Why Is Israel's Life Expectancy So High?

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Abstract

This chapter identifies the factors responsible for Israeli men's high life expectancy, which places it in the top five in the world. An initial series of analyses across 170 countries shows that the national level of wealth, education and inequality, as well as demographic characteristics and characteristics of the health system, do a poor job explaining Israel's high ranking. Israeli men's life expectancy is 7 years higher than the model predicts. A secondary series of analyses adds geographic characteristics and religiosity. Together, these explain about 3 years of Israel's advantage. The final set of models add mandatory military duty (lagged from 1990). It is shown that: (1) countries with any mandatory military duty in 1990 averaged 1.5 years higher life expectancy in 2013 than countries without such service; and (2) length of service also matters. In Israel's case, in particular, a variable capturing months of mandatory military service explains 3.6 years of Israel's excess life expectancy. These findings strengthen the underlying hypothesis that military service improves fitness and therefore reduces mortality from conditions associated with exercise. To test this directly, age-standardized causes of death are compared across the OECD. Israeli men have the lowest mortality from cerebrovascular diseases, and the second lowest mortality from both cardiovascular disease and cancers affected by exercise.

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Introduction

Life expectancy at birth — defined as the average length of a lifespan in a population, given current age-specific mortality rates — is one of the most widely used indicators of social welfa prominently in comparisons between and within countries (Dasgupta and Weale, 1992; Murray et al., 2006). It is also one of three factors that make up the Human Development Index (HDI).

In this chapter, Israel's life expectancy[1] is evaluated in international comparison. The central goal is to understand why it is so high, especially for men. According to data from the World Health Organization, men's life expectancy in Israel in 2013 was 80.2. This places Israel at the top of the global ranking, just behind Iceland, Switzerland, Australia, and Japan, and alongside Sweden.[2] Among women in 2013, life expectancy in Israel was 84, not quite as good in relative terms, but still among the top-10 performers.

These high levels of life expectancy are an impressive accomplishment, but they also demand an explanation. Israel is like Iceland and Switzerland on some dimensions that are associated with better population health: it is a relatively small and wealthy OECD country (if a little less wealthy than those with equally high longevity) and with an educated population. It also has an effective national healthcare system which was one of only two in OECD countries — the other is Japan — to benefit from accelerated health spending between 2009 and 2013 (OECD, 2013, p. 9). On the other hand, Israel is completely unlike Iceland or Switzerland on other dimensions that are also associated with healthier populations: there are substantial social and political divisions between two national groups, Jews and Arabs, and within each of these, there is a high fertility subpopulation whose higher-risk births pull down average measures of health. Within the larger Jewish population,

1 Other measures of life expectancy are also used in the scholarly literature. Most common are life expectancy at age 15 (mean age at death for a 15-year-old, given current age-specific mortality rates above age 15) and life expectancy at age 65 (mean age at death for someone who has survived to 65, given current age-specific mortality rates above age 65). These latter capture, respectively, the general health prospects for people who have survived childhood and survived to retirement age. In this paper, when we use the term "life expectancy," we refer to the more widely used and general measure: life expectancy at birth.

2 Other authoritative estimates are available through the Global Burden of Disease (GBD) Project at the Institute for Health Metrics and Evaluation. These also place Israel toward the top of the ranking. GBD estimates a life expectancy of 80.3 for Israeli men, narrowly trailing (<1 year) Qatar, Andorra, Iceland, and Switzerland, and 84.0 for Israeli women, less than 1-year behind France, Iceland, Switzerland, Cyprus, Italy, Malta, Spain, Singapore, and Australia, and about 2-years behind Andorra and Japan. In this paper, we use the more widely known WHO estimates.

there are also significant immigrant populations from countries with much lower life expectancy, especially Russia and Ethiopia. Add to all these factors the geopolitical element. Not only is Israel not quite as wealthy as its peers in the highest life expectancy club, it also spends a much larger share of its national wealth on the military, which leaves less for the types of institutions that are more typically associated with improved population health and welfare.

Taking all of these differences between Israel and other high health performers into account, the question then arises: why is Israel's life expectancy so high? What factors have allowed it to join that elite club? Identifying those factors in an international comparison will point to ways in which the health of Israel's population — and others — can be maintained, and improved further.

The central result of this research is as surprising as it is important. One of the key factors responsible for Israel's high life expectancy is mandatory military service. This alone adds more than three years to life expectancy in Israel.

This chapter has six main sections.

First, a number of "baseline" factors that are known to affect mortality will be identified.

Second, using data from 2013, a simple regression model will be used to identify what each country's life expectancy should have been, given the baseline factors. This step allows us to estimate how much, and in what direction, each country deviates from its predicted level. This is a crucial step in the analysis, as Israel's life expectancy is much higher than it should be given its characteristics. It is a "positive statistical outlier."

Third, this model is replicated on levels of life expectancy in 2000 and 1990, which makes it possible to look at the stability of Israel's deviation from the expected level across time. The models show that Israel's position as a positive outlier has been relatively stable.

Fourth, other factors are introduced into the model that that may explain some of the variability across countries: their geographic endowment, religiosity, and mandatory military service. These all contribute to our model, but military service contributes the most. It explains a much larger share of Israel's life expectancy advantage.

A fifth section, focused on "cause-of-death" data, provides some additional evidence that strengthens this interpretation of the positive effect of military service on public health, showing that it works primarily through diseases affected by exercise.

A final section links these results to a longstanding debate in the scholarly literature on health: the extent to which further gains in public health can be made by increasing investments in biomedical infrastructure as opposed to other institutions which, at first glance, have no relationship to public health.

Throughout, the general methodological approach is to compare factors that affect life expectancy across as many countries as possible, from the wealthiest to the poorest. As detailed below, not all data are available for all countries. But the sample size in all baseline analyses reaches 170 countries, and in all others exceeds 130 countries. These include all developed countries (OECD and non-OECD), all the major emerging economies, and most countries with more than 2 million residents (see Appendix Table 1 for the complete list). Among the excluded countries (listed in Appendix Table 2), most are tiny states (e.g., island nations in the Pacific or Caribbean). Others are too closed politically to submit statistics to international organizations (e.g., Myanmar, North Korea, Zimbabwe) or lack the infrastructure to collect these data (e.g., Somalia, Western Sahara). Only one, Taiwan — blocked from international organizations by China — has the standard health and economic characteristics of a developed country. In general, therefore, the size and comprehensiveness of the sample underscores the generalizability of this chapter's analytic results.

1. Our baseline indicators

A number of factors are known to affect life expectancy. Table 1 lists them in column 1, alongside the specific indicators that will be used here (column 2). A third column contains a correlation coefficient describing the relationship between each of these indicators and life expectancy at birth in 2013, along with a marker of statistical significance.

Table 1. Known predictors of life expectancy at (aggregate) population level

Associate indicators used in this analysis, and bivariate correlations with 2013 life expectancy across 170 countries

	Predictors	Indicators	Pearson correlation with e0(2013)
	Characteristics of the health system		
1	More health spending	Health spending per capita, 2011-2013 ($)	0.71**
2	Greater accessibility of health services	Physicians and hospital beds per capita (1990-2010)	0.65**
	General level of development		
3	National wealth	GDP per capita, 2013 ($)	0.65**
4	National wealth (Preston curve)	(GDP per capita, 2013 ($))^2	0.35**
5	Lower income inequality	Gini coefficient (139 countries)	-0.29**
6	Higher levels of education	Secondary school enrolment, 1990s-2000s (%)	0.82**
	Demographic characteristics		
7	Lower population growth	Annual growth rate, 2003-2013	-0.33**
8	Higher population density	Number of people per km2 (2013)	0.18*
9	Lower fertility rate	Period total fertility rate, 2011-2013	-0.82**

Correlation with Gini coefficient is estimated across 139 countries. Levels of statistical significance: ** p<0.01; * p<0.05.

Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; UN Population database; WHO.

The first category of factors is specific to the health system. Up to around $2,500 per capita, there is a strong positive relationship between the amount spent on health and life expectancy. Beyond that level, the relationship begins to flatten out (author's calculations using data from WHO Global Health Expenditure Database). Likewise, the accessibility and quality of health services also affects a population's health. Where significant subpopulations have little access to basic services, especially preventive services, life expectancy is pulled down (Falkingham, 2004; Kabir, 2008).

The first of these factors is captured directly with a measure of per year and per capita health spending, 2011 to 2013, measured in US dollars. Since there is no single indicator of quality of health services available for a large sample of developed and developing countries, the second factor is captured indirectly, using a combined measure of number of physicians and hospital beds per capita, from the 1990s to the 2000s.

A second category of factors that affect life expectancy includes three that capture a country's general level of development, including its approach to matters of equity: its wealth, education, and general level of inequality. Wealthier countries in general have better infrastructure, including infrastructure that affects public health: higher quality water and sanitation systems; safer food production and delivery; better regulated transport systems. Here, too, there is the same curvilinear relationship — the "Preston curve" (Preston, 1975) — between life expectancy and wealth that characterizes the relationship between life expectancy and the amount spent on health.[3] Likewise, more educated populations tend to be healthier, for a number of reasons. Here, two mechanisms only are mentioned: more educated people have higher levels of "self-efficacy," a central variable in Health Behavior Models which refers to the ability to both make and realize better behavioral choices in general, and medical choices in particular. For example, being more educated also allows people to confront medical staff more readily than their less-educated peers (LeVine, LeVine and Schnell, 2001; Meara, Richards and Cutler, 2008). Finally, over and above the effects of a country's wealth and educational profile, the level of inequality is also negatively related to life expectancy. Inequality points to the difficulty that certain groups have accessing key types of infrastructure or services that could improve their health (Wilkinson, 1992).

Standard indicators are used to index each of these three factors:

1. GDP per capita, measured in 2013 US dollars; a GDP-squared (GDP2) term to capture the Preston curve;

2. the mean percentage of secondary school age children in the 1990s and 2000s who were enrolled in school;

3. the Gini coefficient.

3 Flipping the causal arrow, healthy populations also tend to be wealthier (Becker, Philipson and Soares, 2006), though the strength of these causal claims is questionable (see Acemoglu and Johnson, 2007).

A third category of factors is related to the demographic characteristics as a whole. High levels of population growth make it more difficult to provide health services, since just to maintain current levels of access, the health system has to grow at the same rate as the population (Crenshaw, Ameen and Christenson, 1997). High population density is now also associated with higher life expectancy, whether because of better access to health services, or selection of healthier people into urbanizing migrant streams (Cutler, Deaton and Lleras-Muney, 2006; Dye, 2008). This urban advantage is a relatively new phenomenon. Prior to investments in public health infrastructure, there was an “urban penalty” (Szreter and Mooney, 1998). Fertility levels in general are negatively associated with life expectancy, mainly because of the increased likelihood of higher risk births that raise both infant and maternal mortality, but also because of reduced spacing between children, which can affect child mortality (Ahmed, Li, Liu, and Tsui, 2012; Cleland Conde-Agudelo, Peterson, Ross, and Tsui, 2012).

Here, too, standard indicators are used. An annualized rate of population growth is estimated for the prior 10-year period, 2003 to 2013, using population estimates from the UN Population Division.[4] Population density is the number of people in the index year per square kilometer. General fertility levels are captured with the period Total Fertility Rate (TFR), a standard measure of the average number of children per woman.

The correlation coefficients in the third column of Table 1 confirm that across the sample of 170 countries — 144 for Gini — each of these factors is associated with life expectancy in the expected direction. Moreover, eight of the nine relationships are statistically significant at the 1 percent level, and the ninth is significant at the 5 percent level.

The initial model

Life expectancy is regressed on these nine baseline indicators in a simple OLS regression model. The model identifies what each country’s life expectancy should be, given the factors identified in Table 1.[5]

4 To estimate an annualized growth rate r between 2003 and 2013, the following formula is used: $r=(ln(N(2013)/N(2003))/10$, where N is population size.

5 It takes the form: $E(Y|X) = \alpha + \beta_1 X_1 + \cdots + \beta p X p$, where the series of parameters (δp) refers to the nine country-specific factors listed in Table 1, and $E(Y|X)$ refers to the predicted value of life expectancy (population mean function) in any country, given the βs’ combined effect. Note that since the goal is to generate a simple predicted value given the βs’ combined effect rather than identify the true value of any single variable’s effect on life expectancy, collinearity is ignored.

Appendix Table 3 presents two sets of regression estimates from this model. Model 1 includes all nine variables and is estimated on a sample of 144 countries. Model 2 does not include the Gini coefficient — missing for some countries — so uses the eight other variables and is estimated on the full 170 country sample. Substantively, results are almost identical. Equally important for the purposes of this research, in both models more than 80 percent of the variability in life expectancy across these countries is explained by these variables.[6]

After running these models, the deviation *(d)* of any given country from the expected level is calculated:

$$d = y - E[Y]$$

where *y* indexes the country's actual life expectancy, and *E[Y]* the model's predicted value.

There are two things to note in order to interpret d correctly. First, where $d>0$, a country's actual life expectancy in 2013 exceeded their predicted life expectancy, given the nine characteristics in the model. In other words, that country is doing better than expected. By extension, the higher the positive value of *d* — the further it gets from 0 — the better a country is doing, given those characteristics. In contrast, the higher the negative value of *d*, the worse a country is doing, given those characteristics.

Second, even though more than 80 percent of the variation in life expectancy is explained by these nine variables, high values of d suggest that some other factor(s) needs to be included in the model to explain more of the variation (this would reduce *d*), especially for countries with high levels of *d*, that is, high levels of deviation from the expected line. This issue is examined in the final set of analyses.

Baseline results

To identify how well or badly countries are doing, they were ranked by *d*. Figures 1 and 2 present parts of these rankings. Figure 1a limits its attention to 32 "excellent performers" among the 170 countries in the main sample. To be an "excellent performer" a country has to meet two criteria. First, actual

6 Although high levels of collinearity mean that it is too risky to infer too much about the value of the individual parameter estimates, they are worth noting. In both models, there are significant positive associations between life expectancy and prior health spending as well as the population's level of education. There is also a significant negative association with total fertility rates.

life expectancy in 2013 exceeds their predicted life expectancy by at least 3 years (*d*>3). Second, actual life expectancy has to be at least 60 years. The idea here is that irrespective of how much a country's actual life expectancy exceeds its predicted level, that country cannot reasonably be considered an "excellent performer" if its life expectancy falls below a certain threshold, set here as the bottom 15 percent of countries.

Figure 1b presents the same rankings for the subset of 34 OECD countries. This includes most — but not all — low mortality countries.

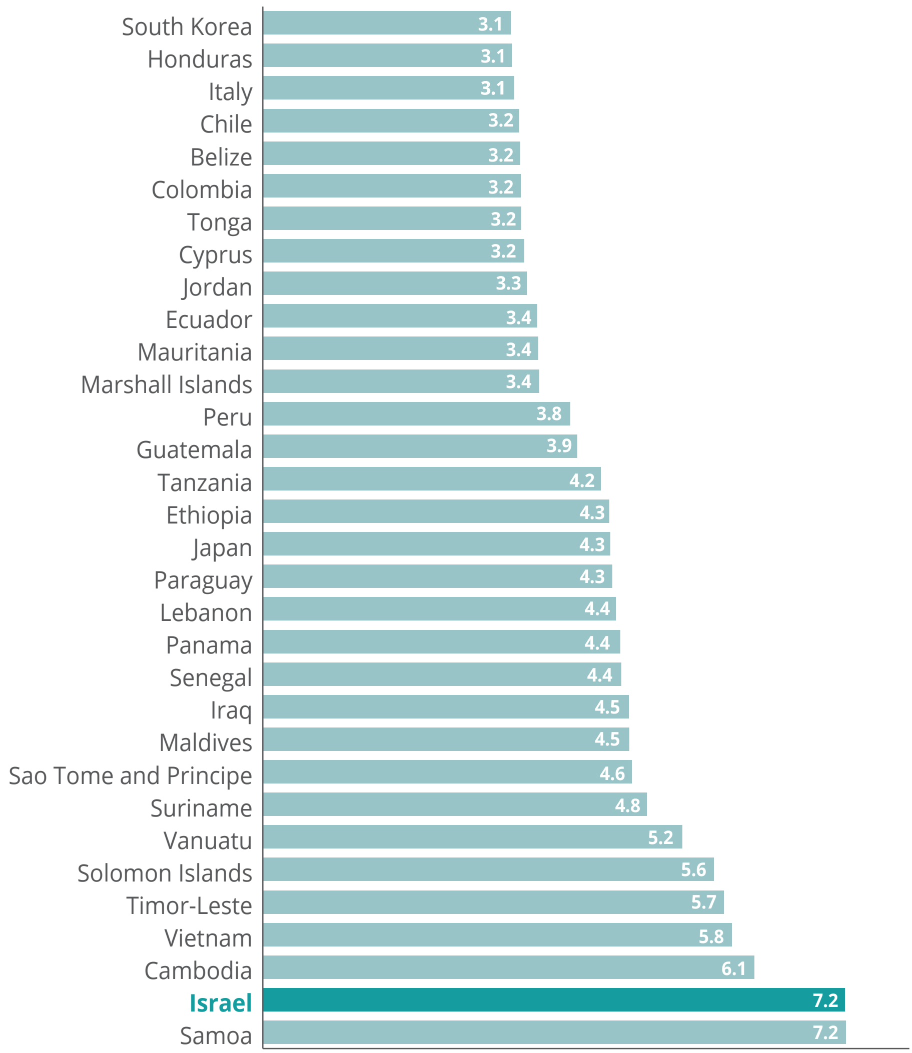
From an Israeli perspective, the rankings presented in Figures 1 and 2 are remarkable. The actual level of life expectancy in Israel is 6.3 years more than it "should" be, given the characteristics used in our baseline model. This excess is even higher — 7.2 years — in models without a control for inequality, allowing for the full sample of 170 countries. In both cases, Israel is not only the top-ranked "positive outlier" in the OECD — much higher than its closest rivals Japan, Chile, Italy, and South Korea — it is also the second-ranked positive outlier in the world, just behind Samoa. Within the framework of this model, then, which explains more 80 percent of the variation in life expectancy across countries, Israel is one of the best health performers in the world.

There are other notable results in this model. First, Figure 1a shows that a disproportionate share of the 32 excellent performers are located in Southeast or East Asia (including the Pacific Islands) or Latin America; that there is only one European representative (Italy); and that the few countries from sub-Saharan Africa in this list includes countries like Senegal, Ethiopia and Tanzania that have long been popular with development specialists.

Second, among the OECD countries, the United States ranks bottom in terms of its actual versus expected life expectancy. Given the factors that are in the model, life expectancy at birth in the US is 4.1 years less than it should be. Note, too, that this is not only because of more health spending per capita in the US (which would raise the expected levels of life expectancy). In models that do not control for health spending per capita, the US remains 6th from the bottom among the 34 OECD countries. The factors driving down US life expectancy have been widely discussed. The key culprit is the enormous variability in access to quality health care, especially across race and class lines, though this is compounded by differences in diet, substance abuse and other behavioral factors (Murray et al., 2006). Indeed, life expectancy among whites with less than a college-degree has actually been falling over the last 20 years (Sasson, 2016).

Figure 1a. A ranking of the difference between predicted and actual life expectancy

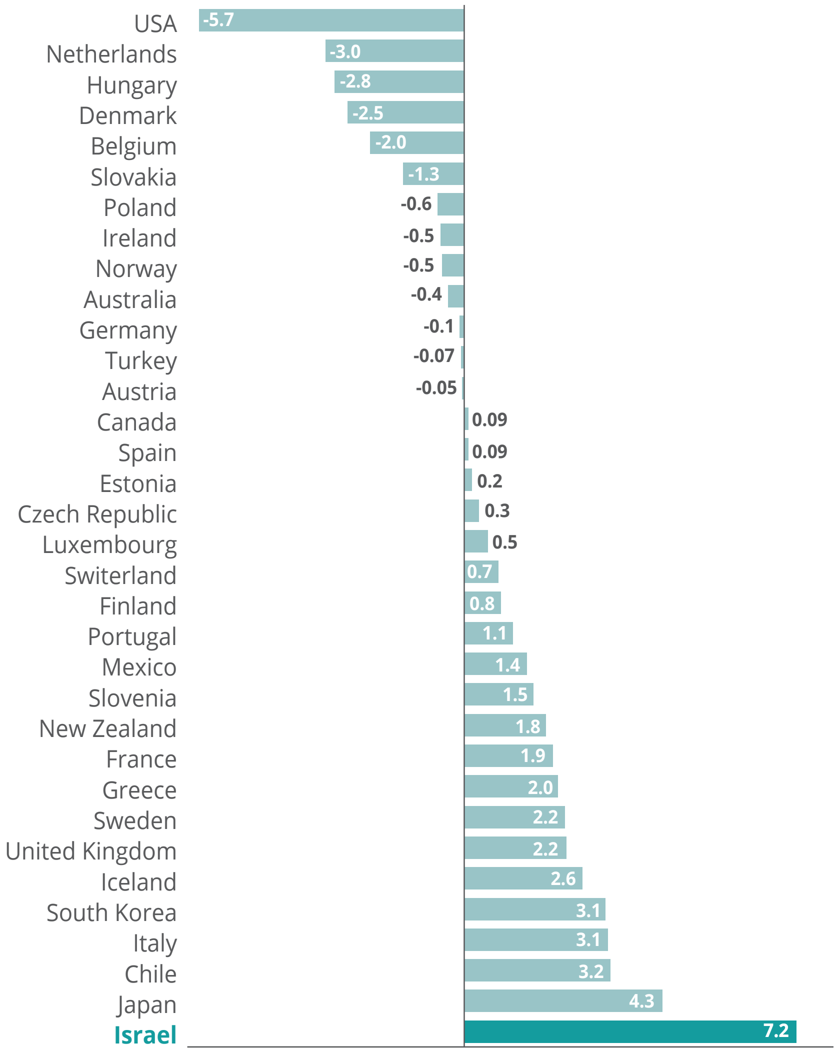
Actual exceeds predicted by more than 3 years, all countries, in years



Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO.

Figure 1b. A ranking of the difference between predicted and actual life expectancy

OECD countries only, in years



Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO.

The stability of Israel's deviation across time

Data from the Israeli Ministry of Health show rapid improvements in Israel's mortality profile rate between 1999 to 2001 and 2008 to 2010. Among men, for example, mortality from cerebrovascular diseases fell by 33 percent; it fell by 31 percent for cardiovascular diseases; and by 17 percent for diabetes. Among women, the equivalent reductions were 27 percent, 27 percent and 17 percent (Goldberger, Aburbeh and Hakla'i, 2013: 17).

These reductions raise the possibility that Israel's outlier status may be a recent phenomenon. To check whether this is the case, the same analysis of life expectancy was replicated using data from 1990 and 2000, changing the reference dates of predictor variables accordingly. The one difference between these models stems from the fact that comparative data on health spending, secondary school enrollment and Gini coefficient are not available for the 1980s for more than 60 countries. To maintain consistency across the models, a more restricted set of five explanatory variables was used, which limits the analysis to 130 countries. Even with that constraint, the models explain between 76 percent and 79 percent of the variability in life expectancy in all three periods. Summary results are in Table 2 (full regression results are in Appendix Table 4).

Table 2. Israel's predicted excess life expectancy in 1990, 2000 and 2013

With associated OECD and global rank (N=130)

	1990	2000	2013
Deviation *(d)* of Israel's actual life expectancy from predicted mean (measured in years)	3.80	5.85	6.96
Israel's international ranking relative to:			
OECD subsample (N-34)	1st	4th	2nd
Global sample (N=130)	22nd	39th	4th
Model R^2	0.805	0.790	0.810

To allow comparability across the 1990-2013 period, regression estimates do not control for health spending, secondary school enrolment or Gini coefficient. Full regression results for all three years in Appendix Table 4.

Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO.

Overall, from an Israeli perspective, we see important similarities across the three periods. In all three periods, 1990, 2000 and 2013, Israel is one of the top countries in the OECD in terms of the deviation between its actual and predicted level of life expectancy. Yet we also see an improvement in its broader international ranking across the 130-country sample. Its excess life expectancy increased from 3.80 years in 1990 to 5.85 in 2000 and 6.96 years in 2013, moving it from 22nd to 4th place across that 23-year period.

The 2013 results observed in Figures 1 and 2 are not a one-off. For at least 20 years, Israel's life expectancy has been higher than we would expect given its levels of wealth, education, inequality, health system characteristics, and general demographic profile. Moreover, this difference between the actual and predicted life expectancy has been growing. Some other factor, or factors, are driving up Israel's life expectancy, relative to other countries.

2. What are the other factors?

Three points have been established thus far:

1. Israel's life expectancy is very high by international standards, especially for men.

2. Israel's life expectancy is higher than we should expect, given its levels of wealth, education, health system characteristics, and general demographic profile. These standard factors may explain more than 80 percent of the variation in life expectancy in general, but the magnitude of Israel's deviation from the predicted line suggests that other factors are at work in Israel's case.

3. Israel's positive outlier status is not specific to 2013 — it was also true in 1990 and 2000 — though it is most notable in the latest year.[7]

A single overarching question emerges from these four points: how can we account for Israel's excess life expectancy? In practical terms, this is equivalent to: what are the other factors that could be included in the model in order to explain Israel's deviation? In statistical terms, this is equivalent to as asking: what are the factors that will pull the value of *d* toward zero?

7 Note, too, that Israel's positive outlier status is also not an artifact of the way we have selected to measure this phenomenon. As shown in Appendix 5, changes across time in the standard factors used to explain variation in life expectancy account for less than 10 percent of Israel's excess life expectancy.

In a second series of models, three groups of factors are added. The first describes the countries' geographic characteristics or endowment. As seen in Figure 1a, the excellent health performers are disproportionately coastal countries. This is consistent with an emerging scientific literature pointing to health benefits of living by the sea, especially for more socioeconomically distressed communities. Hypothesized mechanisms work both through biological factors (exposure to the sea reduces stress, more time outside means more absorption of Vitamin D) and behavioral factors (more moderate and regular physical activity, a diet that is richer in fish than red meat) (Buettner, 2012; Wheeler, White, Stahl-Timmins, and Depledge, 2012). In addition, the excellent performers are also closer to the equator than to the extreme northern or southern hemispheres. Among the top 10 performers in that list, Israel is the only country not within 20 degrees of the equator, and among all the top 32, none are more than 40 degrees from the equator (though less inhabited sections of southern Chile and northern Japan do exceed this line). There is some indication, therefore, that in terms of population health, being closer to the equator — in the range of latitudes where human populations first evolved — has a discrete health dividend. [8]

To capture the potential effects of these geographic characteristics on life expectancy, two new variables are included in the model: the percentage of the population that is within 100 km of the sea; and whether the geometric mean of the country is more than 45 degrees latitude from the equator. These variables are adapted from a country-level dataset used by Nunn and Puga (2012). [9]

A second group of factors is related to religiosity. There is an established and growing literature on the positive effect of religiosity on health at the individual level in both developed and developing countries (Hummer, Rogers, Nam, and Ellison, 1999; Trinitapoli and Weinreb, 2012). In Israel, in particular, Taub Center researchers have already shown that life expectancy is higher than expected — given socioeconomic characteristics — in municipalities with a larger percentage of Haredim, that is, ultra-Orthodox (Chernikovsky and Sharony, 2015, p. 438). They have argued that given

8 This is at odds with the impact of this type of geographic endowment on economic development — the most economically advanced countries tend to be somewhat further from the equator — though there has been some debate about causation, since much of this effect works through the quality of the "institutions" that facilitate underlying social and economic change (Easterly and Levine, 2003; Rodrik, Subramanian and Trebbi, 2004).

9 We also checked the effect of and "percentage of the country that is desert" and "percentage that is tropical." These had no net effect on life expectancy.

the relatively low access to organizations that explicitly promote healthy behavior in Haredi areas, these better-than-expected health outcomes are primarily the product of social capital in the Haredi community, especially high levels of psychosocial support. Other researchers have identified lower rates of smoking and a healthier diet in Israeli (Jewish) religious communities, even as they point to higher rates of childhood obesity and lower women's exercise, indicating future reductions in religious communities' health advantage (Shmueli and Tamir, 2007).

Since there are no religiosity data available for such a large sample of countries, religiosity is captured indirectly here using data from the 2007 to 2012 waves of the Pew Research Center's Global Restrictions on Religion Data.[10]

A third group of factors has to do with mandatory military service. Of the four countries with the highest male life expectancy in the world (WHO estimates), only Iceland does not have mandatory military service. The three others, Israel, Switzerland and Singapore, all have universal conscription with relatively high quality military training and an ongoing commitment to the military that lasts into men's 30s or 40s, depending on country, rank and task. In Israel, women also perform mandatory service.

Similarly, of the five excellent performers in the OECD listed in Figure 1b Israel and South Korea have relatively long periods of mandatory service, 32 and 24 months in Israel for men and women respectively, and 21 to 36 months — depending on one's service — in Korea. Italy, too, had conscription and a short military service until 2005, and Chile officially retains the right to conscription, though it is only enforced when there are an insufficient number of volunteers to fill the training slots (as occurred in 2011).[11] In short, out of these top five, only Japan has not had any form of conscription over the last 30 years.The central point here is that even if a relatively large

10 Using principal components analysis, a single indicator of country-level religiosity was constructed out of the following six variables: are government funds or other resources made available to: religious groups in general; for religious education programs and/or religious schools; for religious property (e.g., buildings, upkeep, repair or land); or for religious activities other than education or property? Do all religious groups receive the same level of government access and privileges? And does the country's constitution or basic law recognize a favored religion or religions? The higher a country's score on this index of religiosity, the more religious it is in terms of national orientation. Note that using this variable would be problematic if the analysis was focused on individuals, since there is a clear danger of ecological fallacy. In the case, however, the focus is on aggregate national-level outcomes, meaning that danger is irrelevant.

11 See "Chilean military in mass call-up" (https://www.theguardian.com/world/2011/oct/18/chilean-military-mass-call-up).

minority of Israel's and South Korea's population avoid military service,[12] a large share of the population in these countries goes through a period of intensive physical exercise in their late teens and early 20s, and certainly a larger share than in countries without conscription. Moreover, for many people in these countries, the period of intensive exercise begins before actual military service, in the last years of high school, as prospective conscripts prepare for military service in a desirable unit. Finally, repeated duty in the military reserves into people's 40s seems likely to maintain somewhat higher fitness in the population as a whole than would be the case absent such service. Prior research has also shown that reserve duty can serve as a "stress-relieving get-away . . . akin to vacation" (Etzion, Eden and Lapidot, 1998).

To capture these potential effects, four variables are used. Since the health effects of exercise affect mortality decades down the line, all deal with mandatory military service in 1990. Given the standard post-high school age of conscription this would mean looking for health effects of military service on people older than 40 in 2013.

The first of three military variables is dichotomous. It simply identifies countries with any form of mandatory military service in 1990. The second identifies the length of mandatory military service, measured in months. Both of these variables are derived mainly from War Resisters International, a UK-based organization that focuses on military service, with some supplemental information from GlobalSecurity.org and Wiki pages on each country's military.

A third variable is military spending as a percentage of GDP. Collected by the Stockholm International Peace Research Institute (SIPRI) Yearbook, these data are part of the World Bank's World Development Indicator's database. Since the models already control for GDP per capita (both linear and quadratic terms), this variable is more an indicator of a government's overall commitment to the military, and therefore its quality, given the overall level of national wealth: it allows us to look at the effects of mandatory military service after having controlled for the level of investment in the military.

The fourth variable takes this a step further. It is an interaction term between military spending as a percentage of GDP and the duration of military service. This is as an indicator of total societal investment — time and financial resources — in the military.

12 In Israel, 73 percent and 58 percent of men and women of conscript age were drafted in 2015 (http://tinyurl.com/h3xgn8g).

How much do these other factors explain Israel's excess life expectancy?

In a series of five models, each of these variables is added to the baseline model used to generate Figures 1 and 2. Selected summary results are presented in Figure 2a, with full results based on analyses of a 133-country sample available in Appendix Table 6.

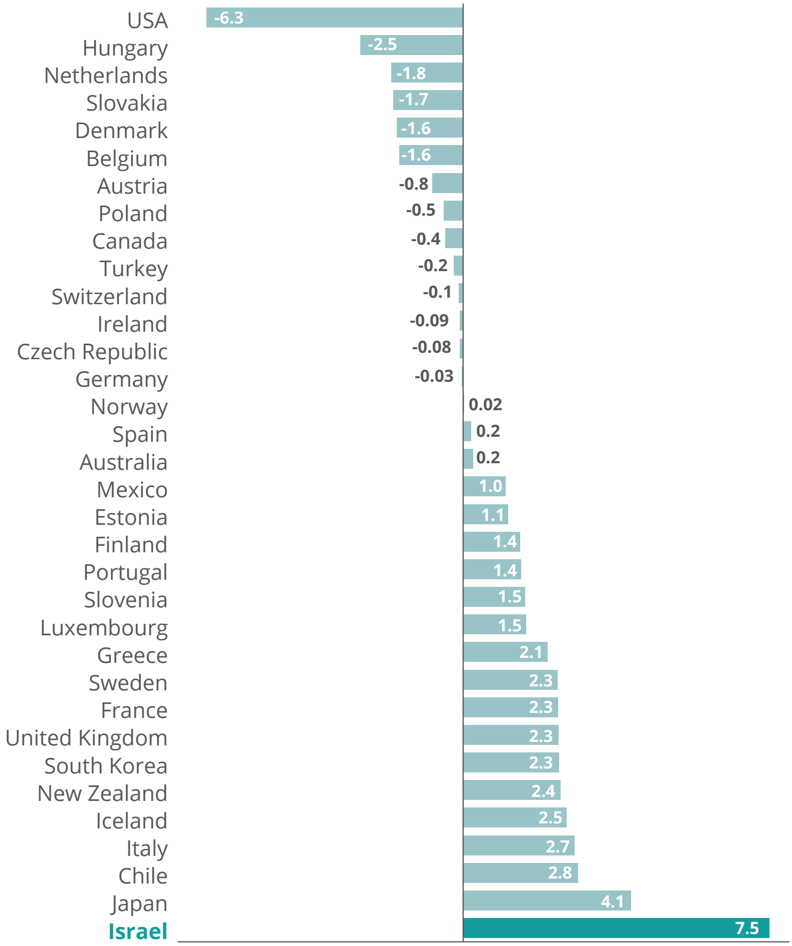
Model 1 replicates the baseline model used to generate Figures 1a and 1b but with the 133-country sample. As depicted in Figure 2a, this marginally increases the estimated size of Israel's deviation from the predicted life expectancy from 6.9 to 7.51 years, but Israel's ranking within the OECD remains the same, and globally it falls from 2nd to 3rd place.

Model 2 adds two geographic controls to the baseline model: the percentage of the population that lives within 100 km of an ice-free coast; and whether the geometric mean of the country is more than 45 degrees latitude from the equator. These have the expected positive and negative effects, respectively, on life expectancy, both of which are statistically significant. Together, they raise the model R^2 to 83.2 percent. Most important for the purposes of this chapter, adding these variables reduces Israel's estimated deviation from the predicted line from 7.51 years in the baseline model to 5.38 years. Although it remains at the top of the ranking within the OECD, it slips down the ranking to 4th place in the full sample.

Model 3 adds the level of state support for religion. As expected, this also has a positive effect on life expectancy and on the model. The R^2 rises to 84.2 percent. Israel's deviation slips a little further to 3.65 years, which pushes Israel's ranking down to 4th place in the OECD (trailing Sweden, Estonia and Slovenia) and 20th place in the 133-country sample. The combined effects of geographic endowment and religiosity characteristics on deviation from predicted life expectancy within the OECD countries are shown in Figure 2b.

Figure 2a (Model 1). A ranking of the difference between expected and actual life expectancy, 2013

Across model specifications of standard of living and health status of the country and the population, in years

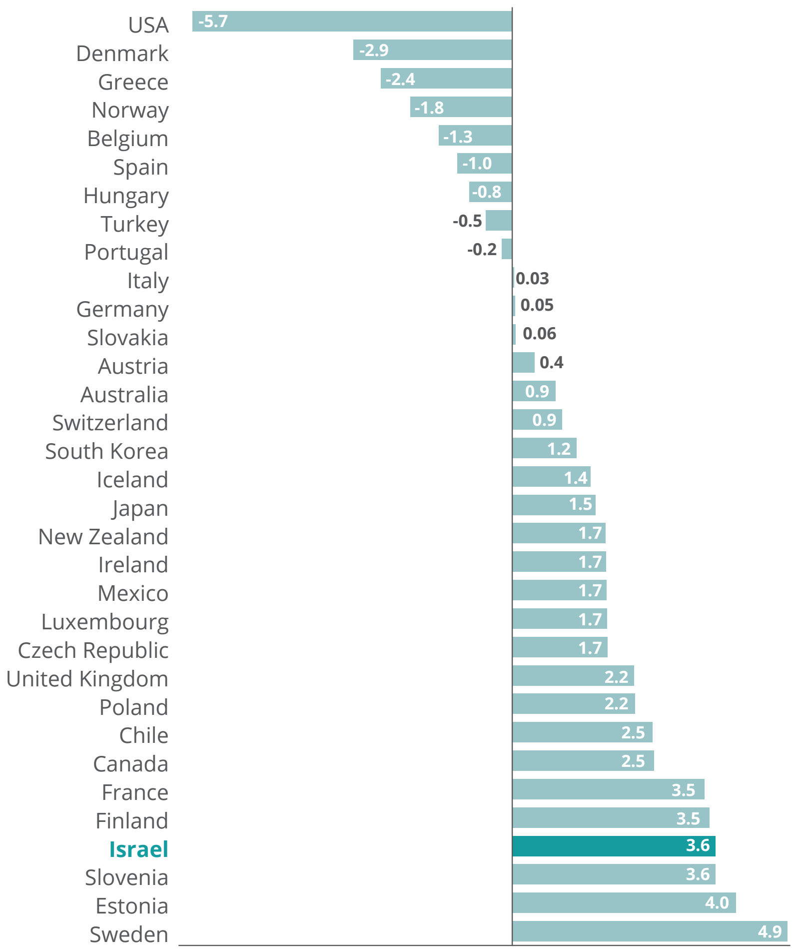


Sample of 133 countries. The countries presented here have the highest life expectancies.

Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO; Pew Research Center's Global Restrictions on Religious Data.

Figure 2b (Model 3). A ranking of the difference between expected and actual life expectancy, 2013

Across model specifications of standard of living and health status of the country, population and geographic characteristics, and level of religiosity, in years



Sample of 133 countries. The countries presented have the highest life expectancies.
Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO; Pew Research Center, Global Restrictions on Religious Data, War Resisters International; SIPRI Yearbook.

3. The influence of military service on life expectancy

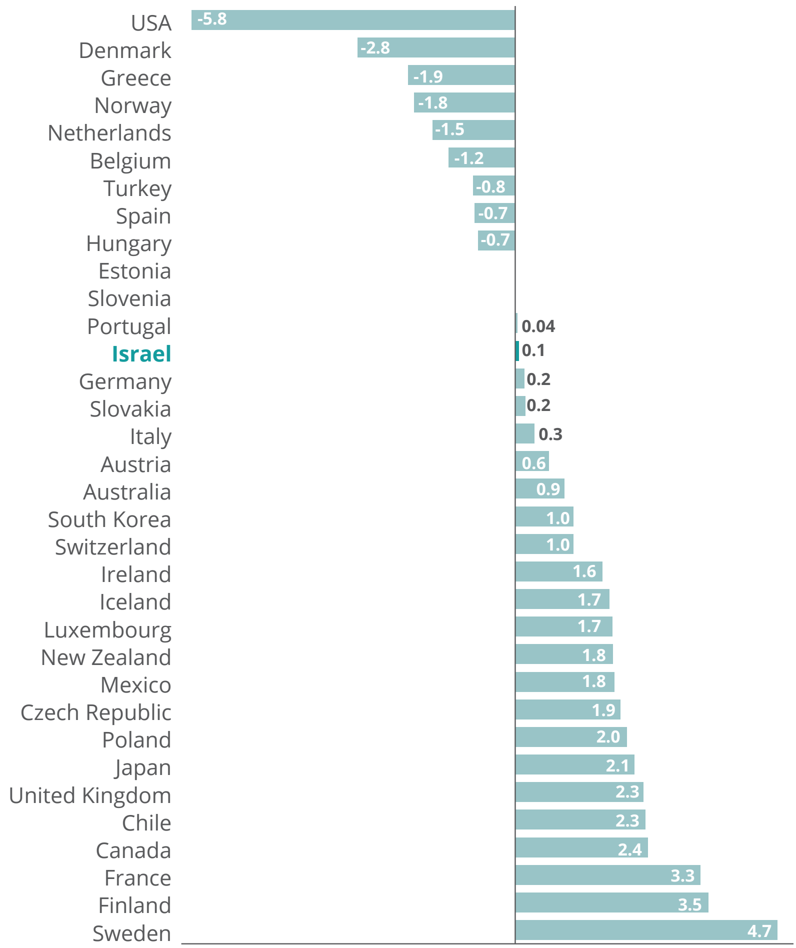
Model 4 adds the control for military spending as a percentage of GDP and the dichotomous measure of any mandatory military service. There is a strong positive effect: net of all other variables in the model, a country with any mandatory military service in 1990 enjoyed 1.47 years higher life expectancy in 2013. Even with this strong effect, however, the model R^2 creeps up only marginally to 84.7 percent, and the deviation in Israel's life expectancy falls by only 0.7 years, pushing Israel's ranking to 5th place in the OECD and 21st place in the 133-country sample.

Model 5 substitutes length of mandatory military service, measured in months, for the dichotomous indicator. Although its effect is not statistically significant in itself, is has a stronger substantive effect on the deviation in Israel's life expectancy, reducing it to 2.38 years. This pushes Israel to 6th place in the OECD in terms of its deviation from predicated life expectancy, and 26th place in the 133-country sample.

The final Model 6 substitutes the interaction term between military spending and length of service. As shown in Figure 2c, this has by far the strongest effect of any of the military variables. The estimated coefficient is 0.008, which suggests that among the 10 countries with a score in excess of 100 on this variable, the gains to life expectancy should exceed 12 months. In Israel, in particular, the effect is very powerful. Israel's score on this variable is 527.3, implying a gain of 42 months in Israeli life expectancy. Not surprisingly, this model transforms the magnitude of Israel's deviation from the expected life expectancy. Israel's predicted life expectancy plummets by more than 3.5 years, from 3.65 years (Model 3, includes controls for baseline, geographic and religious characteristics) to 0.07 years (Model 6). In other words, this single variable explains — in statistical terms — the remainder of Israel's excess life expectancy. In so doing, in terms of the deviation rankings, this variable pushes Israel from 4th in the OECD to 22nd, and from 20th to 70th place among all 133 countries.

Figure 2c (Model 6). A ranking of the difference between expected and actual life expectancy, 2013

By basic characteristics, calculation includes the interaction between length of military service and percent of military expenditure in GDP, OECD countries, in years



Data on the average length of military service is not available for all countries.
Source: Alex Weinreb, Taub Center.
Data: World Bank, World Development Indicators; WHO; GlobalSecurity.org; War Resisters International.

Other evidence supporting a positive effect of military service

The positive public health effects of religiosity and certain types of geographic characteristics are well known and documented. There is an established scholarly literature on both. In contrast, to the best of our knowledge, there is no scholarly literature whatsoever on the positive public health effects of military service. Some additional evidence is therefore presented in order to strengthen the claim that this is a real effect, that is, that the indicator of mandatory military service used here is not indirectly tapping some other unobserved factor.

The first type of additional evidence focuses on the main mechanism linking military service to health: the effects of exercise. Cause-of-death data were taken from the Global Burden of Disease (GBD) project to see whether Israel's health advantage is associated more with diseases that are affected by exercise, than with diseases that are not affected by exercise.[13] All major causes of mortality were categorized according to whether they are affected by exercise. For the most part, this "affected-by-exercise" category includes causes of death that are reduced by exercise: cardiovascular disease, cerebrovascular disease and certain types of cancer identified by Moore et al. (2016): esophageal; liver; lung; kidney; colon; rectal; bladder; and, breast. In one case — malignant melanomas — this "affected-by-exercise" category refers to something that is positively associated with exercise. Arrayed against these desirable exercise-related effects is the "not-affected-by-exercise" category, which includes lower respiratory infections and the following types of cancer, again based on Moore et al. (2016): brain; cervical; gallbladder; Hodgkin lymphoma; larynx; leukemia; oral; nasopharynx; neoplasm; lymphoma (non-Hodgkin); ovarian; pancreatic; stomach; testicular; thyroid; and uterine.[14]

13 GBD data provide "a unique comprehensive framework to systematically assess national trends in age-specific and sex-specific all-cause and cause-specific mortality" (GBD, 2013). They are the most authoritative source of comparable data on mortality currently available.

14 We intended to also use Alzheimer/dementia and diabetes in this comparison, since these are the other major causes of death in low mortality developed countries. We did not use them, however, since there are notable and inexplicable differences in Israel's international ranking between the GBD estimates and other authoritative estimates. Specifically, according to GBD data, Israel is 32nd out of the 36 countries in our OECD-plus-two-sample, giving it one of the worst records. Yet according to data from the Israeli Ministry of Health, Israel has the 6th best (i.e., lowest) rate of dementia among a similar sample of 20 European countries, the USA and Canada. Likewise, in both GBD and Israel's Ministry of Health (MOH) data, Israel has one of the highest levels of diabetes in the OECD. Yet the authoritative International Diabetes

These causes are summarized by category in the first column of Table 3. The remaining columns look at how Israel is faring on these diseases relative to the other 35 countries in the OECD plus Singapore and Taiwan — referred to here as an "OECD-plus-two club" — by presenting Israel's age-standardized mortality rate and international ranking, by disease and sex.[15]

Table 3. Age standardized mortality rates for Israel by cause and Israel's rank relative to 33 other OECD countries

By whether mortality rate is directly affected by exercise, OECD countries include Singapore and Taiwan

Cause of mortality	Men		Women	
	Number per 100,000	OECD rank	Number per 100,000	OECD rank
Directly affected by exercise				
Cardiovascular	146.9	2	118.1	4
Cerebrovascular	26.0	1	29.7	1
Cancers reduced by exercise (except melanoma)	94.4	2	73.6	9
Not directly affected by exercise				
Cancers not affected by exercise	220.7	4	157.6	13
Lower respiratory infections	166.9	18	209.8	15

Cancer categorization based on Moore et al. (2016).
Reduced by exercise includes: esophageal, liver, lung, kidney, colon, rectal, bladder, breast. Increased by exercise: melanoma. Not affected by exercise includes: brain, cervical, gallbladder, Hodgkin, larynx, leukemia, oral, nasopharynx, neoplasm, lymphoma (non-Hodgkin), ovarian, pancreatic, stomach, testicular, thyroid, uterine.

Source: Alex Weinreb, Taub Center. Data: Global Burden of Disease Project.

Federation's Atlas ranks Israel toward the middle, just below France and Spain, and well below the US and Canada (IDF, 2009; MOH, 2011, p. 230). In contrast to these notable differences across sources of data, Israel's ranking in both its own MOH data and the GBD databases is identical in terms of cardiovascular diseases (2nd) and cancers (4th), and highly similar in cerebrovascular diseases (it ranks in the top five countries in both GBD and MOH data). We therefore restrict our attention to the latter, which are also the leading causes of mortality.

15 Note that because these "age-standardized rates" take into account variation in age structure across countries, they should not be used to look at the actual prevalence of a given condition. Their primary function is to allow for a meaningful ranking across populations.

Results are consistent with expectations. Across this sample of 36 developed countries, Israel ranks higher — that is, it does better — on causes of mortality that are affected by exercise. Among men, it ranks either first (cerebrovascular diseases) or second (both cardiovascular diseases and cancers affected by exercise). But it ranks 4th in cancers not affected by exercise, and 18th in lower respiratory infections (LRIs) (including pneumonia). Among women, too, there are differences, albeit not quite as impressive. Israel is tied for first (with Canada) on cerebrovascular disease, 4th in cardiovascular disease and 9th on cancers affected by exercise. Yet it ranks 13th on cancers not affected by exercise, and 15th on LRIs.

More support for the idea that universal military service has positive public health effects comes from looking at different mortality patterns of Israeli Jews and Arabs. The very low rates of military service among Arab Israeli men would lead us to expect higher rates of cardiovascular disease in that population.[16] Data from the Israeli Ministry of Health (MOH, 2011) confirm that this is the case. There is much higher diagnosis of cardiovascular disease among Arab Israelis than Jews (Figure 1b), and the age-standardized mortality rate from cardiovascular disease is also much higher, with the largest relative difference between ages 50 and 69 (Table 2, p. 143). Similar differences in rates of diagnosis and age-standardized mortality can be found in type 2 diabetes: in the early 1980s, it was low among both Arab Israelis and Jews. Since then, it has increased for both, but at a much higher rate among Arab Israelis (MOH, 2011, pp. 228-229, 233).[17]

These Jewish-Arab differences in cardiovascular disease and diabetes stand in sharp contrast to differences in cancer. For both men and women, the age-standardized incidence of cancer in the Arab Israeli population is lower, though it is slowly converging to that of Israeli Jews (Figure 3, p.171), and the age-standardized rate of mortality from cancer is similar among males (Figure 10, p.182).

16 Unfortunately, available data do not distinguish Druze from Arabs so they are combined here. If anything, this should reduce the magnitude of the Jewish-Arab difference, since Druze, who serve in the army in large numbers, should enjoy the same health benefits of military service as their Jewish counterparts.

17 Though the increasing prevalence of diabetes is a global phenomenon that threatens to slow or even reverse some gains in life expectancy (Olshansky et al., 2006), it has increased very rapidly in the Arab Israeli community, making them part of a wider Middle Eastern cluster of high diabetes societies (GBD, 2013).

A third layer of support for our hypothesis comes from looking at gender differences in life expectancy. Across the OECD, women outlive men by an average of 5.5 years. If large-scale mandatory conscription positively affects public health, but its effects are concentrated primarily among men — women's mandatory service is shorter, and fewer women do combat training and reserve duty — then there should be a smaller gender gap than is the norm in high life-expectancy countries. This is, in fact, the case. Alongside Iceland, Israel has the smallest gender gap in life expectancy in the OECD, a mere 3 years.

A fourth and final layer of support for this argument can be found in comparative data on levels of exercise among children. A 2011 report on health in Israel published by Israel's Ministry of Health (MOH) devotes a chapter to physical activity, comparing Israel to 41 other countries that participated in the 2006 Health Behavior in School Aged Children (HBSC) project (MOH, 2011, pp. 347-358). These HBSC data show that Israeli children are among the least physically active among their peers. Assuming that children's exercise patterns in Israel have changed no more than over the last 50 years than they have in other countries, Israel's excellent cardiovascular benefits at older ages are therefore much more a product of exercise beyond childhood. That begins with military service.

4. Alternative explanations

Three potential additional explanations for Israel's outlier status should also be mentioned and discounted. The first is diet. The lack of comparable data on diet across our sample of countries means that its effects on life expectancy cannot be tested directly in the way that we have tested the effects of other factors like wealth, education, geographic location, and military service. Even without those data, however, a diet-centered hypothesis fails a basic face-validity test. It makes little sense to suggest that the Israeli diet is the secret to Israel's higher life expectancy since Israel shares dietary characteristics with many Mediterranean and Middle Eastern countries whose life expectancy is lower. Moreover, where it deviates from the relatively healthy Mediterranean diet, it tends toward a heavy reliance on animal fats, proteins and salt, none of which are associated with longevity. Diet, therefore, does not seem to be driving Israel's exceptional life expectancy.

A second alternative explanation is related to the better-than-expected health characteristics of Israel's Haredi sector, or religious sector in general, summarized earlier. Yet these subpopulations' health cannot explain Israel's overall deviation from its predicted life expectancy. First, at least a portion of that religious effect is captured by the religiosity variable that is already in the model. Second, any additional effect would be minimal since the Haredi community's young mean age means that its contribution to Israel's national mortality profile — which is concentrated at older ages — is minor.

The final alternative builds on an established empirical finding in historical demography: over the last 150 years, Jews in Western countries have tended to live longer than non-Jews (Fauman and Mayer, 1969; Goldstein, Watkins and Spector, 1994; van Poppel, Schellekens and Liefbroer, 2010). This more general Jewish advantage — rooted in behavioral factors, social isolation, and greater access to health system — suggests that the effect of military service on Israel's life expectancy seen here is actually capturing a broader ethno-cultural pattern. Again, as promising as this argument sounds initially, it cannot explain the pivotal results of this analysis: a statistically significant positive effect of military service on life expectancy across a sample of 133 countries (Models 4 and 6 in Appendix Table 6). Jews, therefore, are not driving this phenomenon. Military service is driving it, irrespective of populations' ethno-religious characteristics.

Summary and conclusions

The question posed at the beginning of this chapter asked why Israel's life expectancy is so high. In a series of analyses, it has been demonstrated that it is much higher than one would expect given its health infrastructure, socioeconomic and demographic characteristics, and geographic location. It has also been shown that this is not a new phenomenon. Although Israel's "excess" life expectancy has grown over the last 20 years, Israel has been a better-than-expected health performer since at least 1990.

A further set of analyses suggest that the most important factor underlying Israel's higher-than-expected life expectancy is mandatory military service. In regression models, net of all other controls, it alone explains more than 3 years of this excess, far more than indicators of Israel's geographic endowment and religiosity.

This is an important finding for at least three reasons. First, this is a very large effect. To place it in perspective, epidemiological models suggest that the total elimination of smoking in the US would add between 1 and 2 years to life expectancy (Silverstein, Nietert, Zoller, and Silvestri, 2001; Stewart, Cutler and Rosen, 2009). Likewise, in models estimated here, it has been shown that the combined effect of distance from the equator and percentage of population living close to the sea was between 2 and 3 years (Table 3, Model 3). That is, the positive impact of military service in Israel today is at least as great as the estimated effect of ending smoking, and it is roughly equivalent to having been blessed with a healthy geographic location. That is significant.

Second, the contribution of mandatory military service has not yet been acknowledged in either the general scholarly literature on health, or in publications on the determinants of health in Israel. To some extent, this is not surprising. The scholarly literature on health is driven by research paradigms developed in the US and Western Europe, where only a small minority of citizens serve in the military and where, therefore, there is little reason to think that military service would have any direct effect on public health.[18] This research highlights the problem that can occur when that epistemologically limited line of sight is applied to Israel or other settings — where mandatory military service is a pivotal stage in the life course, and where it occurs at the very age at which sport and physical activity become an optional pastime for people in most OECD countries. The global approach adopted here is more context-sensitive in general. But it is particularly sensitive to life course patterns in Israel.

Ironically, even official Israeli Ministry of Health publications overlook the possible effect of military service. The 491-page 2011 report on health in Israel published by the Ministry of Health (MOH) is an example. It devotes a chapter to physical activity (MOH, 2011, pp. 347-358) that includes comparisons between Israel and a number of Western countries in terms of physical activity for both school-age children and adults above age 21 — inexplicably leaving out the core ages of military service. Nowhere in that chapter — or any other in the report — is there any mention of the relationship between military service and health.[19]

18 An example: across eleven substantive chapters in a highly-regarded collection of scholarly essays on the effects of general social and economic policy on health in the US (Schoeni et al., 2008), there is no mention of the relationship between health and military service.

19 The army is only mentioned twice in the 491 pages: a reference to the prevalence of asthma among new conscripts born in Israel, Ethiopia and the former Soviet Union (p. 239), and a reference to sexual harrassment (p. 402).

The third reason that our research is important follows from the first two. Even if the contribution that mandatory military service makes to public health is an unintended benefit of military service, it needs to inform future policy decisions in Israel. There are at least two ways in which this could occur.

First and foremost, by lowering the incidence and impact of the many diseases that are reduced by intensive exercise, the military saves the state an unknown — but likely significant — amount of money both directly and indirectly. Directly, in terms of the cost of treatment of conditions that arise less frequently because of military service; and indirectly, in terms of reducing sick days and associated productivity issues. Health economists can estimate the dollar-value of these savings. Here, it will suffice to say that any discussion about reducing the duration of mandatory military service, or switching from a "people's army" to a professional military, needs to take into account the loss of any long-term health benefits associated with the current model. In the simplest terms, some portion of every dollar spent on mandatory military service goes toward public health. It is a quiet investment. In turn, this suggests that future versions of plans like the MOH's 2005 "To a Healthy Future 2020" — intended to improve the health of Israel's population — need to take into account health-related benefits of military service and even build on them, especially in their focus on physical activity (see MOH, 2011, p. 357). No other institution in any developed country can push as many young adults through as intensive a series of physical exercise as the military.

This idea — that societies can promote public health and push the boundaries of "best-performance life expectancy" (Oeppen and Vaupel, 2002) by investing in institutions that have no overt relationship to health — takes us into the heart of a longstanding debate in the scholarly literature on health. A dominant view, especially within health economics, is that mortality reduction in developed countries in the last 80 years has been primarily affected by ". . . big medicine, starting with vaccination and antibiotics, and moving on to the expensive and intensive personal interventions that characterize the medical system today" (Cutler, Deaton and Lleras-Muney, 2006, p. 106). In this framework, "public health" — referring especially to investments in clean water, effective sewage systems, and health behaviors — played its major role from the late 19th century until the 1930s.

Other social science scholars of health, especially demographers and sociologists, have taken issue with this characterization. They point to the flat part of the Preston curve (Preston, 1975) — above a certain level of national wealth, there is no relationship between wealth and life expectancy

— which means that any variability in life expectancy above that level must be generated by other factors. Typically, those scholars have focused on the effects of poor educational opportunities, or limited geographic and social mobility, arguing that to improve a public's health in societies above the threshold, investments need to be made in solving those broader problems, not merely adding to the heft of an already-developed biomedical system (Schoeni, House, Kaplan, and Pollack, 2008; Braveman et al., 2011).

The analyses presented here largely support this second line of thought, albeit with one important change. The military needs to be on that list of institutions through which societies can augment public health. It is uniquely placed to influence health. This is especially true in Israel.

Mandatory military service is not a cure-all. Even within the narrow analytic frame applied in this paper, there are many causes of mortality that even the most extensive and intensive exercise regimes does not affect, and cannot affect. This includes diseases on which Israel ranks very poorly in international comparisons. Across the OECD, for example, Israel has the highest mortality rate from sepsis, and among the highest mortality rates from kidney disease (Goldberger, Aburba and Hakla'i, 2015, pp. 44-45). No amount of mandatory military service will help Israel reduce mortality rates from these causes. More standard types of health investments will be needed.

Military service will also not magically offset the undesirable health effects of an increasingly poor diet or physical inactivity, especially in childhood, as is increasingly common in many countries (Boreham and Riddoch, 2001; Ebbeling, Pawlak and Ludwig, 2002). An accumulating body of research has demonstrated how profoundly these childhood conditions can affect long-term health (Haas, 2008; Montez and Hayward, 2014). More specific to Israel, there are increasing levels of childhood obesity and the rising incidence of both type 1 and type 2 diabetes, though as noted previously, increases in diabetes have been sharper in the Arab Israeli population (MOH, 2011, pp. 228-229, 233). Mandatory military duty may come too late to moderate the effects of this increase.

More broadly and beyond the narrow analytic frame used here, there may be undesirable health-related consequences to mandatory military service in terms of mental health, or in terms of injuries that reduce the quality of life in the long-term. Those effects are not directly considered here, even if they cast a small indirect shadow, since they can influence life expectancy — for example, through suicide — even when they are not measured directly.

Even with these reservations, however, the unambiguous strength of our findings, and the fact that they describe patterns in a comprehensive global sample, allow us to make a number of claims with a high degree of confidence and generalizability:

1. Mandatory military service has a positive effect on public health in general, and a profound effect on public health in Israel.

2. It is one of the secret ingredients underlying Israel's excellent public health. Relative to other OECD countries, it may even be the most important ingredient.

3. Unless some other way can be found to get a large percentage of Israel's population to engage in intensive physical activity, the longer that Israel can maintain mandatory service, and the more universally that service is enforced, the better for Israel's future public health.

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Ministry of Health (2011), *The State of Health in Israel, 2010*, Israel Center for Disease Control.

Appendix

Appendix Table 1. Countries in main sample (N=170)

Afghanistan~[M]	Cameroon	Gambia	Korea, South
Albania	Canada	Georgia~[M]	Kuwait~[G]
Algeria	Central African Republic	Germany	Kyrgyzstan
Argentina	Chad	Ghana	Lao PDR
Armenia	Chile	Greece	Latvia~[M]
Australia	China	Grenada~[G,~M]	Lebanon~[G]
Austria	Colombia	Guatemala	Lesotho
Azerbaijan	Comoros~[M]	Guinea	Liberia
Bahamas~[G, ~M]	Congo	Guinea-Bissau	Libya~[G, ~M]
Bahrain~[G]	Congo, Dem. Rep.~[M]	Guyana	Lithuania~[M]
Bangladesh	Costa Rica	Honduras	Luxembourg
Barbados~[G, ~M]	Cote d'Ivoire~[M]	Hungary	Macedonia, FYR~[M]
Belarus	Croatia~[M]	Iceland~[G]	Madagascar
Belgium	Cuba~[G]	India	Malawi
Belize	Cyprus~[G]	Indonesia	Malaysia
Benin	Dominican Republic	Iran	Maldives~[M]
Bhutan~[M]	Ecuador	Iraq~[M]	Mali
Bolivia	Egypt	Ireland	Malta~[G]
Bosnia and Herzegovina~[M]	El Salvador	Israel	Marshall Islands~[G,~M]
Botswana	Equatorial Guinea~[G,~M]	Italy	Mauriania
Brazil	Estonia~[M]	Jamaica	Mauritius~[G]
Brunei Darussalam~[G]	Ethiopia	Japan	Mexico
Bulgaria	Fiji	Jordan	Micronesia~[M]
Burkina Faso	Finland	Kazakhstan	Moldova
Burundi	France	Kenya	Mongolia
Cabo Verde	Gabon~[M]	Kiribati~[G, ~M]	Montenegro~[G,~M]

Appendix Table 1. (continued) **Countries in main sample (N=170)**

Morocco	Paraguay	Seychelles	Trinidata and Tobego
Mozambique	Peru	Sierra Leone	Tunisia
Namibia	Philippines	Slovakia	Ukraine
Nepal	Poland	Slovenia~[M]	United Arab Emirates~[G,~M]
Netherlands	Portugal	Swaziland	United Kingdom
New Zealand	Qatar	Sweden	United States
Nicaragua	Romania	Switzerland	Uruguay
Niger~[M]	Russian Federation	Tajikistan	Uzebekistan~[M]
Nigeria	Rwanda	Tanzania	Vanuatu~[G]
Norway	Samoa~[G,~M]	Thailand	Venezuela
Oman~[G]	Sao Tome and Principe~[M]	Timor-Leste~[G,~M]	Vietnam
Pakistan	Saudi Arabia~[G]	Togo	Yemen
Panama	Senegal	Tonga~[G,~M]	Zambia

~G = No data on Gini coefficient: sample drops to 144 (baseline models) or 123 (models with military spending).

~M = No data on either conscription or military spending in 1990: sample falls to 133 (without Gini) or 123 (with Gini).

Appendix Table 2. Countries/Territories not in sample (N=71)

American Samoa
Andorra
Angola
Anguilla
Antigua and Barbuda
Aruba
Bermuda
Bosnia-Herzegovina
British Indian Ocean Territory
British Virgin Islands
Brunei
Cayman Islands
Christmas Islands
Cocos (Keeling) Islands
Cook Islands
Curucao
Eritrea
Faeroe Islands
Falkland Islands (Malvinas)
Faroe Islands
French Guiana
French Polynesia
Gibraltar
Greenland
Guadeloupe
Guam
Haiti
Holy See
Hong Kong
Korea, North
Kosovo
Liechtenstein
Macau
Martinique
Mayotte
Monaco
Montserrat
Myanmar
Nauru
Netherlands Antilles
New Caledonia
Niue
Norfolk Island
Northern Mariana Islands
Palau
Palestinian territories
Papua New Guinea
Pitcairn
Puerto Rico
Reunion
Saint Helena
Saint Kitts and Nevis
Saint Lucia
Saint Pierre and Miquelon
Saint Vincent and the Grenadines
San Marino
Somalia
South Sudan
St. Martin (French part)
Svalbard and Jan Mayen Islands
Syrian Arab Republic
Tokelau
Turkmenistan
Turks and Caicos Islands
Tuvalu
United States Minor Outlying Islands
United States Virgin Islands
Wallis and Futuna Islands
Western Sahara
Zimbabwe

Appendix Table 3. OLS regression of life expectancy at birth (2013) on selected "baseline" parameters

With robust standard errors

		(1) Gini sample	(2) Full sample
GDP per capita, 2013		0.00025**	5.46e-05
		(0.544)	(0.128)
(GDP per capita, 2013)^{squared}		-2.69e09***	-8.52e-10**
		(-0.577)	(-0.186)
Gini		-0.0389	
		(-0.0410)	
Physicians and beds per capita, 2000-2013: Factor		-0.383	-0.252
		(-0.042)	(-0.028)
Mean health spending per capita, 2011-2013		0.00069	0.0012***
		(0.123)	(0.215)
percent secondary-school age children enrolled in school (1990s-2000s)		0.0608**	0.0955***
		(0.342)	(0.305)
Population growth, 2003-2013		2.164***	0.878**
		(0.342)	(0.160)
Population density (person/km), 2013		0.0001	0.0004
		(0.008)	(0.032)
Total fertility rate, 2011-2013		-4.281***	-3.286***
		(-0.714)	(-0.553)
Constant		73.55***	69.81***
		0.0002**	5.46e-05
Number of countries		144	170
R^2		0.817	0.796
Deviation (*d*) of Israel's actual life expectancy from predicted mean (measured in years)		6.26	7.20
Israel's international ranking	All countries (life expectancy>60)	2nd	2nd
	OECD countries only	1st	1st

Robust standard error in parentheses: *** p<0.01, **p<0.05, *p<0.1.

Source: WHO; World Bank, World Development Indicators; UN Population Division Database.

Appendix Table 4. OLS regression of life expectancy at birth on selected parameters at three points in time

With robust standard errors

Variable	1990	2000	2013
GDP per capita[1]	0.00057***	0.00049***	0.00046***
	(0.581)	(0.622)	(0.936)
(GDP per capita, 2013)[squared]	-7.36e-09***	-6.14e-09***	-4.57e-09***
	(-0.426)	(-0.464)	(-0.584)
Physicians and hospital beds per capita[2]	-0.387	-0.963	-0.627
	(-0.042)	(-0.071)	(-0.074)
Population growth rate[3]	2.050***	2.232***	-0.0709
	(0.270)	(0.262)	(-0.012)
Population density[1]	-0.0016***	-0.0011***	0.0006*
	(-0.073)	(-0.059)	(0.053)
Total fertility rate[4]	-4.547***	-5.356***	-3.305***
	(-0.919)	(-0.900)	(-0.573)
Constant	77.05***	77.83***	75.59***
Number of countries	130	13	130
R-squared	0.805	0.790	0.810

Robust normalized beta coefficients in parentheses: ***p<0.01, ** p<0.05, *p<0.1.

1 - GDP and population density estimated from the same year as life expectancy; 2 - Physicians and beds per capita is the mean of the preceding 10-year period; 3 - Population growth rate covers the change in population over the preceding 10-year period; 4 - Total fertility rate is estimated over the preceding three years.
Data: WHO; World Bank, World Development Indicators; UN Population Division Database.

Appendix 5. A methodolocial tangent: An artifact of measurement?

One problem with ranking countries based on deviation from a predicted mean is that countries rise in the ranking if they are doing poorly on some parameter. Take, for example, two countries with the same life expectancy and equivalent characteristics on seven of the eight parameters in an analysis. If the eighth parameter is health spending and one country spends $1,000 per capita per year on health while the other spends $10,000 per capita per year, the country with lower spending will rank higher. The same point can be made about any of the other eight determinants.

A priori, it seems unlikely that Israel's high ranking is an artifact of low scoring on these factors. We know, for example, that among OECD countries, only in Israel and Japan did health spending growth accelerate in the 2009 to 2013 period (OECD, 2013, p. 9).

But to make sure that Israel's rise in the "deviant rankings" is not caused by drastic changes in these determinants, we regress the change in life expectancy between 2000 and 2013 on the change in the explanatory variables. In other words, we estimate how much of the change in life expectancy in Israel between 2000 and 2013 is driven by a shift in time-varying factors included in the baseline model: national wealth (per capita); health spending (per capita); number of physicians and hospital beds; total fertility rate; and adolescent fertility rate. More formally, the model we estimate is:

$$\Delta E[y_c] = (ß_{1c}x + \Delta ß_{1c}x) + (ß_{2c}x + \Delta ß_{2c}x) \ldots + (ß_{nc}x + \Delta ß_{nc}x) \quad (3)$$

where Δ indexes the change in value between 2000 and 2013, and all other terms are as defined in equation (1).

Again, we estimate the country-specific deviation *dc* from the predicted change in $\Delta E[yc]$.

$$d_c = \Delta y_c - \Delta E[y_c]$$

We interpret this predicted deviation as the portion of the change in life expectancy that is a product of changes in predictor variables. Results show that 6.9 percent of Israel's high ranking — 0.47 years out of the total 6.8 years of excess life expectancy — is due to changes across the five variables. Yet this still leaves more than 90 percent of that excess as unexplained.

Appendix Table 6. OLS regression of life expectancy at birth (2013) on selected "baseline" parameters

With robust standard errors, net of baseline characteristics estimated in Model 2 of Table 3

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
% population within 100 km of ice-free coast		0.0196**	0.0216**	0.0268***	0.0236**	0.0211**
		(0..009)	(0.009)	(0.010)	(0.009)	(0.009)
Country is >45 degrees (latitude) from equator		-2.384***	-2.818***	-2.863***	-2.647***	-2.492***
		(0.836)	(0.858)	(0.894)	(0.882)	(0.861)
State supports particular religion, 2007			1.062***	0.880***	0.950***	0.941***
			(0.335)	(0.330)	(0.334)	(0.339)
Military expenditures as % of GDP, 1988-1993				0.0083	0.0053	
				(0.075)	(0.075)	
Any mandatory military service in 1990				1.471***		
				(0.691)		
Mandatory military service in 1990 (months)					0.0513	
					(0.034)	
Interaction term: Military expenditures as % of GDP, 1988-1993 X mandatory military service (months), 1990						0.0082***
						(0.003)
Constant	74.14***	73.21***	72.02***	70.69***	71.28***	71.83***
	(2.708)	(2.688)	(2.629)	(2.703)	(2.597)	(2.524)
No. of sample countries	133	133	133	133	133	133
R-squared	0.818	0.832	0.842	0.847	0.845	0.844
Deviation (*d*) of Israel's actual life expectancy from predicted mean (in years)	7.51	5.38	3.65	2.94	2.38	0.07
Israel's international ranking in d:						
All countries (life expectancy > 60)	**3rd**	**4th**	**20th**	**21st**	**26th**	**70th**
OECD countries only	**1st**	**1st**	**4th**	**5th**	**6th**	**22nd**

All models control for variables used in Appendix Table 3: GDP per capita, 2013 (linear and quadratic terms); physicians and hospital beds per capita, 2000-2013; mean health spending per capita, 2011-2013; percent secondary-school age children in enrolled in school ; population growth, 2003-2013; population density (person/km), 2013; total fertility rate, 2011-2013.
Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Data: WHO; World Bank, World Development Indicators; UN Population Division Database; Nunn and Puga (2012); Pew Research Center, Global Restrictions on Religion Data; SIPRI Yearbook; War Resisters International; GlobalSecurity.org.