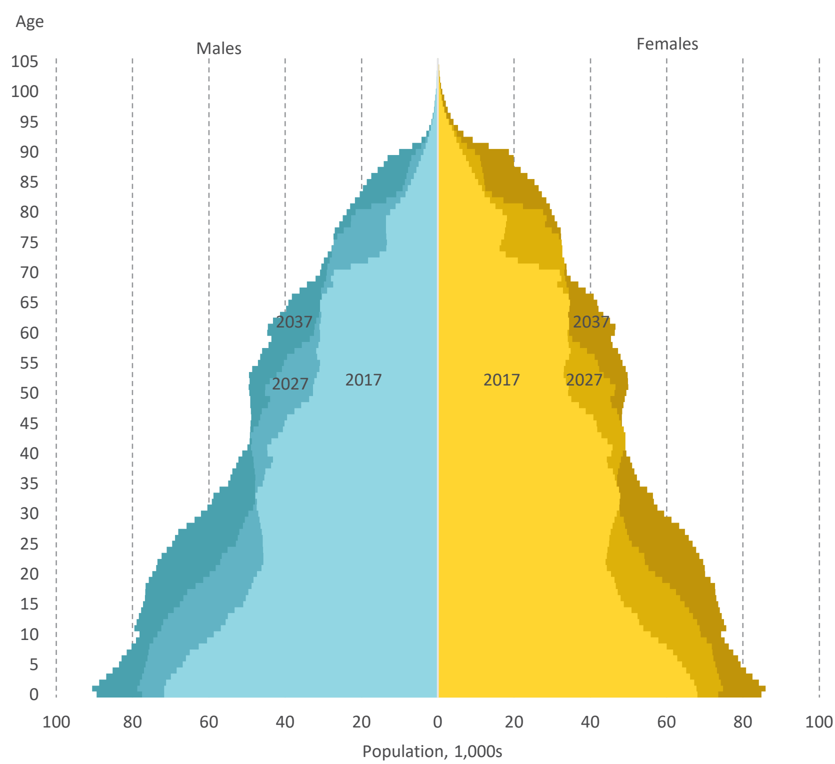
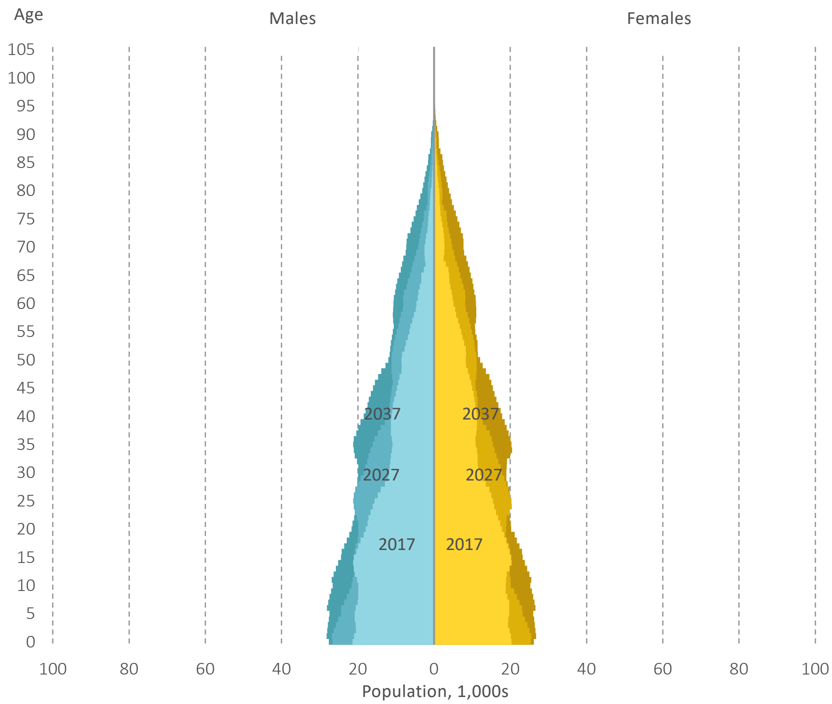


Figure 6 (continued). Projected age structure of population in 10-year intervals, 2017–2037

b. Arab Israelis



Source: Alex Weinreb, Taub Center, Population projections

4. Main results

The elderly population

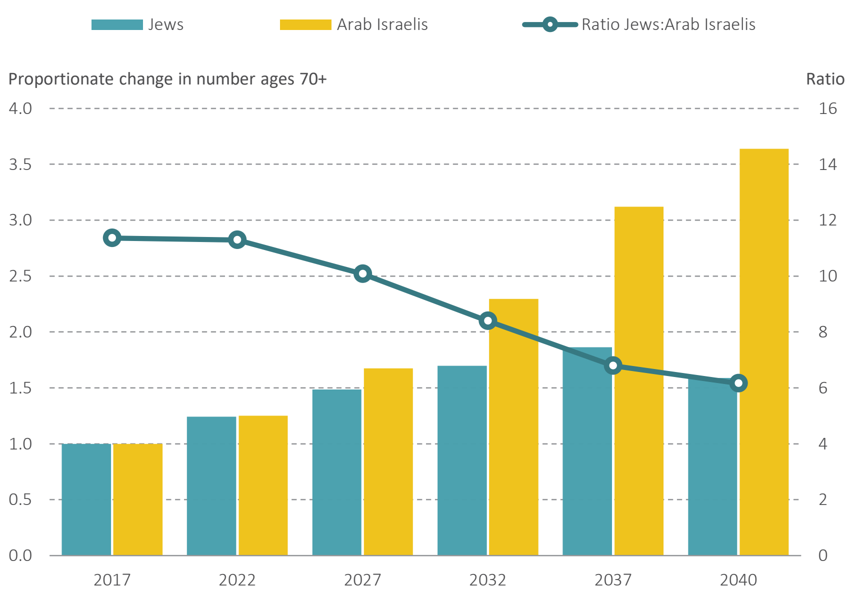
There will be substantial growth in the population older than 70: from 669,000 in 2017 to 1.326 million in 2037 (and 1.411 million in 2040). The pace of aging will be rapid for the next 15 years, driven by the large age bulge among current 55 to 70-year-olds in the Jewish population, discussed above. It will then slow in the mid-2030s, and remain quite slow until the prime-age bulge — currently in their 30s and early 40s — begin to age into their 70s in the late 2040s.

Note, too, that this population of people older than 70 will be disproportionately female, though marginally less so over time as ongoing reductions in male mortality push more men past that threshold: the ratio of women to men in the 70+ age group is projected to fall from 1.34 to 1.30 among Jews/Others and from 1.23 to 1.18 among Arab Israelis.

More notable, as shown in Figure 7, the pace of growth in the aged will be much higher among Arab Israelis than Jews. Among Jews the population aged 70 or above will increase 88 percent, from about 615,000 to 1.214 million. Among Arabs, it will increase almost four-fold, from 54,000 to 197,000. These different rates of growth will transform the relative numbers of elderly in the two sectors. Whereas in 2017 there were 11.4 Jews aged at least 70 for every Arab Israeli of the same age, by 2040, that ratio will shrink to 6.2. This change points to emerging issues regarding elderly work and welfare in the Arab Israeli sector over the next couple of decades.

Figure 7. Proportionate change in the size of population aged 70+

In 5-year intervals, by sector



Source: Alex Weinreb, Taub Center, Population projections

Children

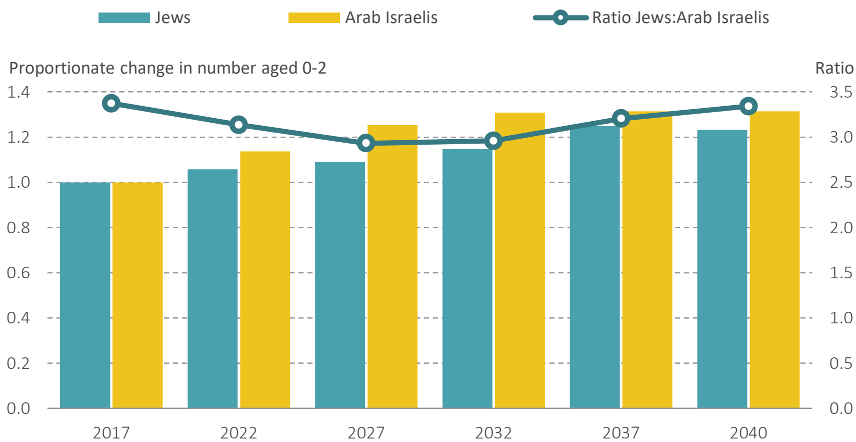
Moving to the other end of the age distribution, we see an initial slowdown in the rate of growth of the number of children born over the next 10 years in the Jewish sector, despite our assumption that age-specific fertility rates will remain relatively unchanged. The cause of the slowdown is the relatively small number of women in their early- and mid-20s entering peak fertility ages of late 20s and early 30s. By the early 2030s, however, this will change, giving rise to a more rapid increase in the annual number of births in the Jewish sector.

Trends look quite different in the Arab Israeli sector. The large cohorts born from the late 1980s to early 2000s have now begun to enter peak ages of fertility. Even with ongoing reductions in the age-specific fertility rates, this will generate substantial increases in the number of children born in the sector, which will only begin to taper off as the smaller successor cohort — currently aged 0 to early-teens — matures into their mid-20s and 30s.

In Figure 8, these trends are combined, expressed as both proportionate growth in the number of children aged 0–2 in 5-year intervals, and the ratio of these children between the Jewish and Arab Israeli sectors. The figure confirms the faster initial increase in the Arab Israeli sector, leading to a sharp reduction in the ratio of Jewish to Arab Israeli children between 2017 and 2027 — from 3.4 to 2.9 — before the relative increase in the number of Jewish women entering peak reproductive ages, and continued reductions in ASFR in the Arab Israeli sector, flip this ratio back up to 3.3 by 2040.

Figure 8. Proportionate growth in the number of children aged 0–2

In 5-year intervals, by sector



Source: Alex Weinreb, Taub Center, Population projections

The productive middle

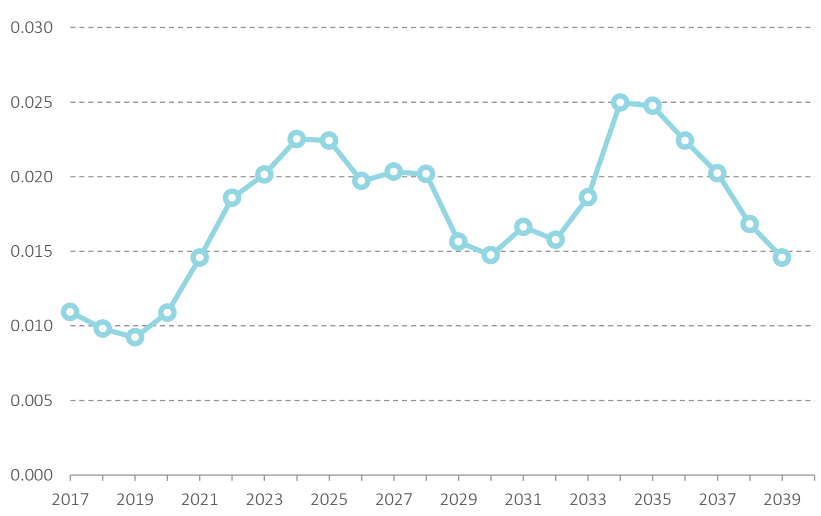
Moving to the middle of the age distribution, over the next twenty years, the prime-age bulge will age into its 50s, the peak productivity and earnings ages. The largest single-year birth cohort in this bulge is currently (2019) aged 35. They outnumber all younger birth cohorts in the 25–34 age group.

Although macroeconomic benefits associated with this large age bulge should not be considered a full "demographic dividend"[15] — there is merely a

15 A demographic dividend refers to a period in the demographic transition in which a large cohort of working age individuals support a relatively small number of elderly and small number of children. It generally occurs only once in a given population: when a cohort reduces its fertility to around or below replacement. Because that working-age population greatly outnumbers the number of elderly and has relatively few children to support, there is more money to support other things in the economy: government investments in infrastructure that has little to do with children or the elderly, public and private investments in human capital, consumer spending on leisure, etc. On the flipside, when that larger cohort is un- or underemployed, it can become both an economic and political drag on the country. From this perspective, it is likely not a coincidence that the large cohort currently centered around age 35 was in its mid- to late-20s during Israel's 2011 ("Cottage Cheese") social protests.

delay until the next bulge of children — the surfeit of people in their early 30s over people in their late 20s has implications for consumption, economic growth in general, taxes, and housing stock. This is in addition to the implications for fertility already discussed. On the flipside, it also means that the year-on-year increase in the number of people entering the labor force — and the army and higher education — will increase over the next 15 years, relative to what it has been over the last several years. This can be seen in Figure 9, which graphs the annualized growth rate of the total (Jewish and Arab Israeli) population aged 25–29 for the 2017 to 2039 period. We see sharp increases in the early-to-mid 2020s to more than 2 percent per year — more than double the current 1 percent growth per year. In the late 2020s, this growth rate will slowly fall to around 1.5 percent — this is still a significant rate of growth in absolute terms — but then rapidly increase in the early 2030s, peaking by 2035 at 2.5 percent growth per year, before dropping sharply in the late 2030s. These are very significant rates of increase that will pose significant challenges to the Israeli economy in terms of higher education, employment, and housing.

Figure 9. Projected annual growth rates of the population aged 25–29, 2017–2040



Source: Alex Weinreb, Taub Center, Population projections

Conclusion

Israel’s population is exceptional in a number of ways. It has an unusual combination of very high fertility, very low mortality, net in-migration — though this has fluctuated dramatically over time — and substantial circular migration. These generate rapid rates of growth, with 80 percent from the excess of births and deaths, and the rest from net positive in-migration.

In the projections presented here, we have tried to move beyond merely showing that Israel’s population will increase from around 9.1 million today to approximately 12.8 million in 2040. Although that absolute number is important, it is equally important for social and economic policy to show how discrete age groups and subpopulations increase at different speeds and at different times over that period. This variation is a foreseeable product of current age structures in addition to likely rates of fertility, mortality, and migration.

In this vein, three key findings arise in these projections, irrespective of the specific scenario.

First, until the mid-2030s, there will be rapid growth in the population older than 70 among both Jews and Arab Israelis, with the pace of growth particularly strong in the Arab Israeli sector. This will demand a parallel increase in the amount of funds devoted to cash benefits and associated services for the elderly — from pension arrangements to home-based and institutionalized care to branches of geriatric medicine — before a slowdown in this expansion from the mid-2030s until the late 2040s.

Second, until about 2027, the number of young children in the Jewish sector will grow at a much slower rate than has been the case over the last 10 years. In fact, until then, the pace of growth in this age group will be faster in the Arab Israeli sector, even with continued reduction in Arab Israeli fertility rates. Only after the late 2020s will the rate of increase in number of children become higher in the Jewish sector. In either case, these different rates of growth have implications for the timing of investments in schools in the two sectors. It also has implications for the year-over-year increase in the number of people subsequently entering the labor force, higher education, and the housing market.

Finally, Israel is now entering a period with a relatively large cohort in its peak productivity and earnings years. As implied above, the excess size of cohorts in their early 30s over late- and mid-20s can act as a mild demographic dividend, assuming continued high rates of employment, and rising labor force participation in the Arab Israeli and Haredi sectors. Yet, on the negative side, this also means that there will be more pressure on the Israeli economy to provide enough labor opportunities and housing for the relatively large incoming cohorts currently in their teens. The concentration of poverty in the Haredi and Arab Israeli sectors makes it particularly important that Israel does not waste the opportunities associated with these large incoming cohorts.

Together, these projected changes across the age distribution will modify the child- and old-age dependency ratios over the next 20 years. By this we refer, respectively, to the number of children and elderly per working-age adult, conventionally understood as people in the 18–65 age range. Israel currently has the highest total dependency ratio in the OECD — that is the sum of child- and old-age dependency ratios. For every 100 working-age adults in Israel in 2019, there were 60.0 children aged 0–17 and 21.7 people aged 65 or more. The respective OECD averages (in 2015) were 35.0 and 25.1, yielding a total dependency ratio of 60.1. Our projections suggest that this total dependency ratio in Israel will continue to increase over the next several years, peaking at around 60.2 children and 24.2 elderly per 100 working-age adults in 2026, before stabilizing and falling marginally by 2040, by which time reductions in the child-dependency ratio (to 56.3 children:100 working-age adults) will have outweighed ongoing increases in the old-age dependency ratio (27.5 elderly: 100 working-age adults). All in all, however, these remain very high dependency ratios. Relative to their peers in other developed countries, the working-age population in Israel will continue to support more children and retirees.

These projections are not, of course, the final word on the near- and medium-term future of Israel's population. Forthcoming elaborations will focus on how these projections vary by educational status and religiosity, and how they intersect with other trends in marriage, co-residence, divorce and widowhood. Those elaborations will allow us to identify areas that require investment in much more concrete ways, and project the impact on the labor and housing markets.

For now, however, we return to our basic conclusion. By 2040, all signs point toward Israel's population falling in the 12.4 to 12.8 million range. Due to Israel's current age structure, that growth will occur at different speeds in different age-groups and subpopulations. We can anticipate those differential growth patterns within the population and we can use that to shape preemptive rather than reactive public spending on key services for Israel's rapidly growing population.

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Appendix

Cohort component projection model

The projections are estimated using a standard cohort component model applied discretely to Jews/Others and Arab Israelis, disaggregated by gender. The models include migration at all ages up to 90.

The baseline data is the mid-year population in 2017 (June 30) for each of these groups, by single year of age. We project each of them in single years to 2040, adapting methods described by Preston, Heuveline and Guillot (2000). For all ages 1 to 89, the projected population ***N*** aged ***x*** in year ***t+1*** is equivalent to the number of people aged ***x-1*** in year ***t***, plus half the number of net in-migrants aged ***x-1*** (in-migrants minus out-migrants) that arrived between ***t*** and ***t+1***, and half the net in-migrants that arrived age ***x***. This total sum of prior residents in year ***t*** and recent migrants is reduced by q_x the age-specific probability of death at age x (described in more detail below).

$$N_x(t+1) = \left(N_{x-1}(t) + \frac{I_{x-1}[t,t+1]+I_x[t,t+1]}{2}\right) \times (1 - q_x[t,t+1]) \qquad (1)$$

For all people in the 90-104 age range, the projected population assumes zero migration — that is, a closed population — so uses a simpler estimate:

$$N_x(t+1) = N_{x-1}(t) \times (1 - q_x[t,t+1]) \qquad (2)$$

Anyone surviving to age 105 is assigned a probability of death of 1.0.[16] At the other extreme of the age distribution, we use a different procedure. We estimate the number of people below their first birthday as:

$$N_0(t+1) = B[t,t+1] \times (1 - q_0[t,t+1]) + \frac{I_0[t,t+1]}{2} \qquad (3)$$

That is, the number of people aged 0-1 is equivalent to the number of births, ***B***, between ***t*** and ***t+1***, reduced by an infant mortality rate q_0, and augmented by net in-migration of infants. Here we also see the dual impact of migration

16 Since we are projecting in single years and not estimating life expectancy, we ignore person-years lived within each of these age groups, implicitly assuming equal distribution of mortality in both halves of the year.

on population growth, since the number of births ***B*** in the period ***t*** to ***t+1*** is a function of age specific fertility rates multiplied by the number of women of reproductive age in the population, where the latter includes both native born and in-migrants. More formally:

$$B_x[t, t+1] = F_x \times (N_x^f(t) + \frac{I_{x-1}^f[t,t+1] + I_x^f[t,t+1]}{2}) \quad (4)$$

where ***F*** is the age-specific fertility rate, superscript ***f*** indexes female, and all other terms are as defined above.

Two patterns of mortality change

As described in the main body of the paper, two different patterns of future mortality are used in these projections. The baseline for each is age-specific probabilities of death published in ***Israeli Life Tables*** covering the period 2013 to 2018.

To project the future mortality pattern in these age-specific probabilities, we estimate the annualized change in age-specific probability of death from 2007 to 2015, Δ_x^q , for each 5-year age group up to age 89, as in:

$$\Delta_x^q = \frac{\ln\left(\frac{q_x[2015]}{q_x[2007]}\right)}{8} \quad (5)$$

Estimating change in 5-year age groups smooths fluctuations that arise from very low mortality in Israel's relatively small population, especially at young ages.

For ages 90 to 105 we estimate the annualized change in probability of death between 2012 and 2015.

The main mortality pathway, used in projection scenarios 1, 3, 5 and 6, applies this rate of change to the relevant age-specific mortality rate every five years — that is, 2018–2022, 2023–2027, 2028–2032, 2033–2037, and 2038–2040 — such that:

$$q_x^{Main}[t+5, t+10] = q_x[t, t+5]e^{\Delta_x^q t} \quad (6)$$

The secondary mortality pathway, used in projection scenarios 2 and 4, applies half this rate of changes in:

$$q_x^{Second}[t+5, t+10] = q_x[t, t+5]e^{0.5 \times \Delta_x^q t} \quad (7)$$