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Original Contribution

Holocaust Experience and Mortality Patterns: 4-Decade Follow-up in a Population-Based Cohort

Iaroslav Youssim*, Malka Gorfine, Ronit Calderon-Margalit, Orly Manor, Ora Paltiel, David S. Siscovick, Yechiel Friedlander, and Hagit Hochner*

* Correspondence to Dr. Iaroslav Youssim, Braun School of Public Health, Hebrew University of Jerusalem-Hadassah Medical School, P.O. Box 12271, Jerusalem 9112102, Israel (e-mail: iaroslav.youssim@mail.huji.ac.il); or Dr. Hagit Hochner, Braun School of Public Health, Hebrew University of Jerusalem-Hadassah Medical School, P.O. Box 12271, Jerusalem 9112102, Israel (e-mail: hagit.hochner@mail.huji.ac.il).

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Research on mortality associated with exposure to the Holocaust is relevant for a better understanding of the effects of genocides on survivors. To our knowledge, previous studies have not investigated the long-term *cause-specific* mortality of Holocaust survivors. We compared mortality rates among Israelis born in European countries controlled by the Nazis during World War II with those among Israelis of European descent who did not have this exposure. Records of 22,671 people (45% women; 5,042 survivors) from the population-based Jerusalem Perinatal Study (1964–1976) were linked to the Israeli Population Registry, which was updated through 2016. Cox models were used for analysis, with 2-sided tests of statistical significance. Risk of all-cause mortality was higher among exposed women (hazard ratio (HR) = 1.15, 95% confidence interval (CI): 1.05, 1.27) than in unexposed women. No association was found between Holocaust exposure and male all-cause mortality. In both sexes, survivors had higher cancer-specific mortality (HR = 1.17 (95% CI: 1.01, 1.35) in women and HR = 1.14 (95% CI: 1.01, 1.28) in men). Exposed men also had excess mortality due to coronary heart disease (HR = 1.39, 95% CI: 1.09, 1.77) and lower mortality from other known causes combined (HR = 0.86, 95% CI: 0.75, 0.99). In summary, experiencing the Holocaust was associated with excess all-cause and cancer-specific mortality in women and cancer- and coronary heart disease–specific mortality in men.

cancer; cohort studies; coronary heart disease; genocide; Holocaust; mortality; survival analysis

Abbreviations: CHD, coronary heart disease; CI, confidence interval; HR, hazard ratio; ICD-9, *International Classification of Diseases, Ninth Revision*; ICD-10, *International Classification of Diseases, Tenth Revision*; SEP, socioeconomic position; SHARE-IL, Israeli component of the Survey of Health, Ageing and Retirement in Europe.

The Holocaust undoubtedly stands out in human history as an extraordinary outburst of extreme violence. Tragically, genocides continue to occur and are not diminishing in frequency (1). In order to better understand long-term effects of extreme violence on human biology, research on mortality and morbidity associated with the Holocaust is as relevant in the 21st century as ever.

Epidemiologic literature has demonstrated that social environment at different stages of life can have substantial health consequences over the life course (2–6). Whether as captives in concentration/death camps or as escapees, Jewish survivors of the Holocaust have faced a combination of severe multifaceted stress conditions—for example, extreme physical and emotional abuse, sleep deprivation, strenuous physical activity, and exposure to infectious diseases and toxic waste (7–9). Many victims died quite soon after the Holocaust (10) or were too physically or mentally injured to resume a "normal" life (11). While a considerable number of survivors nevertheless managed to rebuild their lives (12, 13), it is a reasonable hypothesis that the Holocaust may have had a profound long-term impact on survivors' health.

At the time we conducted this research, extant studies on the health consequences of the Holocaust had yielded conflicting findings, particularly with respect to mortality

(14, 15). While some recent research in Israel found that the Holocaust did not affect old-age all-cause mortality (13, 16, 17), other studies showed that it was even lower among the survivors (18, 19).

Several explanations have been proposed to account for the conflicting evidence (15, 16, 20), yet Fund et al. (19) recently noted that more research is warranted to understand Holocaust-related death hazards. Moreover, we are not aware of any study that has investigated long-term cause-specific mortality in Holocaust survivors. Using data from a population-based cohort with mortality records spanning the period from the 1960s to 2016, we aimed to assess whether exposure to the Holocaust affected all-cause and cause-specific mortality among survivors who were able to immigrate to Israel and had offspring.

METHODS

Study design and data source

The Jerusalem Perinatal Study is a population-based cohort study of 92,408 live births and stillbirths that occurred in Jerusalem, Israel, during the period 1964–1976, as well as the parents in those births (21). The current analysis focused on the parents' generation, baseline data on whom included detailed sociodemographic characteristics (e.g., date and country of birth, education) and health-related and perinatal factors in mothers (21). Using unique Israeli identity numbers, vital status and dates of death (up to December 31, 2016) were obtained by linkage of the cohort members' baseline records to the Israeli Population Registry. For a very small number of participants (0.06%), these data were verified through April 1, 2005. Underlying causes of death were available through the end of 2015 via record linkage with the Israel Ministry of Health. The cohort was also linked to the Israel National Cancer Registry, which was established in 1960 and updated through December 31, 2014. Deceased subjects for whom the cause of death was unknown were determined to have died from cancer if they had been diagnosed with cancer and passed away within 5 years following the first diagnosis. The remaining cases with unknown causes of death were combined and analyzed as a separate category.

The study was approved by the Institutional Review Board of Hadassah-Hebrew University Medical Center in Jerusalem.

Selection of the study sample and definition of exposure status

This work relied on a definition of a Holocaust survivor used by Israel's research and governmental institutes, according to which a Holocaust survivor is a person who lived in one of the countries occupied by or under the influence of the Nazi regime for any length of time between 1933 and 1945. According to this definition, the survivor population also includes persons who were forced to leave their place of residence because of the Nazi regime (22).

Figure 1 shows how exposed, unexposed, and excluded groups were defined on the basis of the initial sample. As in similar studies (12, 17, 23), to minimize biases related to cultural, environmental, and genetic differences between survivors and unexposed individuals, we included only persons of European descent born before or during 1945. Following the approach used by Lurie et al. (23), survivors were further defined as those who had been born in a Nazi-occupied country and had immigrated to Israel during or after the year in which Nazi persecutions in that particular country had started (see Web Table 1, available online at https://doi.org/10.1093/aje/kwab021). The comparison group was defined as either 1) persons born in the same country who immigrated to Israel *before* the Nazi persecutions or 2) persons of European descent born in any other country (including Israel) before or during 1945. Since the country-of-birth variable did not specify a particular republic for immigrants from the Union of Soviet Socialist Republics, we could not establish whether they had been born under Nazi occupation and therefore excluded these participants (about 2% of the sample) from all analyses. The resulting exposure variable was coded as a dummy variable (1, exposed; 0, unexposed). Following this exposure definition, 10,210 women and 12,461 men (comprising 25% and 30% of the original samples, respectively) were included in the reported analyses, of whom 2,133 females and 2,909 males were Holocaust survivors (Figure 1).

We tested this exposure definition using data from the Israeli component of the Survey of Health, Aging and Retirement in Europe (SHARE-IL) (24–26), which includes self-reported information about subjects' Holocaust experiences (e.g., see Shrira et al. (27)). Applying our definition of exposure to the SHARE-IL data and comparing it with the SHARE-IL self-reports demonstrated high reliability of our definition: 93% overall agreement (Cohen's $\kappa = 0.72$) including countries within the Union of Soviet Socialist Republics (Belarus, Estonia, Latvia, Lithuania, Moldova, and Ukraine) and 94% agreement ($\kappa = 0.75$) excluding these countries.

Key variables

The outcomes studied were all-cause and cause-specific mortality. The underlying causes of deaths that occurred between the 1960s and 1997 were categorized according to *International Classification of Diseases, Ninth Revision* (ICD-9) codes, and the causes of deaths that occurred from 1998 onwards were categorized according to *International Classification of Diseases, Tenth Revision* (ICD-10) codes (28). Causes of death were categorized into the following groups: deaths due to all circulatory conditions (ICD-9 codes 390–459; ICD-10 codes I0–I99); deaths due specifically to coronary heart disease (CHD) (ICD-9 codes 410–414, 427.4, and 427.5; ICD-10 codes I20–I25, I46, and I49); deaths due to all neoplasms (ICD-9 codes 140–239; ICD-10 codes C0–C99 and D0–D48); deaths due to unnatural causes (ICD-9 codes 80–99; ICD-10 codes S0–T88 and V0–Y99); and deaths due to all other known causes combined. We created a separate category for persons with an unknown cause of death.

The following variables were included in the analyses as covariates, in addition to the main explanatory variable: sex

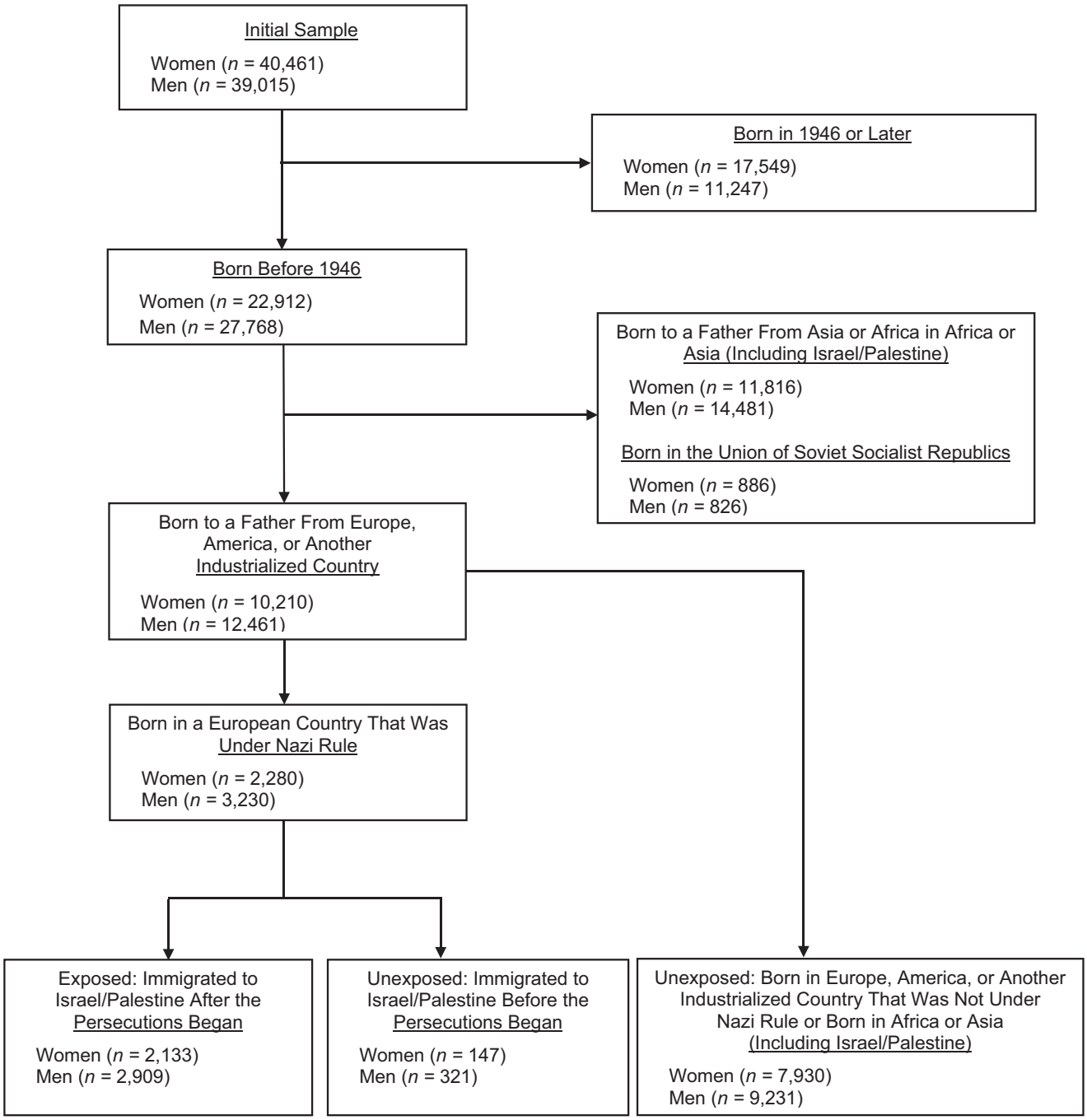

Figure 1. Selection of participants for a study of Holocaust experience and mortality patterns, Jerusalem Perinatal Study, Israel, 1964–1976.

(unless stated otherwise, all of the analyses were performed separately in subsamples of men and women), a 6-point socioeconomic position (SEP) scale (ranging from 1 (highest) to 6 (lowest)) based on men's occupations, and educational level in years (categorized as 0, 1–4, 5–8, 9–12, and ≥13). For women, we were also able to control for parity (reported number of children born before first registration in the Jerusalem Perinatal Study cohort, plus those born within the cohort (categorized as 1, 2–4, 5–9, and ≥10)), the presence of obstetrical conditions (toxemia, heart disease, diabetes, or prediabetes) (1, yes; 0, no), and average birth weight of all of a woman's offspring who were registered in the cohort, in grams (categorized as <2,500, 2,500–2,999, 3,000–3,499, and ≥3,500). The values for SEP and education were copied from the record of a person's last offspring born in the cohort. Although some people in the cohort could

have increased their achievements later, it is reasonable to assume that these variables reflect well the participants' lifetime social position.

Statistical analysis

To investigate mortality hazards, we employed survival analysis based on the age scale. We faced the statistical issue of left-truncation (also known as delayed entry). In particular, we had no information on Holocaust survivors who died before the Jerusalem Perinatal Study was initiated on January 1, 1964. To address the left-truncation issue, we adopted the risk-set correction method (29). An unbiased comparison of survival distributions between the exposed and the unexposed groups requires that the minimal ages at recruitment in the 2 groups were similar (29). This assumption is verified in Web Table 2.

Cox proportional hazards regression models were used to assess the association between exposure to the Holocaust and all-cause and cause-specific mortality, controlling for educational level and SEP. A separate Cox model with a multiplicative interaction term (exposure × sex) was fitted to the pooled sample of women and men to formally test whether a difference between male and female all-cause mortality was statistically significant. Cox models that also controlled for obstetrical conditions (toxemia, heart disease, diabetes, or prediabetes), parity, and the offspring's birth weight were fitted to the subsample of women. Tests of statistical significance were 2-sided, and we report hazard ratios and 95% confidence intervals obtained from the Cox regressions. The models' goodness of fit was evaluated and confirmed graphically using plots of Cox-Snell residuals (29), as well as numerically using the Gronnesby and Borgan test (30). Finally, we examined the proportional hazards assumption using the Grambsch and Therneau test (31), as well as by plotting $-\log[-\log(S(t))]$ as a function of $\log(t)$, and did not find evidence for time dependency in the reported results.

Data on education were missing for 4% of women and 3% of men, and obstetrical data were missing for a slightly higher percentage of women (12%). Persons with missing information were excluded from the analyses. The analyses were repeated using a multiple imputation by chained equations (MICE) algorithm and yielded similar estimates. Analyses were performed in Stata 12 (StataCorp LLC, College Station, Texas).

RESULTS

Descriptive statistics

Table 1 shows that at the (country-specific) time when the Holocaust persecutions began, most of the survivors were young children or teenagers, and male survivors were older than female survivors. SEP was slightly lower among the Holocaust survivors, as was the number of years of education. In women, obstetrical conditions, parity, and offspring's birth weight were roughly similar among the exposed and unexposed.

Table 2 shows that during the period of follow-up (i.e., from the first offspring registered in the Jerusalem Perinatal Study to December 31, 2016), women contributed 471,316 person-years of observation, and 2,270 (22%) of them died. Men contributed 539,876 person-years, and 4,665 (37%) of them died. For participants who died, the mean age at death was 69 years for women and 71 years for men.

The all-cause mortality rate (number of deaths per 1,000 person-years) was 4.8 in women and 8.6 in men. With the exception of mortality due to unnatural causes, all-cause and cause-specific mortality rates were higher among Holocaust survivors than among the unexposed for both sexes (Table 3).

The leading cause of death for both women and men was cancer (Table 4). However, while 44% of the deceased women died from cancer, in men this percentage was lower (29%). Except for the 2 composite categories (any other known cause of death and unknown cause of death), the second-largest cause of death in both sexes was circulatory disorders. However, while among women circulatory disorders caused only 14% of deaths, among men they accounted for 22% of deaths.

Cox proportional hazards models

Table 4 shows that after controlling for the sociodemographic variables, exposure to the Holocaust was associated with a significant increase in all-cause mortality in women yet had no relationship to male all-cause mortality. Specifically, compared with unexposed women, the hazard ratio for the female Holocaust survivors was 1.15 (95% confidence interval (CI): 1.05, 1.27). The differential association between Holocaust exposure and survival in men and women was formally examined using a multiplicative interaction term (i.e., Holocaust exposure × sex); results were significant (P for interaction = 0.028).

In the female subsample, we also fitted a model (Web Table 3) that controlled for perinatal and obstetrical characteristics at baseline as well as for socioeconomic variables. This further adjustment only slightly attenuated the effect of exposure on all-cause mortality produced by the model in Table 4 (hazard ratio (HR) = 1.12, 95% CI: 1.01, 1.24).

Next, we examined relationships between the Holocaust and specific causes of death (Table 4). In women, excess risk was found only for mortality due to cancer (HR = 1.17, 95% CI: 1.01, 1.35). This risk decreased somewhat after the model further adjusted for perinatal and obstetrical conditions (HR = 1.12, 95% CI: 0.95, 1.31) (Web Table 3). In men, among Holocaust survivors we observed statistically significant excess mortality due to CHD (HR = 1.39, 95% CI: 1.09, 1.77) and cancer (HR = 1.14, 95% CI: 1.01, 1.28) as compared with nonexposed men. Mortality due to "any other known cause" was significantly lower in male Holocaust survivors than in the unexposed (HR = 0.86, 95% CI: 0.75, 0.99). To further investigate this observed relationship, we broke down this composite category into 7 subcomponents of diseases based on ICD-10 codes and analyzed each of them separately. This analysis did not yield hazard ratios significantly different from 1 in any of the 7 categories (Web Tables 4 and 5), probably because of the small number of observations in each category.

Table 1. Characteristics of Participants in a Study of Holocaust Experience and Mortality Patterns, by Sex and Exposure Status, Jerusalem Perinatal Study, Israel, 1964–1976

Characteristic	Sex and Exposure Status							
	Women (*n* = 10,210)				Men (*n* = 12,461)			
	Unexposed (*n* = 8,077)		Holocaust Survivor (*n* = 2,133)		Unexposed (*n* = 9,552)		Holocaust Survivor (*n* = 2,909)	
	No.	%	No.	%	No.	%	No.	%
Age at exposure, years[a]								
Unexposed	8,077	100.0			9,552	100.0		
<1 (newborn)			873	40.9			774	26.6
1–12 (child)			1,172	54.9			1,652	56.8
13–19 (adolescent)			88	4.1			421	14.5
≥20 (adult)			0	0			62	2.1
Socioeconomic position[b]								
Low	661	8.2	212	9.9	821	8.6	304	10.5
Middle	2,932	36.3	770	36.1	3,548	37.1	1,029	35.4
High	4,484	55.5	1,151	54.0	5,183	54.3	1,576	54.2
Participant's duration of education, years								
0	29	0.4	10	0.5	18	0.2	5	0.2
1–4	33	0.4	22	1.0	15	0.2	16	0.6
5–8	1,060	13.1	277	13.0	728	7.6	274	9.4
9–12	2,553	31.6	725	34.0	3,038	31.8	903	31.0
≥13	4,136	51.2	997	46.7	5,469	57.3	1,600	55.0
Unknown	266	3.3	102	4.8	284	3.0	111	3.8
Ever being diagnosed with an obstetrical condition[c]								
No	6,690	82.8	1,802	84.5				
Yes	416	5.2	104	4.9				
Unknown	971	12.0	227	10.6				
No. of live births								
1	954	11.8	254	11.9				
2–4	5,586	69.2	1,454	68.2				
5–9	1,334	16.5	346	16.2				
≥10	190	2.4	75	3.5				
Unknown	13	0.2	4	0.2				
Average offspring birth weight, g								
<2,500	406	5.0	119	5.6				
2,500–2,999	1,518	18.8	392	18.4				
3,000–3,499	3,599	44.6	907	42.5				
3,500–3,999	2,075	25.7	551	25.8				
≥4,000	449	5.6	149	7.0				
Unknown	30	0.4	15	0.7				

[a] At the beginning of Nazi persecutions (country-specific year).
[b] By husband's occupation for women and by occupational status for men.
[c] Toxemia, heart disease, diabetes, or prediabetes.

Table 2. Age and Follow-up Time in a Study of Holocaust Experience and Mortality Patterns, by Sex, Jerusalem Perinatal Study, Israel, 1964–1976

Variable	Women (*n* = 10,210)		Men (*n* = 12,461)	
	No. of Persons or PY	Mean (SD)	No. of Persons or PY	Mean (SD)
Age at death or end of follow-up, years	10,210	75.4 (8.0)	12,461	75.4 (9.3)
Age at death among persons who died, years	2,270	68.7 (12.3)	4,665	70.7 (12.3)
PY of observation[a]	471,316		539,876	

Abbreviations: PY, person-years; SD, standard deviation.
[a] PY from birth of the first offspring in the cohort to death or the end of follow-up.

We conducted several sensitivity analyses that all produced similar results. First, models were fitted using 1939 as the year in which the Holocaust began instead of the country-specific year of Nazi invasion. Additional analyses were carried out in a sample that also included immigrants from the Union of Soviet Socialist Republics. In a further analysis, we used a sample that excluded the Israeli-born group and fitted Cox models with and without control for participant's age at immigration. Finally, we conducted an analysis where instead of counting time from the participant's own birth and correcting for left-truncation, we counted time from the moment a participant entered the study while controlling for her or his age at that moment.

DISCUSSION

Strikingly, our findings show that among persons who sired or gave birth to children in midlife, exposure to the Nazi regime early in life was associated with excess all-cause and cause-specific mortality later in life. Differences in mortality rates were also found by survivor's sex. Overall, compared with women who were not exposed to the Holocaust, female survivors exhibited higher all-cause mortality rates. Furthermore, we detected statistically significant excess mortality due to cancer in survivors of both sexes and, in exposed men, excess mortality due to CHD as well. It is noteworthy that in men, death due to other known causes combined was the second-largest category, accounting for almost one-quarter (24%) of deaths. The fact that the mortality rate among male survivors was significantly lower in this category than among the unexposed probably explains why there was no significant excess all-cause mortality in male survivors, even though risks of mortality due to cancer and CHD were significantly increased.

These results have several implications. First, they differ from those of other studies on mortality among Holocaust

Table 3. Mortality by Cause of Death, Exposure to the Holocaust, and Sex in a Study of Holocaust Experience and Mortality Patterns, Jerusalem Perinatal Study, Israel, 1964–1976

Cause of Death[a]	Sex and Exposure Status							
	Women (*n* = 2,270 Deaths)				Men (*n* = 4,665 Deaths)			
	Unexposed		Holocaust Survivor		Unexposed		Holocaust Survivor	
	No. of Deaths	Mortality Rate[b]	No. of Deaths	Mortality Rate	No. of Deaths	Mortality Rate	No. of Deaths	Mortality Rate
CHD	58	0.2	27	0.3	220	0.5	105	0.9
All circulatory disorders[c]	223	0.6	95	1.0	703	1.7	309	2.5
Cancer	729	1.9	244	2.5	950	2.3	397	3.2
Unnatural causes	31	0.1	11	0.1	117	0.3	32	0.3
Any other known cause	341	0.9	123	1.3	815	2.0	313	2.6
Unknown cause	338	0.9	135	1.4	743	1.8	286	2.3
All-cause mortality	1,662	4.4	608	6.3	3,328	8.0	1,337	10.9

Abbreviation: CHD, coronary heart disease.
[a] Causes of death were updated through the end of 2015.
[b] Number of deaths per 1,000 person-years.
[c] Including CHD.

Table 4. All-Cause and Cause-Specific Mortality in the Study Sample and Mortality Risk as a Function of Exposure to the Holocaust (Cox Models), Jerusalem Perinatal Study, Israel, 1964–1976

Cause of Death[a]	Women (*n* = 9,842 Observations)				Men (*n* = 12,066 Observations)			
	No. of Deaths	% of Deaths	HR[b]	95% CI	No. of Deaths	% of Deaths	HR[b]	95% CI
All-cause mortality	2,137	100.0	1.15	1.05, 1.27	4,448	100.0	1.02	0.95, 1.09
Specific causes								
CHD	77	3.6	1.28	0.78, 2.12	306	6.9	1.39	1.09, 1.77
All circulatory disorders[c]	298	13.9	1.22	0.94, 1.57	960	21.6	1.12	0.97, 1.29
Cancer	930	43.5	1.17	1.01, 1.35	1,282	28.8	1.14	1.01, 1.28
Unnatural causes	40	1.9	1.34	0.67, 2.70	141	3.2	0.77	0.51, 1.16
Any other known cause	425	19.9	1.06	0.85, 1.32	1,087	24.4	0.86	0.75, 0.99
Unknown cause	444	20.8	1.17	0.95, 1.45	978	22.0	1.00	0.87, 1.15

Abbreviations: CHD, coronary heart disease, CI, confidence interval; HR, hazard ratio.
[a] Causes of death were updated through the end of 2015.
[b] The models adjusted for participant's education and socioeconomic position.
[c] Including CHD.

survivors in Israel. As we noted above, previous research did not find excess all-cause mortality among Holocaust survivors (13, 15–19). Our analyses point out the importance of considering specific causes of death. Indeed, although in the male subsample there was no excess all-cause mortality among Holocaust survivors, when mortality was broken down into specific causes of death, it appeared that survivors were in fact affected by higher rates of mortality due to some causes but not others. In addition, some studies that did not find excess all-cause mortality among survivors studied only those who lived a relatively long time (e.g., conducting interviews in the late 1990s or the 2000s) or used relatively late mortality data (i.e., only records from the late 1980s onwards) (16, 17, 19). However, many frail survivors might have died much earlier. Instead, our mortality data spanned several decades.

The excess mortality due to cancer and CHD in this study is in line with recent research showing higher prevalence of cancer (7, 9, 32, 33) and cardiovascular morbidity and associated risk factors (8, 12, 14, 33, 34) among Holocaust survivors. Several mechanisms have been proposed to explain the survivors' vulnerability to these ailments. Apart from studies that found detrimental health effects of undernutrition around the time of birth (3–6, 9), others have suggested that the abrupt increase in caloric intake upon arrival in Israel might have been responsible for late-life morbidity (34). Furthermore, acutely stressful events have also been shown to affect cancer and cardiovascular morbidity by distressing various physiological systems, such as the hypothalamic-pituitary-adrenal axis or the immune system (7, 12, 14, 28). Additionally, researchers have pointed to the exposure of survivors to such carcinogens as infectious diseases (e.g., hepatitis) (7) and toxic waste (33).

Second, it is important to note that in female survivors, mortality due to other known causes of death combined was not higher than among the unexposed, and in exposed men it was even lower. Breaking the category "other known causes of death" down into its separate components yielded nonsignificant results in both sexes. Although this lack of findings might be attributed to the small number of subjects who died from these causes, previous research has suggested that the lack of excess all-cause mortality might hint at survivors' resilience (18). Indeed, a theoretical model has suggested that Holocaust survivors can be characterized by general health resilience combined with specific vulnerabilities (15, 20). Thus, although the vulnerabilities to cancer and CHD had persisted throughout the survivors' lives, they had not necessarily precluded the possibility of a normal life after the trauma.

Third, we note the aforementioned differences in mortality patterns by sex. It should be kept in mind, however, that on average our female survivors were younger than the males. This dissimilarity in age structure could explain some of the observed sex differences in mortality patterns, both by differential timing of exposure to the Holocaust and by differential risks of CHD mortality according to age and sex (35). It is therefore possible that future follow-up in this population might also show increased CHD mortality in women.

Several limitations of this study should be mentioned. One limitation was the inability to adjust for risky health behaviors (e.g., diet or a sedentary lifestyle) or psychological variables (e.g., personality characteristics or mental health). In addition, some scholars have claimed that the ecological definition of a Holocaust survivor used in this paper might be inferior to respondents' self-reports or the Israeli state codes that designate survivors, because it does not provide adequate details on individual exposure (7). However, authors who have relied mainly on the Israeli codes have admitted that their exposure definition, too, might have been subject to some misclassification (7, 8). Furthermore, researchers who have used self-reports have suggested that some of their

"unexposed" participants in fact have been persecuted due to residing as Jews in Nazi-occupied countries (13). Finally, we found a substantial degree of agreement between our definition of exposure and the self-reports in the SHARE-IL data set.

A further limitation was the lack of information on Holocaust survivors who were not included in the cohort. To account for the lack of records on survivors who died before the study was initiated, we corrected the risk set for left-truncation (29). Nevertheless, the absence of information about survivors who immigrated elsewhere or did not have children might affect the generalizability of our results. While country of immigration might affect a person's ability to adapt to a new environment and thus mortality, a meta-analysis by Barel et al. (36) found no difference between elderly survivors living in Israel and those living elsewhere with respect to physical health. In addition, people without offspring might, on average, have worse health and a shorter life span due to both causal effects (e.g., social support from one's children in old age) and/or selection (e.g., not having children for health reasons). On the basis of these considerations, we believe that while settling in Israel (and specifically in Jerusalem) possibly did not affect mortality, the absence of data on immigrants without offspring might have led to underestimation of the survivors' mortality rates.

Our study had several strengths. This is one of the rare works to have evaluated cause-specific mortality in Holocaust survivors. Our high-quality data spanned the period from the 1960s to 2016, thus allowing estimation of mortality over the course of 4–5 decades. The rich data set also enabled us to control for several important covariates on which data were collected between 1964 and 1976, such as education and SEP, as well as perinatal and obstetrical characteristics in women.

In summary, this study contributes to understanding of the consequences of extreme adversity early in life with regard to long-term mortality among parous Holocaust survivors. Our results suggest that sex-specific intervention strategies may be warranted to treat and prevent cancer and cardiovascular ailments in Holocaust survivors. In addition, our findings are relevant for understanding and predicting the life-course mortality of survivors of more recent genocides, for whom fewer long-term data are currently available (9).

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Author affiliations: Braun School of Public Health, Hebrew University of Jerusalem-Hadassah Medical School, Jerusalem, Israel (Iaroslav Youssim, Ronit Calderon-Margalit, Orly Manor, Ora Paltiel, Yechiel Friedlander, Hagit Hochner); Department of Statistics and Operations Research, School of Mathematical Sciences, Tel Aviv University, Tel Aviv, Israel (Malka Gorfine); and New York Academy of Medicine, New York, New York, United States (David S. Siscovick).

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Conflict of interest: none declared.

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