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Original Research Article

The "Sick immigrant" and "Healthy immigrant" phenomenon among Jews migrating from the USSR to Israel

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ABSTRACT

The "healthy immigrant" phenomenon finds that immigrants are in better health than natives, while the "sick immigrant" phenomenon finds the opposite. We examined this phenomenon using the relationship between immigration and mortality, stratified by income level, among Soviet immigrants to Israel in the 1990s, compared to veteran immigrants with similar ethnic origin.

A retrospective cohort study of mortality during 1990–2016 was conducted among 63,847 immigrants born during 1940–1950 in the USSR or Eastern Europe, and who immigrated to Israel during 1990–1995. They were compared to a control group of 75,347 Israeli Jews born during the same period in the same countries or second-generation immigrants with parents from these countries and who immigrated by 1960.

After adjusting for sex, age, income, and marital status, we found higher mortality rates among immigrants than non-immigrants for the total study population (adjusted hazard ratio (AHR) = 1.399, 99% confidence intervals (CI) = 1.341, 1.459) and among 19,033 men (AHR = 2.852, 99%CI = 2.619, 3.107) and 24,355 women (AHR = 1.705, 99%CI = 1.566, 1.857) with low incomes. The opposite relationship was found for 25,436 men (AHR = 0.710,99%CI = 0.617, 0.0.816) and for 12,922 women (AHR = 0.693,99%CI = 0.534, 0.900) with high incomes.

When examining the total study population, we found evidence to support the "sick immigrant" phenomenon. However, both men and women in the high-income subgroup, and women in the middle-income subgroup, demonstrated the "healthy immigrant" phenomenon. Decision-makers in Israel should pay particular attention to immigrants from a low socioeconomic level. Our results emphasize the need for social stratification when examining the relationships between immigration and health outcomes.

1. Introduction

Throughout the 1990s, approximately one million immigrants arrived in Israel from the USSR (Central Bureau of Statist, 2006) under Israel's Law of Return (Israel, 1950). This law gives the right to every member of a Jewish family to immigrate to Israel. Previous studies conducted on this immigrant population demonstrated poorer health outcomes than that of the local population (Constant et al., 2018; Konstantinov, 2015). However, some advantage was demonstrated for life expectancy among female immigrants to Israel compared non-immigrants. Male immigrants, on the other hand, demonstrated lower life expectancy (Ott et al., 2009). This contradicts results from studies conducted in Western countries, which show a health advantage for immigrants compared to the local population (Constant et al., 2018; Shor et al., 2017), particularly in countries that absorb immigrants with good health and welfare systems (Shor et al., 2017).

In addition to the fact that immigrants usually come from countries with high health risks, mental stress, low socioeconomic status, and language barriers faced by immigrants when dealing with the healthcare system make it difficult to explain the "healthy immigrant" phenomenon (Shor et al., 2017). Some explain the paradox by the advantage of correct health behavior, social support, and genetic advantages (Constant et al., 2018; Shor et al., 2017; Wallace & Kulu, 2014). In contrast, others consider this phenomenon to be biased in several ways. This includes, for example, the immigration of healthy, strong people, intentional registration biases when entering the country of destination, filtering of

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healthy immigrants by the absorbing countries, a tendency of immigrants with weakening health to return to their mother country prior to their death, known as "the salmon effect" (Constant et al., 2018; Shor et al., 2017; Wallace & Kulu, 2014). Indeed, some studies have shown that the 'healthy immigrant effect' is dependent on sex (Ikram et al., 2016; Oksuzyan et al., 2019), specifically indicating an advantage for women, and age (Guillot et al., 2018). One study conducted among immigrants to the United States and the United Kingdom found that the relationship between age and mortality was U-shaped, and that the greatest advantage was among immigrants aged 45. As immigrants got older, their health advantage waned. Immigrants began to show a health advantage around the age of 20; those who came at a younger age did not have health advantages (Guillot et al., 2018). Furthermore, studies have shown that the 'Healthy Immigrant' phenomenon does not occur in all absorbing countries. Ikram et al., 2016, Oksuzyan et al., 2019, Moullan & Jusot, 2014.

In addition to these selection biases, in many studies the control group generally consisted of the local population of the absorbing country, without accounting for variance in genetic and cultural traits. This in itself may provide an explanation for the differences in health outcomes and morbidity. Therefore, this study included a control group of veteran Jewish immigrants with similar ethnic backgrounds who had immigrated or whose parents had immigrated to Israel from the same countries. This control group allowed us to more accurately examine the relationship between immigration and mortality, in an immigration-absorbing country (Israel, 1950) in which the immigrant receives extensive health services provided within the framework of a National Health Insurance law (Kneset Israel. National H, 1994).

Furthermore, in contrast to the common phenomenon of immigration among relatively young adults, mass immigration of Soviet Jews to Israel during the 1990s included a broad range of ages. These immigrants came to Israel over the course of a relatively short period, without any selection, encouraged by Israel's prevailing immigration policy, due to the situation in the USSR at that time. Compared to the general population of Israel, this immigration was characterized by a higher level of education, a lower income level, and a higher proportion of women, (though a lower proportion of married women). (Central Bureau of Statist, 2006). The unique characteristics of this group, which includes educated, but relatively low-income earners, prompted us to examine the relation of income level to immigration and mortality.

The Jewish population in Israel has a large proportion of immigrants and second-generation immigrants from many different countries, which is likely related to both genetic and cultural traits that distinguish between groups from different areas. To prevent biases that can potentially arise from this situation, this study compares immigrants from the USSR who arrived in Israel in the 1990s to immigrants from the USSR who arrived in Israel prior to 1960 or second-generation whose parents arrived prior to 1960.

This study examines the relationship between immigration and mortality from all causes by income level, among immigrants from the USSR during 1990–1995, compared to veteran immigrants who arrived in Israel prior to 1960 or second-generation immigrants whose parents had immigrated from the USSR and Eastern Europe prior to 1960.

2. Methods

Using data from several sources (Population Registry, Tax Authority, Education Registry, Ministry of Health), a retrospective cohort study was conducted on all-causes of mortality between January 1, 1990 and December 31, 2016. The data for this study were collected and combined by the Israel Central Bureau of Statistics (CBS). Data analysis was conducted in the CBS research room.

This study was approved by the Ethics Committee of the Population Registry, Tax Authority and CBS. All statistical analyses extracted from the CBS research room were approved as meeting ethical standards.

2.1. Study population

The study group (immigrants) included **63,847** Jews born between 1940 and 1950, and who immigrated to Israel between 1990 and 1995, and were born in an Eastern European country or a former Soviet state.

The control group included **75,347** Israeli Jews born between the years of 1940 and 1950 who were born in an Eastern European country or former Soviet state and immigrated to Israel prior to 1960 or whose parents were born in an Eastern European country or Soviet state and immigrated to Israel prior to 1960. To create two similar ethnic groups, we included only those who, according to the population registry, were identified as Jewish. Not included were those recorded as not being Jewish or without religion, who most likely came to Israel by virtue of the Law of Return, which permits immigration to people with Jewish relatives, even if they themselves are not Jewish.

2.2. Research variables

Variables obtained from the Population Registry included: year of birth, sex, country of birth, year of immigration to and/or emigration from Israel.

Marital status at the beginning of follow-up period, obtained from the Population Registry, was converted into a dichotomous variable in which 'single', 'divorced' and 'widowed' were defined as 'unmarried'.

Socioeconomic status by residential area, the residence of the individual during 2017 or during his/her last year of life, was based on the 2013 socioeconomic index of the community of residence, obtained from the CBS, and classified into socioeconomic levels for community of residence on a scale of 1–10. For the purposes of this study, this variable was classified into low (1–5), middle (6–7), and high (12–14) socioeconomic status. Seemingly, the average income during the follow-up period is the most appropriate measure for income level for this study. However, significant changes in the average income of Israel that occurred in this period (it was 2.18 times higher at the end of the study period compared to at the beginning of the study). Additionally, the long follow-up period could include years where an individual is registered as receiving a pension significantly lower than the actual income level, but this does not properly reflect their actual income level. Therefore, calculating an individual's average income for the entire period properly does not necessarily reflect his actual income level. For this reason, the income level of each individual was calculated in the following manner. First, the relative income was calculated for each year, and then we calculated the highest level of income that the individual achieved throughout the entire study period, based on the calculated annual relative income.

The highest relative income level per individual during the follow-up period was based on data obtained from the Tax Authority regarding individual income from wages or from annual business earnings (not including income from dividends, national insurance, or any other income not considered wages or self-employed work). These data were obtained for the years 1996 and 2016 and for the years that the individual reached the age of 50 and/or 60 and/or 65 and/or 70 during the monitoring period. To construct a unified variable, the income distribution of the entire study population in each of these years was divided into deciles. Based on this distribution, individual income level was determined by the relative decile for each year. These variables were grouped into a unified variable that represents the highest relative income level reached by the individual during the follow-up period. This variable was classified into three categories: low income level, in which the highest relative income level reached was up to decile 3,; middle income level, in which the highest relative income level of the individual was between deciles 4–7; and high income level, in which the highest relative income level of the individual during this period stood at deciles 8–10.

The education level variable was constructed using data obtained from the Education Registry, managed by the CBS, and based on

education data from different sources such as academic institutions, Ministry of Education, sample surveys, and censuses. We classified these data into three education levels: High – 15 years of education or more; Intermediate – 11–14 years of education; and Low – up to 10 years of education.

The outcome variables for this study – mortality and year of death – were obtained from the Population Registry, based on data from the Ministry of Health and death certificates.

2.3. Statistical analysis

First, we examined the distribution of the variables sex, age, marital status, education, socioeconomic status by residential area, and immigration/emigration of immigrants and non-immigrants. Chi-square test was used to compare frequency distributions of categorical variables and *t*-test was used for age.

Second, mortality rates were examined with respect to the following variables: immigration, sex, marital status, education and socioeconomic status by residential area. Adjusted Hazard Ratio (AHR) for mortality, adjusted for age and/or sex, was used to compare mortality rates between groups.

We note that due to a relatively high rate of missing information for the education variable among non-immigrants (20%), and a high correlation between this variable and the income variable, we decided not to include the education variable in the models in the remainder of the analysis.

Third, using Cox regression and adjusted Kaplan Meier curves we constructed models to evaluate the relationship between immigration and mortality, after controlling for sex, age, income level and marital status, and their interactions. Likelihood ratio tests were used to compare between models, as described in detail in Online Resource 1. Effect estimates are presented as hazard ratios (HRs) and 99% confidence intervals (CIs) of a death associated with immigration group or with other covariates.

Model 1 included main effects of the immigrant group, sex, age, income level, and marital status. In Model 2, we added 2-way interactions to the variables included in the first model, and in Model 3 we added 3-way interactions. We used stepwise selection criteria with $P < 0.005$ to add variables to each model and only covariates that added to the explanatory power of the model were included in the final adjusted model.

Finally, to better understand the interaction between immigration, sex, and income, we divided the study population into six groups by income level (3) and sex (2). Cox regression and adjusted Kaplan Meier curves were used to analyze associations between mortality and immigration within each group, controlling for age and marital status.

We did not have mortality data for individuals who emigrated from Israel during the study period and did not return by the end of the study period. These individuals were considered censored and contributed to the number at risk in the survival analyses until the year they left Israel.

All statistical analyses were conducted using SPSS version 23.0

3. Results

3.1. Demography

The study population included 139,194 individuals, with **63,847** (45.8%) immigrants and **75,347** (54.2%) non-immigrants. The percentage of women was higher in the immigrant population (52.6%) compared to the non-immigrant population (47.6%) ($p < 0.001$). Immigrants were older, more educated, lived in lower socioeconomic status residential areas, and received lower incomes than that of non-immigrants ($p < 0.001$). Similarly, the proportion of married participants was higher among male immigrants than among non-immigrants (84.1% vs. 76.0%) ($p < 0.001$), but lower among female immigrants than among non-immigrants (67.0% vs. *73.2%*) ($p < 0.001$) (Table 1).

3.2. Mortality

The overall mortality rate during the study period among all 139,194 participants was 12.6%. Distribution of mortality rate by study variable (Table 2) showed that the mortality rate was higher among immigrants (14.3% vs. 11.1%) even after adjusting for age and sex (AHR = 1.345, 99% CI = 1.294, 1.399).

Similarly, a higher mortality rate was found even after adjusting for age and sex among those individuals who were unmarried at the beginning of the study period, compared to those who were married (AHR = 1.253; 99%CI = 1.199, 1.309).

When examining the role of the socioeconomic variables in predicting mortality after adjusting for age and sex, mortality rates were found to be higher for people with low (AHR = 2.211; 99%CI = 2.090, 2.339) and intermediate (AHR = 1.354; 99%CI = 1.290, 1.422) levels of education compared to those with a high level of education.

Likewise, higher mortality rates were found among low-income (AHR = 2.888; 99%CI = 2.727, 3.058) and middle-income (AHR = 1.731; 99%CI = 1.634, 1.833) earners than among high-income earners (Table 2).

3.3. Multivariable models to evaluation the relationship between immigration and mortality

The multivariable Cox model evaluating the relationship between immigration and mortality among all 139,194 participants in the study population included the base variables immigration, sex, age, income level, and marital status (Model 1, Table 3). A higher mortality rate was found among immigrants compared to non-immigrants (HR = 1.399; 99%CI = 1.341, 1.459).

Results for this model, and for all other models described below, indicated higher mortality rates for men than women, for unmarried individuals than married, and for low- and middle-income earners than

Table 1
Distribution of study variables by immigration (n = 139,194).

		Immigrants (N = 63,847)	Non-immigrants (N = 75,347)	p-exact sig (2-sided)	Percentage missing
% Women		52.6%	47.6%	<0.001	0.00%
Average age at beginning of follow-up period (s.d)		44.11 (3.16)	43.97 (2.86)	<0.001	0.00%
% Married men		84.1%	76.0%	<0.001	0.04%
% Married women		67.0%	*73.2%*	<0.001	0.02%
Education level	High	55.1%	37.4%	<0.001	17.8%
	Intermediate	29.4%	49.8%		
	Low	15.5%	12.8%		
Socioeconomic status by residential area	High	9.6%	41.5%	<0.001	0.80%
	Middle	37.6%	39.9%		
	Low	52.8%	18.7%		
Income	High	15.3%	37.9%	<0.001	0.00%
	Middle	59.4%	25.9%		
	Low	25.3%	36.2%		

Table 2
Distribution of mortality rates by study variables. NAHR (Non-Adjusted Hazard Ratio) and AHR (Adjusted Hazard Ratio).

		% Mortality	NAHR		AHR	
			NAHR (99%CI)	p	AHR (99%CI)	P
Total		12.6%				
Immigration	Non-immigrants	11.1%	1.00		[b]1.00	
	Immigrants	14.3%	1.338 (1.286–1.391)	<0.001	[b]1.345 (1.294–1.399)	<0.001
Sex	Female	10.2%	1.00		[a]1.00	
	Male	14.9%	1.506 (1.447–1.567)	<0.001	[a]1.534 (1.474–1.596)	<0.001
Marital status	Married	12.1%	1.00		[b]1.00	
	Unmarried	14.0%	1.196 (1.146–1.250)	<0.001	[b]1.253 (1.199–1.309)	<0.001
Education level	High	9.8%	1.00		[b]1.00	
	Intermediate	13.2%	1.359 (1.294–1.427)	<0.001	[b]1.354 (1.290–1.422)	<0.001
	Low	21.8%	2.372 (2.242–2.508)	<0.001	[b]2.211 (2.090–2.339)	<0.001
Socioeconomic status by residential area	High	10.4%	1.00		[b]1.00	
	Middle	12.1%	1.163 (1.104–1.226)	<0.001	[b]1.158 (1.099–1.221)	<0.001
	Low	14.9%	1.457 (1.384–1.535)	<0.001	[b]1.443 (1.371–1.520)	<0.001
Income	High	7.7%	1.00		[b]1.00	
	Middle	11.9%	1.615 (1.525–1.709)	<0.001	[b]1.731 (1.634–1.833)	<0.001
	Low	17.7%	2.772 (2.621–2.931)	<0.001	[b]2.888 (2.727–3.058)	<0.001

[a] Age adjusted Hazard Ratio.
[b] Age and sex adjusted Hazard Ratio.

Table 3
Results of Cox models for predicting mortality by social variables and their interactions within the entire study population (N = 139,194). HR (Hazard Ratio).

		Model 1		Model 2		Model 3	
		HR (99%CI)	P	HR (99%CI)	P	HR (99%CI)	P
Immigration	Non-immigrants	1.00		1.00		1.00	
	Immigrants	1.399 (1.341–1.459)	<0.001	0.497 (0.431–0.572)	<0.001	0.661 (0.510–0.856)	<0.001
Sex	Female	1.00		1.00		1.00	
	Male	1.797 (1.725–1.871)	<0.001	1.447 (1.295–1.615)	<0.001	1.529 (1.356–1.723)	<0.001
Age		1.088 (1.081–1.094)	<0.001	1.079 (1.073–1.086)	<0.001	1.080 (1.073–1.086)	<0.001
Income level	High	1.00		1.00		1.00	
	Middle	1.511 (1.423–1.604)	<0.001	1.426 (1.270–1.601)	<0.001	1.370 (1.204–1.559)	<0.001
	Low	2.828 (2.666–3.000)	<0.001	1.782 (1.593–1.993)	<0.001	1.992 (1.765–2.248)	<0.001
Marital status	Married	1.00		1.00		1.00	
	Unmarried	1.085 (1.009–1.156)	<0.001	1.057 (1.009–1.106)	<0.001	1.064 (1.017–1.114)	<0.001
Immigration X Sex				1.490 (1.366–1.624)	<0.001	1.041 (0.776–1.397)	0.725
Sex X Income	High income level			1.00		1.00	
	Middle income level			1.215 (1.062–1.390)	<0.001	1.341 (1.142–1.574)	<0.001
	Low income level			1.017 (0.893–1.157)	0.893	0.844 (0.728–0.979)	0.003
Immigration X Income	High income level			1.00		1.00	
	Middle income level			1.479 (1.283–1.704)	<0.001	1.283 (0.970–1.696)	0.022
	Low income level			3.823 (3.324–4.396)	<0.001	2.535 (1.930–3.330)	<0.001
Sex X Immigration X Income	High income level					1.00	
	Middle income level					1.119 (0.809–1.547)	0.371
	Low income level					1.831 (1.333–2.515)	<0.001

high-income earners.

Model 2 included the base variables as well as their interactions: sex X immigration, sex X income, and immigration X income. These interactions were found to be statistically significant when they were added to the model the relationship between immigration and mortality was reversed (HR = 0.497; 99%CI = 0.431, 0.572).

Model 3 included the interaction sex X immigration X income in addition to the base variables and the interactions in Model 2. This interaction was significant for low-income earners in comparison to high-income earners ($p < 0.001$) and but was not significant for middle-income earners ($p = 0.371$). When this interaction was added to the model, the estimate was somewhat attenuated in comparison to Model 2 (HR = 0.661; 99%CI = 0.510, 0.856), but the direction of the relationship was maintained (Table 3).

Analysis of the relationship between immigration and mortality when classifying by sex and income level.

The multivariable Cox models evaluated the relationship between immigration and mortality within subgroups included the variables immigration, age, and marital status. These models were run separately for each sex, and then for each combination of sex and income level (6 subgroups).

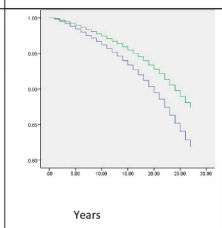
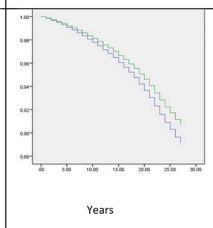
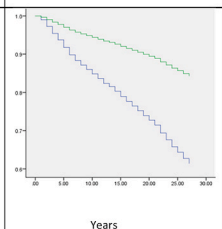
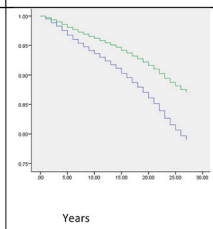
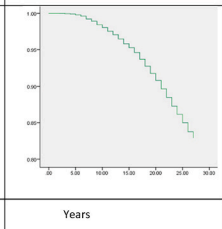
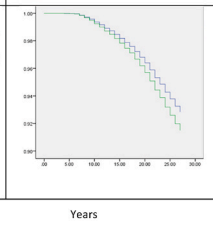
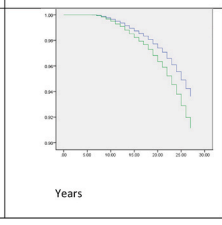
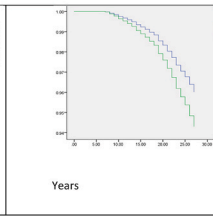
Among the 69,789 male participants, a higher mortality rate was found for immigrants than non-immigrants (HR = 1.483; 99%CI = (1.410–1.561)). A weaker association but with similar directionality was found among 69,405 women (HR = 1.181, 99%CI = 1.111, 1.256).

However, separate models for each income level within sex revealed differences in the strength and directionality of the estimates. Among 19,033 men with low incomes the mortality rate was higher among immigrants than among non-immigrants (HR = 2.852; 99%CI = 2.619, 3.107), but the opposite directionality was found among 25,436 men with high incomes (HR = 0.710; 99%CI = 0.617, 0.816). No relationship between immigration and mortality was found for 25,320 men with middle-level incomes (HR = 1.000; 99%CI = 0.917, 1.090) (Table 4).

Similarly, for 24,355 women with low incomes the mortality rate was higher among immigrants than among non-immigrants (HR = 1.705; 99%CI = 1.566, 1.857), but an inverse relationship was found among 32,128 women with middle incomes and 12,922 women with high incomes (HR = 0.836; 99%CI = 0.753, 0.927 and HR = 0.693; 99% CI = 0.534, 0.900, respectively) (Table 4).

It is important to note that with a sample of this size, common to many population-based studies, the effect size is a better measure than significance level to understand the results. It is also important to point

Table 4
Analysis of mortality rates for men and women among immigrants compared to non-immigrants, adjusted for age and marital status, focusing on the total study population and on each income level separately. Non-immigrants (green line); immigrants (blue line).

	Men			Women		
	N	Kaplan Meier survivor curve	AHR (99% CI)	N	Kaplan Meier survivor curve	AHR (99% CI)
Total population	69,789		1.483 (1.410-1.561) p<0.001	69,405		1.181 (1.111-1.256) p<0.001
Low income level	19,033		2.852 (2.619-3.107) p<0.001	24,355		1.705 (1.566-1.857) p<0.001
Middle income level	25,320		1.000 (0.917-1.090) p=0.992	32,128		0.836 (0.753-0.927) p<0.001
High income level	25,436		0.710 (0.617-0.816) p<0.001	12,922		0.693 (0.534-0.900) p<0.001

out that this study used a 99% significance level, higher than the standard 95% utilized in the majority of studies. To conclude, when examining the relationship between immigration and mortality in the total population, immigration is a risk factor for mortality among both sexes, but more so among men. When classifying the cohort by sex and income level, we found that among low-income men and women, immigration was associated with increased mortality. However, among high-income men and middle- and high-income women the risk of mortality was lower among immigrants.

4. Discussion

Similar to previous analyses (Central Bureau of Statist, 2006), the results of our study show that the immigrants from the USSR to Israel between 1990 and 1995 were better educated, earned less, included a higher proportion of women, and a lower proportion of married women than the non-immigrant population of similar background. This may be related to the large differences in life expectancy between the sexes in the USSR during the 1990s (Bobak & Marmot, 1996; Ott et al., 2009). In addition, consistent with other studies, the current study found that having high income (Brodish & Hakes, 2016; Chetty et al., 2016; Marmot, 2002; Mustard & Etches, 2003; Pickett & Wilkinson, 2015), higher education (Byhoff et al., 2017; Lleras-Muney, 2005; Regidor et al., 2016), and being married (Tatangelo et al., 2017) were associated with better health outcomes.

Our study, which examined the relationship between immigration and mortality by comparing an immigrant group to a control group of similar ethnic origin in a country that encourages immigration, produced results that support the 'sick immigrant' phenomenon. Nevertheless, when stratified by income level, some income groups, specifically the high-income subgroup, produced results that support the 'healthy immigrant' phenomenon.

The relationship between immigration and mortality in the total study population.

When examining the relationship between immigration and mortality in the total study population, our results showed an opposite trend to that expected between immigration and mortality. Support for the 'sick immigrant' phenomenon in this immigrant group can be found in a study that examined the relationship between immigration and state of health in European countries and Israel. This study demonstrated, as expected, a health advantage for immigrants in European countries in comparison to the local populations. However, poorer health was found

among immigrants to Israel from the USSR in the 1990s (Constant et al., 2018).

Our results corroborate results of previous population surveys conducted in Israel, which indicated that these immigrants evaluate their state of health as being worse than native Israeli Jews, and had a higher rate of hospitalization than the local Jewish population (Konstantinov, 2015). However, this finding is not consistent with the results of a different study (Ott et al., 2009) conducted on this population, which demonstrated a certain life expectancy advantage among female immigrants compared to non-immigrants. We note that the control group in that study included all Israeli citizens, including Arab Israeli citizens, who have a higher mortality rate than the Jewish population (Weiss, 2017), while in the current study we chose to include only Jews of Eastern European origin.

When comparing the mortality rate of these immigrants to the mortality rate of non-immigrants it is important to remember that the countries of origin have lower life expectancy than in Western countries (Bobak & Marmot, 1996; Ott et al., 2009; Rennert, 1994); Israel has one of the highest life expectancies in the Western world. Nevertheless, there have been studies that support the 'healthy immigrant' phenomenon among immigrants from developing countries with low life expectancy to Western countries (Constant et al., 2018; Shor et al., 2017). Furthermore, in line with previous studies (Shor et al., 2017), we could have expected that in Israel, as a multicultural country characterized by high immigrant absorption and with good health and welfare systems, immigrants would have an advantage.

During the 1990s, with the fall of the Soviet Union, immigration options for Soviet Jews were primarily the USA and Israel. Immigration to the USA during that period was conditional on obtaining a visa and having family ties. Those who were unable to pass the American selection, applied to immigrate to Israel. A study of Russians who immigrated to the United States from the USSR in the 1990s (with Jews consisting of a majority of this group) found a higher rate of disability within this population than among the native, white population in the United States. (Mehta & Elo, 2012). This finding was explained by poor conditions in early life such as poor nutrition during childhood and infectious diseases that may have long-term consequences, along with the social and psychological pressures related to the Soviet economic crisis. In addition to these explanations, there are other possible explanations for the unique 'sick immigrant' phenomenon among Soviet immigrants to Israel during 1990–1995. First, these people immigrated under the Law of Return (Israel, 1950). This law allows any Jewish family member to immigrate to Israel without the customary filtering and health examinations practiced in other Western countries, which could potentially explain the 'healthy immigrant' phenomenon in these countries (Constant et al., 2018).

Second, high life expectancy, a high level of available healthcare services, and the broad spectrum of healthcare services provided to every immigrant within the framework of the National Health Insurance Law (Kneset Israel. National H, 1994) may serve as a catalyst for immigration among sick people who need these health services and who are at higher risk of mortality.

Third, biases in the registration of entries to and exits from the country, raised in the literature as a potential explanation for the 'healthy immigrant' phenomenon in Western countries (Shor et al., 2017; Wallace & Kulu, 2014) seem less applicable to in Israel. This is because each immigrant is assigned a personal identification number and is included in the Population Registry.

Fourth, healthy behavior among immigrants, which is considered to be one of the explanations for the 'healthy immigrant' phenomenon (Constant et al., 2018; Shor et al., 2017; Wallace & Kulu, 2014), is not relevant with respect to this immigrant population. Specifically, this immigrant group consumes more alcohol than the general Israeli population (Schiff et al., 2005; Weiss, 2008) and has poorer health behavior than the general population in Israel (Rennert, 1994).

Finally, the genetic advantage attributed to immigrants, which serves as one of the explanations for the 'healthy immigrant' phenomenon (Constant et al., 2018; Shor et al., 2017; Wallace & Kulu, 2014), is less relevant to this study, as our control group consists of a local population with a similar ethnic origin.

4.1. Classifying the cohort by income level

Stratifying the association between immigration and mortality by income level, our results show that immigration is a protective factor against mortality for high-income earners, but it is a risk factor for low-income earners. The 'sick immigrant' phenomenon among low-income earners which is in stark contrast to the 'healthy immigrant' phenomenon among high-income earners, can be explained in several ways. First, we suggest that immigrants with high income potential made an educated decision to immigrate after evaluating other potential options. The stronger and healthier people who decided they would be able to manage the transition are those who eventually immigrated to Israel (Shor et al., 2017; Wallace & Kulu, 2014). In contrast, immigrants with low-income potential might consider immigration to Israel as an opportunity. Possibly, their decision to immigrate was part of an overall sweeping wave of immigration, leading to a situation where the weak also immigrated. This is evident in the mortality differences within the immigrant group.

Furthermore, we suggest that the bias of returning to the country of origin known as the 'salmon effect', whereby immigrants return to their homeland when their health deteriorates prior to their death (Constant et al., 2018; Shor et al., 2017; Wallace & Kulu, 2014), is expected to be more prevalent among high income earners who can afford to emigrate from Israel, despite the healthcare services they receive through the National Health Insurance Law (Kneset Israel. National H, 1994). Additionally, although these immigrants have poorer health habits (Rennert, 1994; Schiff et al., 2005; Weiss, 2008) than the local population in Israel, we suggest that those who achieved high income earner status have more contact with Israeli society, and this could have exposed them to healthier behavior. Lastly, we propose that earners who achieved high income status have fewer language barriers, higher literacy skills, and are less inclined to experience the mental stress characteristic of immigrants.

Effect modification by income level was indicated in a study conducted in Finland in which lower mortality rates were found among immigrants at all income levels. However, differences between immigrants and non-immigrants were greater among immigrants with low socioeconomic status. In other words, a more widespread 'healthy immigrant' phenomenon was found among those with *low* socioeconomic status. These findings, which contradict our results, were explained by poor health behavior among non-immigrants with low socioeconomic status. The 'salmon effect' occurs more among low-income earners who cannot afford the cost of healthcare treatment in Finland, and other selection biases (Patel et al., 2018). It seems that the characteristics of immigration in Finland are different from those of the USSR immigration to Israel, where immigrants have poorer health behavior than the local population (Rennert, 1994; Schiff et al., 2005; Weiss, 2008), and the 'salmon effect' among them is inhibited due to the comprehensive health services provided to all immigrants.

4.2. Sex differences in the relationship between immigration and mortality

When examining the relationship between immigration and mortality within the total study population we found that immigration is a risk factor for mortality among both sexes, but more so among men. This is in contrast to previous studies conducted in other Western countries in which the opposite relationship was found, i.e. a higher mortality advantage among male immigrants (Shor et al., 2017).

Effect modification by sex in the total study population may be explained by the exceptional differences in life expectancy between the sexes in the USSR in 1990s (Bobak & Marmot, 1996; Ott et al., 2009;

Weiss, 2008). Specifically, the difference in life expectancy among Israeli and Soviet males during the 1990s was greater than for women. However, it is important to note that the disparity in life expectancy among the sexes was not as high among Jews in Russia as among non-Jews (Shkolnikov et al., 2004).

This difference was also explained partly by the poorer health habits of men (Guillot et al., 2018; Ott et al., 2009), which may also explain the difference between the sexes in regards to the strength of the relationship between immigration and mortality at low income. One could argue that male immigrants of low socioeconomic status have poorer health habits and are less inclined to health-promoting behavior. Moreover, previous studies have demonstrated a stronger relationship between income and mortality in males than for females (Chetty et al., 2016; Mustard & Etches, 2003), similar to the results of our study.

4.3. Strengths and limitations of the study

The main strength of this study lies in the fact that we had widespread real-time population and income data; however, we do not have the tools to determine the reliability of variables in these data sources. Furthermore, the income data in this study are based on income of individuals, which excludes income of partners. This could affect the quality of the study's results. On the other hand, marital status of the individual was included in all models.

A further bias related to income data may stem from the fact that income from dividends, social insurance or any other income other than wages or self-employed work, was not included in the 'Income' variable in this study. However, we could assume that most of the population does not receive a significant income from dividends and that support from social insurance is received according to individual income level and age.

An additional bias that may occur arises when comparing this fixed property for immigrants and non-immigrants over time since migration. Relative income for both immigrants and non-immigrants may improve over time, but for immigrants soon after arrival it is likely to improve faster compared to non-immigrants. Soon after arrival and before they have acquired language skills and local work experience immigrants will be at a lower position in the relative income distribution, and as a population their position will improve over duration of residence. Therefore, those who live longer will have a better chance of 'catching up' simply because they live for a longer period of time.

In order to compare groups with similar ethnic origin, our control group comprised immigrants and children of immigrants who came from Eastern Europe countries and former Soviet states. In contrast, we must remember that the former Soviet states are diverse with respect to health level and health behavior characteristics; this may affect the quality of the study results and there may be there is justification for classification by the state of origin.

This study included participants native to the Chernobyl disaster region. In the Israeli Population Registry, immigrants from Belarus and Ukraine were classified as immigrants from the USSR until the fall of the Soviet Union. This made it difficult to properly identify these immigrants for exclusion. Including these immigrants can create a potential confounding factor. However, a previous study conducted in Israel found no excess mortality among immigrants in very exposed areas around the disaster compared to less exposed. (Slusky et al., 2017).

This study has a uniform analysis for all immigrants from the former Soviet Union who immigrated between the years of 1990 and 1995. It would make sense to assume that immigrants from specific years have specific characteristics that differentiate between them and immigrants from other years. Future studies could seek to evaluate the differences in the association between immigration, income, and mortality among immigrants from specific years.

An additional limitation of our study may stem from the disparities during the follow-up period. This study followed participants born between 1940 and 1950 who arrived in Israel between 1990 and 1995. This creates a situation whereby those arriving between 1990 and 1991 have a longest follow-up period than those who arrived later. This bias may be significant in a situation where earlier immigrants are younger than immigrants coming in later years. To overcome this potential bias, the age range of the participants was quite narrow and immigration years were limited.

4.4. Implications for the future

Decision-makers in Israel, as an immigrant-absorbing country, should invest in, and pay particular attention to immigrants of low socioeconomic status, who, according to the results of our study have worse health outcomes than those of non-immigrants. The results of this study emphasize the need to examine the relationships between immigration and health outcomes using social stratification. This conclusion is important in view of the ever-growing immigration around the world.

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Declaration of competing interest

The authors have no conflicts of interest to declare.

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