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Predictors of respiratory cancer-related mortality for Jews and Arabs in Israel

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ABSTRACT

Background: Respiratory cancers, including lung, tracheal and bronchus cancers, are a leading cause of cancer-related mortality in Israel; however, incidence can differ among demographic groups. Despite the importance of sociodemographic characteristics and the interactions between them to incidence and mortality, this topic is understudied. This study analyzes sociodemographic disparities by sex and ethnicity among Jews and Arabs to understand cancer outcome differences stratified by SES, marital status, and number of children as potential contextual factors.

Methods: This retrospective cohort study analyzed respiratory cancer-related mortality rates among Israelis born between 1940 and 1960 over 21-years. The follow up period was between January 1, 1996 and 12.31.2016. Mortality rates for Jews and Arabs were calculated. Using a Cox Regression, a multivariate model was constructed to determine the association between ethnicity and respiratory cancer mortality. The study population was then divided into four groups, by sex and ethnicity, to determine the association between marital status, number of children, and SES with respiratory cancer mortality for each subgroup.

Results: The overall mortality rate was 0.6%. Arabs had higher mortality rates compared to Jews, even after adjusting for demographic factors including age, sex and SES (Adjusted Hazard Ratio (AHR) = 1.442, 99% confidence intervals (CI) = 1.354,1.546). Among men, a higher mortality rate was found among Arabs (AHR = 1.383, 99%CI = 1.295,1.477), while among women, Arabs had lower mortality rates (AHR = 0.469, 99%CI = 0.398,0.552). Significant mortality rate differences were observed by ethnicity and sex for each sociodemographic variable.

Conclusions: This study highlights the importance and implications of understanding differences in respiratory cancer mortality between Jews and Arabs, a minority group in Israel, and is relevant for minority groups in general. There is a need to tailor interventions for these groups, based on differing underlying causes and contextual factors for these cancers. Cancer outcomes among these groups should also be studied separately, by sex, to better understand them.

1. Introduction

Respiratory cancers, including lung, tracheal and bronchus cancers, are a significant source of morbidity and mortality. In the United States (U.S.), they are the second most common type of cancer (Centers for Disease Control and Prevention and National Cancer Institute, 2020). In Europe, they are the fourth most common type of cancer. In both places, they are the most common cause of cancer-related death (Ferlay et al., 2018; Siegel et al., 2018).

The incidence of respiratory cancers is higher among men compared to women, and women have higher chances of survival (Centers for Disease Control and Prevention and National Cancer Institute, 2020). Data show that lung cancer rates among men are decreasing in high-income countries (Torre et al., 2016). Socioeconomic status (SES) has been found to be associated with lung cancer mortality. Specifically, many studies have found lower survival rates to be connected with

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decreasing income and/or education (Finke et al., 2018; Van der Heyden et al., 2009; Yim et al., 2010). Other risk factors for mortality include being unmarried and number of children (Ou et al., 2009; Paulus et al., 2010; Skuladottir & Olsen, 2006). For example, a study conducted in the U.S. found that married men but not women, have a higher chance of survival. It is posited that marriage serves as a proxy for a stronger support system, which has been proven to positively affect survival (Vyfhuis, 2018).

Studies have found an association between the number of children and survival from lung cancer, although the optimal number of children is unclear. Some studies show they have a linear relationship with survival, while others show an advantage only for parents with one to three or four children, and similar survival rates for childless individuals and those with four or five children or more. Additionally, studies were inconclusive as to whether this advantage was associated with both sexes, or just women (Paulus et al., 2010; Skuladottir & Olsen, 2006).

Increasing age is a risk factor for lung cancer, especially when combined with smoking and the majority of lung cancer cases are found among older adults. Incidence of lung cancer increases with age, until the age of 85 (Centers for Disease Control and Prevention and National Cancer Institute, 2020). However, the risk of age alone is not very strong (Alberg & Nonemaker, 2008; Moyer, 2014). Smokers are more likely to be diagnosed with lung cancer at an earlier age than never-smokers (Ou et al., 2009).

The most significant risk factor for lung cancer and mortality from lung cancer is the use of tobacco products. Over 80% of deaths from lung, tracheal and bronchus cancers are attributable to cigarette smoking (Siegel et al., 2015). Involuntary exposure to tobacco (second-hand smoke) also increases a person's risk for lung cancer. Studies found that people exposed to smoke at home or in the workplace had a 20%–30% increase in risk of lung cancer (Office on Smoking and Health (US), 2006).

Some minority groups have worse cancer outcomes than majority or other minority groups (Ellis et al., 2018). Rates of smoking is a significant contributor to these disparities in relation to lung cancer. Black American men, for instance, have much higher rates of lung cancer than white American men, though rates among black and white women are similar. Black Americans also have lower survival rates compared to white Americans (16.7% vs. 19.3%) (Centers for Disease Control and Prevention and National Cancer Institute, 2020; Jones et al., 2018). Other studies have found that other ethnicities, such as Asian, have a lower risk than white Americans (Ou et al., 2009). These racial disparities can largely be attributed to higher rates of lower SES, higher rates of less education, and less access to healthcare among certain minority populations, manifesting as higher smoking rates and a higher probability of a later stage diagnosis with less access to care (Jones et al., 2018; O'Keefe et al., 2015).

1.1. Israeli society

The Israeli population is comprised of a Jewish majority, and with an Arab minority (approximately 25%). Arabs are more likely to be of lower SES than Jews, less likely to complete high school or to have a college degree. More Arab women than men are likely to get a college education (Chernichovsky et al., 2017, p. 325; Hadad Haj-Yahya, 2017; The Central Bureau of Statistics, 2019a). Overall, Israeli Arabs tend to have poorer overall health outcomes and lower life expectancy compared to Israeli Jews, although the gap is narrowing (Chernichovsky et al., 2017, p. 325). Significant gaps between marriage and fertility rates exist between Jews and Arabs who were born between 1940 and 1960. In later years, those gaps have narrowed (The Central Bureau of Statistics, 2019b).

1.2. Respiratory cancer in Israel

Respiratory cancer is the most common cause of death from cancer among Israeli men, and the third most common cause of death from cancer among Israeli women. Mortality rates from lung cancer in Israel are higher among Arabs compared to Jews, similar to other minority groups around the world. Ethnic and gender differences should be considered when examining respiratory cancer morbidity rates. Arab men have an incidence rate of 44.5 cases per 100,000 residents, compared to 27.9 per 100,000 among Jewish men. Arab women have 6.2 cases per 100,000 residents compared to 15.1 per 100,000 among Jewish women (Ministry of Health, n. d.). Arab men also have the lowest respiratory cancer survival rates (18%) compared to Jewish men (21%), Jewish women (33%), and Arab women (27%). The chances of survival decrease with increased age at diagnosis for all population groups (Ben Lessen et al., 2019; Jones et al., 2018; Silverman et al., 2019).

Furthermore, studies have shown associations between lung cancer-related mortality and sex, marital status, and number of children. Israeli Arabs are characterized by lower SES compared to the Jewish population, higher rates of marriage, and, until recent years, a higher fertility rate. However, despite the importance of sociodemographic characteristics and the interactions between them as contextual factors in understanding variations in respiratory cancer incidence and mortality between Jews and Arabs and despite potential implications for efforts to reduce mortality from cancer in Israel, this topic has not been studied.

Beyond demographic differences, there are additional reasons why there may be differences in respiratory system cancer incidence and mortality between Jews and Arabs in Israel. Arabs are a minority group, which has been associated with a range of poorer health outcomes, both in general and for Arabs in particular (Averbuch et al., 2020; Daoud et al., 2018). Smoking rates are an important cause of lung and other respiratory cancers (Siegel et al., 2015). There are higher smoking rates among Arabs as compared to Jews (Geva Hospil & Education, 2020; Kalter-Leibovici et al., 2016). This is especially true among Arab male adults with 22.4% of them reporting smoking at least 20 cigarettes a day as compared to 9.3% of Jewish males (Geva Hospil & Education, 2020).

There also is poorer access to care among Arabs in Israel, which may potentially lead to later diagnosis of the disease or inadequate treatment (Baron-Epel et al., 2007; Daoud et al., 2018). Arabs tend to live in the periphery of the country where there are poorer health outcomes (Averbuch et al., 2020). There is evidence of differences in care received for serious health issues, including pre- and post-hospitalization services (Abdel-Rahman et al., 2019; Schuster et al., 2016). These differences can be a particularly important aspect of disparities related to respiratory cancers as some studies have shown that it is the stage of diagnosis, rather than racial differences that contribute to the disparities among minorities and the general population (Jones et al., 2018). If Arabs live in the periphery and tend to have poorer access to care, their chance of an early diagnosis is lower.

There are potentially important policy implications a result of these differences between Israeli Arabs and Jews as there may a need for interventions tailored to different groups based on differing underlying causes and contextual factors, related to lung and other respiratory cancers.

This study will examine disparities in respiratory system cancers between Israeli Jews and Arabs, born between 1940 and 1960, during a 21-year follow-up period, providing a robust dataset. This study will analyze these disparities by sex and ethnicity to better understand the differences among demographic subpopulations and evaluate rates stratified by SES, marital status, and number of children as potential confounding factors.

2. Materials and methods

This retrospective cohort study analyzed cases of respiratory cancer among Israeli citizens born between 1940 and 1960 to calculate mortality rates. The follow-up period was between January 1, 1996 and 12.31.2016. The study utilized and combined data collected by Israel's Central Bureau of Statistics (CBS), Population Registry (PR), and

Ministry of Health (MOH). Work on the combined data was conducted in the Research Room at the CBS. This study was approved by the Ethics Committee of the CBS and the Population Registry; furthermore, any research conducted in the CBS Research Room must be approved for ethical conditions.

2.1. Study population

The study population included 1,667,650 Israeli citizens born between 1940 and 1960: 196,974 Arabs (11.8%), and 1,470,676 Jews (88.2%).

2.2. Study variables

Data for the following variables were received from the Population Registry: Ethnicity (Jewish/Arab), Year of Birth, Sex, Year of Immigration to/Emigration from Israel. Marital status at the beginning of the study and number of children were also received from the Population Registry, and both were converted into dichotomous variables (married/unmarried and 0–3 children/4+ children respectively) for the purposes of this study.

The socioeconomic status (SES) variable was based on the combination of two variables: data from the CBS Education Registry, and data collected from various other sources including institutions of higher education, administrative files, surveys, censuses, and others. These data were divided into three final categories: high (15 years of education or more), middle (11–14 years of education), and low (10 years of education or less). Due to the large amount of missing data for this variable (20.1%), we utilized the residential SES variable from the PR as it is defined for the State of Israel Population Census, on a scale of 1–10. The variable was divided into three SES groups: high (8−10), middle (6–7), and low (1–5). Therefore, for the purposes of this study, high SES was defined as 15 years of education or more for participants for whom this information was available or a residential SES of 8–10 if education data was missing. Middle SES was defined as 11–14 years of education for participants for whom this information was available or residential SES of 6–7 if education data was missing. Low SES was defined as 10 years of education or less for participants for whom this information was available or residential SES of 1–5 if education data was missing. Data on year of death and cause of death were received from the MOH, based on ICD-9 and ICD-10 codes. Codes for cause of death for lung, bronchial, or tracheal cancer were recoded into cause of death for respiratory cancer.

2.3. Statistical analyses

We analyzed the distribution of the study variables among the study groups (Arabs and Jews): sex, age, marital status, number of children, and SES. The degree of significance in relation to differences among the groups was calculated by X^2 for categorical variables and *t*-test for the age variable. Additionally, we calculated differences between groups in relation to mortality from respiratory cancer per 100,000 life-years and cancer rates during the follow up period, as well as the statistical significance for these differences (Table 1).

Next, we analyzed mortality rates from respiratory cancer during the follow up period for the entire study sample, stratified by the variables: ethnicity, sex, age, marital status, number of children, and SES. To determine the effect size and significance of the differences between the groups, we calculated an Adjusted Hazard Ratio (AHR) for mortality, adjusting for age and/or sex (Table 2).

Using a Cox Regression and adjusted Kaplan Meier graph, we created a multivariate model to determine the association between ethnicity and respiratory cancer mortality (Table 3). Model 1 included the following variables: ethnicity, sex, age, marital status, number of children and SES. Model 2 included all the variables from Model 1, as well as the interaction between ethnicity and sex. Model 3 included all the variables from Models 1 and 2, in addition to the interaction between ethnicity X sex X marital status, the interaction between ethnicity X sex X number of children, and the interaction between ethnicity X sex X SES.

Due to the significant interaction between sex and ethnicity in predicting mortality from respiratory cancer, we calculated a multivariate model for ethnicity for each sex individually (graph 1).

Finally, we divided the study sample into four groups, by sex and ethnicity. Using Cox Regression and adjusted Kaplan Meier graphs, we calculated a model to determine the association between marital status,

Table 1
Israeli Jews and Arabs born between 1940 and 1960 Distribution of study variables by ethnicity among total population (n = 1,667,650).

		Arabs	Jews	p-exact sig (2-sided)	Percentage missing
N (%)		196,974 (11.8%)	1,470,676 (88.2%)		
Women		49.5%	50.2%	<0.001	0.00%
Average age at beginning of follow-up period (s.d)		44.128 (5.95)	45.050 (5.65)	<0.001	0.00%
Married at beginning of follow-up period		79.2%	75.7%	<0.001	0.1%
Number of children	4 or more	65.2%	24.0%	<0.001	0.00%
Socioeconomic status	High	7.8%	32.9%	<0.001	0.9%
	Middle	18.2%	43.7%		
	Low	74.0%	23.4%		
Total number of life years contributed during the follow-up period		3,902,915	28,810,077		
Mean life-years per person contributed during the follow-up period		19.814	19.590		
Total number of respiratory cancer mortality cases during the follow-up period		1615	8740		
Respiratory cancer mortality rate per 100,000 person-years		41.379	30.337		
Respiratory cancer mortality rate during the follow-up period		0.8%	0.6%	<0.001	

Table 2
Distribution of respiratory cancer mortality rates by study variable: AHR (Age-and-sex Adjusted Hazard Ratio) (n = 1,667,650).

		% respiratory cancer mortality	Adjusted Hazard Ratio (AHR) (99%CI)
Total		0.6%	
Ethnicity	Jews	0.6%	[b]1.00
	Arabs	0.8%	[b]**1.442(1.354–1.546)**
Sex	Female	0.4%	[a]1.00
	Male	0.9%	[a]**2.515 (2.382–2.662)**
Marital status	Married	0.6%	[b]1.00
	Unmarried	0.6%	[b]1.033 (0.972–1.098)
Number of children	4 or more	0.7%	[b]1.00
	0–3	0.6%	[b]**0.827 (0.784–0.972)**
Socioeconomic status	High	0.4%	[b]1.00
	Middle	0.6%	[b]**1.583 (1.475–1.700)**
	Low	0.9%	[b]**2.131(1.985–2.287)**

[a] = Age adjusted Hazard Ratio.
[b] = Age and Sex adjusted Hazard Ratio.

Table 3
Results of Cox models predicting respiratory cancer mortality by demographic variable within the total study population (n = 1,667,650).

		Model 1	Model 2	Model 3
		HR (99%CI)	HR (99%CI)	HR (99%CI)
Ethnicity	Jews	1.00	1.00	1.00
	Arabs	1.142 (1.056–1.236)	**0.371(0.302–0.456)**	**0.378 (0.307–0.465)**
Sex	Female	1.00	1.00	1.00
	Male	**2.553 (2.415–2.700)**	**2.180(2.055–2.321)**	**2.189 (2.064–2.322)**
Age		1.097 (1.091–1.102)	1.096 (1.091–0.101)	1.097 (1.092–1.102)
Marital status	Married	1.00	1.00	1.00
	Unmarried	**1.081 (1.014–1.151)**	**1.082 (1.015–1.152)**	**1.170(1.096–1.249)**
Number of children	4 or more	1.00	1.00	1.00
	0–3	0.969 (0.913–1.027)	**0.925(0.871–0.982)**	**1.022(0.959–1.090)**
Socioeconomic status	High	1.00	1.00	1.00
	Middle	**1.578 (1.469–1.695)**	**1.581 (1.472–1.698)**	**1.595 (1.483–1.716)**
	Low	**2.039 (1.892–2.197)**	**2.067(1.908–2.215)**	**2.076 (1.922–2.243)**
Sex X Ethnicity			**4.095(3.293–5.092)**	**4.591(3.125–6.745)**
Sex X Ethnicity X Marital status				**0.367(0.275–0.490)**
Gender X Ethnicity X Number of children				**0.821(0.676–0.997)**
Sex X Ethnicity X Socioeconomic status	High			1.00
	Middle			1.010 (0.704–1.451)
	Low			1.077 (0.774–1.498)

number of children, and SES and age-adjusted mortality from respiratory cancer (Table 4). Contribution of life-years for people who emigrated from Israel and did not return by the end of the follow up period, and for whom there was no mortality information available, were included up until the year they left Israel.

All statistical analyses were conducted using SPSS version 23.0.

3. Results

3.1. Demography

The total study population of 1,667,650 Israeli adults included 196,974 Arabs, who contributed 3,902,915 life-years during the follow-up period and 1,470,676 Jews, who contributed 28, 810, 077 life-years. The percentage of women was higher among Jews (50.42%) compared to Arabs (49.5%) ($p < 0.001$). The average age at the start of the study among Jews was older (46.05) compared to Arabs (44.12) ($p < 0.001$).

More Arabs were married (79.2% compared to 75.7% of Jews) ($p < 0.001$). Similarly, more Arabs had four or more children (65.2%) compared to Jews (24%). Arabs were more likely to be categorized in a low SES (74%) compared to Jews (23.4%) ($p < 0.001$).

Significant differences were found among the groups for mortality from respiratory cancer. The overall mortality rates from respiratory cancer per 100,000 life-years are 41.379 for Arabs is 41.379 and 31.226 for Jews ($p < 0.001$).

3.1.1. Mortality

The overall mortality rate from respiratory cancer for all 1,667,650 study participants was 0.6%. Distribution of mortality rates by study variables showed higher mortality rates among Arabs (0.8%) compared to Jews (0.6%) ($p < 0.001$) (Table 2). Even after adjusting for sex and age, we found higher mortality rates among Arabs (AHR = 1.442, 99% confidence intervals (CI) = 1.354,1.546) compared to Jews.

After adjusting for age, we found higher mortality rates among men compared to women (AHR = 2.515, 99%CI = 2.382,2.662). We did not find significant differences in mortality rates among married participants and unmarried participants, even after adjusting for age and sex (AHR = 1.033, 99%CI = 0.972, 1.098). However, we did find significantly lower mortality rates among participants with 0–3 children, compared to those with four or more (AHR = 0.827, 99%CI = 0.784, 0.972). Higher mortality rates were also observed among participants with lower SES (AHR = 2.131, 99%CI = 1.985, 2.287) and middle SES (AHR = 1.583, 99%CI = 1.475, 1.7) compared to high SES.

3.2. Multivariate models for evaluating the association between ethnicity and mortality from lung cancer

To evaluate the association between ethnicity and mortality from respiratory cancer, we used multivariate Cox regression models for all 1,667,650 study participants with the following variables: ethnicity, sex, age, marital status, number of children and SES. Higher mortality rates were observed among Arabs compared to Jews (AHR = 1.142, 99%CI = 1.056,1.236); among men compared to women, among unmarried individuals compared to married individuals, and among low and middle SES compared to high SES (Table 3, Model 1).

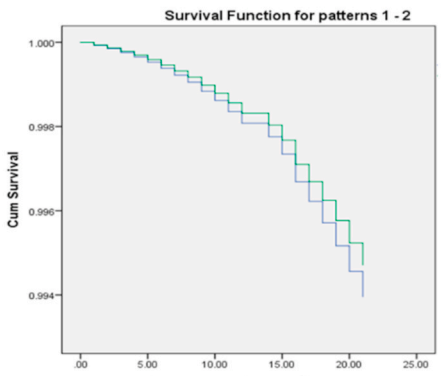
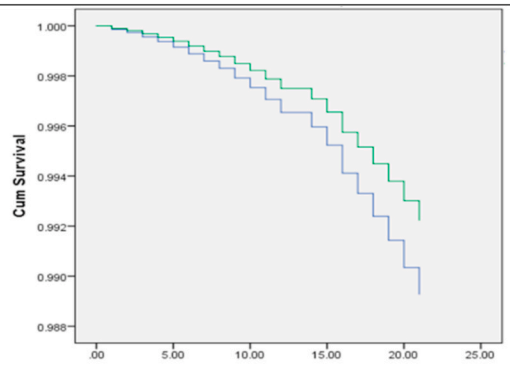
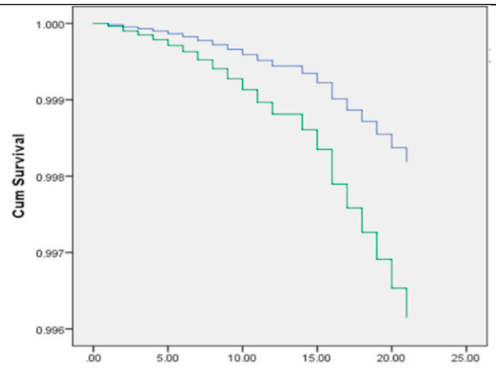
Model 2 was adjusted for the variables in Model 1 in addition to the interaction between ethnicity X sex. The interaction was statistically significant (AHR = 4.095, 99%CI = 3.293, 5.092). This model also showed that the association between ethnicity and mortality changes directionality and Arabs have a lower risk compared to Jews (AHR =

Table 4
Results of Cox models for predicting respiratory cancer mortality by demographic variable among 4 separate groups: Arab women, Arab men, Jewish women and Jewish men.

		Jews		Arabs	
		Men	Women	Men	Women
Total N		731,808	738,868	99,491	97,483
Marital status	Married	1.00	1.00	1.00	1.00
	Unmarried	1.060 (0.994–1.130)	**1.369 (1.262–1.485)**	**0.430 (0.347–0.533)**	**1.680 (1.147–2.460)**
Number of children	4 or more	1.00	1.00	1.00	1.00
	0–3	0.971 (0.916–1.029)	**1.169 (1.065–1.283)**	**0.843 (0.733–0.969)**	**0.626 (0.431–0.909)**
Socioeconomic status	High	1.00	1.00	1.00	1.00
	Middle	**1.708 (1.592–1.833)**	**1.404 (1.267–1.556)**	**1.609 (1.229–2.107)**	0.837 (0.366–1.912)
	Low	**2.570 (2.389–2.764)**	**1.434 (1.310–1.570)**	**2.207 (1.727–2.822)**	1.123 (0.460–2.745)

Table 1
Analysis of respiratory mortality among Jews and Arabs by sex, adjusted for age, sex, marital status, number of children, and socioeconomic status.

Arabs ——— , Jews ———

Total population (N=1,667,650)	
Kaplan Meier Survival Curve	**Adjusted Hazard Ratio (99%CI)**
 Total years contributed to calculating mortality per life-years	Jews = 1.00 Arabs= 1.142(1.056-1.236)
Men (N=831,299)	
Kaplan Meier Survival Curve	**Adjusted Hazard Ratio (99%CI)**
 Total years contributed to calculate mortality per life-years	Jews = 1.00 Arabs = 1.383(1.295-1.477)
Women (N=836,351)	
Kaplan Meier Survival Curve	**Adjusted Hazard Ratio (99%CI)**
 Total years contributed to calculate mortality per life-years	Jews = 1.00 Arabs = 0.469 (0.398-0.552)

0.371, 99%CI = 0.302,0.456). Additionally, unlike the first model, lower mortality was found among those with 0–3 children. Similar to Model 1, there was a higher mortality rate among men compared to women, unmarried individuals compared to married individuals, and individuals of low and middle SES compared to those with high SES (Table 3, Model 2).

Model 3 was adjusted for the variables in Models 1 and 2 in addition to the interaction between ethnicity X sex X marital status, the

interaction between ethnicity X sex X number of children, and the interaction between ethnicity X sex X SES. The interaction between ethnicity X sex was statistically significant (AHR = 4.591, 99%CI = 3.125, 6.45). The interactions between ethnicity X sex X marital status and ethnicity X sex X number of children were also significant (AHR = 0.367, 99%CI = 0.275, 0.49 and AHR = 0.821, 99%CI = 0.676,0.997, respectively). Conversely, the interaction between ethnicity X sex X SES was not significant. The directionality of the association between ethnicity and mortality was the same as Model 2 (AHR = 0.378, 99%CI = 0.307, 0.465). There were higher mortality rates among unmarried individuals and among those of low and middle SES. However, no significant association was found between number of children and mortality (Table 3, Model 3).

Due to the significant association between sex and ethnicity and mortality, we ran a multivariate Cox regression model to evaluate the association between ethnicity and mortality from respiratory cancer among men and women. This model included the following variables: ethnicity, age, marital status, number of children, and SES. When the model was run among the 831,299 men included in the study, higher mortality was found among Arabs (AHR = 1.383, 99%CI = 1.295, 1.477). In the parallel model run among 836,531 women included in the study, Arab women had lower mortality rates (AHR = 0.469, 99%CI = 0.398, 0.552). (Graph 1).

The population was then separated into four subgroups based on ethnicity and sex (Jewish men, Jewish women, Arab men, Arab women). For these models, the variables (marital status, children, SES, and mortality from respiratory cancer) were run separately for each ethnic group and was adjusted for age.

Lower mortality rates were observed among unmarried Arab men (HR = 0.43, 99%CI = 0.347, 0.533), while unmarried Arab and Jewish women demonstrated higher mortality rates (HR = 1.68, 99%CI = 1.147, 2.46; and AHR = 1.369, 99%CI = 1.262, 1.485, respectively). Conversely, there was no significant association between marital status and mortality among Jewish men.

The was a significant association between number of children and mortality among Jewish women; specifically, there was a higher mortality rate among women with 0–3 children compared to those with four or more (AHR = 1.169, 99%CI = 1.065, 1.283). Among Arab women and men, there was a lower mortality rate among those with 0–3 children compared to those with 4 or more (AHR = 0.626, 99%CI = 0.431, 0.909, and AHR = 0.843, 99%CI = 0.733,0.969). No significant relationship was found among Jewish between number of children and mortality.

When looking at the association between SES and mortality, higher mortality rates were observed among Jewish men of lower SES (compared to high SES) (AHR = 2.570, 99%CI = 2.389, 2.764) and Arab men of low SES (AHR = 2.207, 99%CI = 1.727,2.822). A weaker association was also observed among Jewish women (AHR = 1.434, 99%CI = 1.31,1.57). (Table 4).

4. Discussion

Our study examined lung respiratory cancer-related mortality rates among Jews and Arabs in Israel. When analyzing the association between ethnicity and mortality, a higher mortality rate was found among Arabs. This is consistent with earlier studies and similar to findings show that certain minority groups, such as Blacks in the U.S., demonstrate significantly higher mortality rates those of the majority population (Jones et al., 2018). However, as this finding is not true of all minorities, other factors should be evaluated.

The significant disparities between Israeli Jews and Arabs in relation to SES is well-known. From previous studies, there is a strongly established association between smoking, SES, and the mortality from respiratory cancers. This association could lend itself as a possible explanation for the relationship we found between ethnicity and mortality in Israel. However, this study found disparities between the groups even after controlling for sex, marital status, number of children and SES.

Furthermore, when stratifying by sex we found higher mortality rates among Arab men (compared to Jewish men) and among Jewish women (compared to Arab women). This finding can be a result of the difference in smoking prevalence among the sexes in the Jewish and Arab populations as 80% of lung cancer mortality can attributed to smoking (Siegel et al., 2015). Smoking rates are higher among Arab men compared to Israeli men, and among Jewish women compared to Arab women (Blumenthal, 2017). Smoking rates in the Israeli population (among adults older than 21) have been stable since the mid-1990s, hovering at around 20%, compared to 45% in the 1970s. Among men, the decline in the number of smokers was much sharper compared to women, lessening the gap among the sexes (Eichenrand Kol-El, 2002; Geva Hospil & Education, 2020). Currently, 25% of men in Israel smoke, compared to 15% of women, however when stratified by ethnicity, Arabs are more likely to smoke then Jews (23% compared to 19%). Arab men are 1.5 times more likely to smoke than Jewish men (35.5% vs. 22.9%). Israeli women are 1.6 times more likely to smoke than Arab women (16% vs. 10.7%) (Geva Hospil & Education, 2020).

Lopez et al. described a four-stage model which outlines the four stages of the smoking epidemic in developed countries. Transition between stages is marked by changes in smoking prevalence and smoking-related mortality rates (such as from lung cancer or other respiratory cancers). The first stage is defined by a significant increase of smoking among men, followed by a moderate increase among women a decade or two later. During the second stage, smoking rates increase among both sexes, and while the rate among men is higher, the disparity between them decreases. A sharp decline in smoking rates among men characterizes the third stage. The smoking rates of both sexes are now similar. A more moderate decrease is evident among women. The rates continue to decrease among both men and women throughout the fourth and final stage, at which rates are almost identical (Lopez et al., 1994).

The disparity in cigarette smoking rates among Arab men and women reported in the Health Minister's Report (35.5% among men vs. 10.7% among women) indicates that they are likely at beginning the second phase of the model where smoking is primarily among men, even though rates are beginning to drop. Based on the same report, the disparity in smoking rates among Jewish men and women is much more moderate (22.9% vs. 16% respectively), while the rate of smoking among Jewish men is much lower than that among Arab men and the rate of Jewish women higher than the rate of Arab women (Geva Hospil & Education, 2020).

This would indicate that Jewish Israelis are likely in the third phase whereby smoking among men decreases although there is still a gap between men and women (Geva Hospil & Education, 2020; Lopez et al., 1994). Therefore, the health consequences reflect that phase, and Arab men have higher mortality rates than Jewish men, while Arab women have lower mortality rates than Jewish women. Smoking can also explain why some minorities have significantly higher rates of respiratory cancer than other populations, because of their disproportionate representation among lower SES populations, lack of accessible healthcare, and the prevalence of smoking. (Centers for Disease Control and Prevention and National Cancer Institute, 2020; Jones et al., 2018).

To better understand the effect of the interaction between ethnicity and sex, we looked at Jewish women, Jewish men, Arab women, and Arab men separately. We found that the sociodemographic variables that are adjusted for in this study (marital status, number of children, and SES) have different associations with each group, highlighting the different behavior of each group.

Both Jewish men and Arab men had significant associations between SES and mortality. This association was negative, the lower the SES, the higher the risk. This finding is consistent with previous studies, showing that men have a positive association between SES and lung cancer mortality (Van der Heyden et al., 2009).

Similarly, the mortality risk was higher among Jewish women of

both middle and low SES, but this increased mortality risk was not as high as the risk among men. This finding was not surprising, given the lower prevalence of smoking among Jewish women compared to both Arab and Jewish men. Previous studies have also shown a stronger association between lower SES and lung cancer rates among men compared to women (Van der Heyden et al., 2009; Yin et al., 2010).

However, we found no significant association between mortality and SES among Arab women. According to data from the Ministry of Health, only 4% of all cancer cases among Arab women were lung cancer, compared to almost 20% among Arab men, 11.9% among Jewish men and 7.6% among Jewish women (Silverman et al., 2020). Another explanation could be related to Lopez's model of transition, whereby the Arab women are at the first stage of the model, where there are less women who smoke, but those who do are more likely to be of higher SES (Lopez et al., 1994).

Both unmarried Jewish women and Arab women had a higher risk of lung cancer-related mortality, compared to married women. This finding is similar to previous research on the association between marital status and cancer outcomes. The researchers emphasize the importance of social support that can be provided by spouses during each stage of the disease, thus lowering the risk of mortality from cancer (including lung cancer) (Aizer et al., 2013).

Another possible explanation for higher mortality rates among unmarried Arab women is that in a traditional society, such as Israeli Muslims (around 60% define themselves as religious) (Levi, 2016), unmarried Arab women could be seen as shirking societal norms and are considered more likely to engage in undesirable behavior. These same women may also be more likely to smoke for the same reason and thus be at increased risk for respiratory cancer.

Conversely, unmarried Arab men had lower risk of mortality, in contrast to previous studies which demonstrated higher mortality among unmarried men (Vyfhuis, 2018). Similar to unmarried Arab women, in such a traditional society where marriage is an important aspect of family life, Arab men who remain unmarried may not conform to societal norms. With almost 44% of Arab men smoking, also a potential societal norm, it could be that men who are unlikely to get married are also unlikely to begin smoking, and thus lower their respiratory cancer risk.

Similar to previous findings, both Arab men and women with up to three children have a lower respiratory cancer-related mortality risk. As stated in previous findings, children can represent social support, similar to that provided by marriage. Furthermore, among women this could be related to a protective factor from reproductive hormones (Paulus et al., 2010; Skuladottir & Olsen, 2006).

Another explanation could be related to education. Educated people are less likely to have many children, especially women. As having up to 3 children (below the country average) is a protective factor, it could be that these groups are also more educated and are aware of the dangers of smoking thus lowering their risk of developing lung cancer (Weinreb et al., 2018).

Finally, fewer people in a household means a lower risk of smoking in the house and exposure to secondhand smoke, also lowering the risk of lung cancer. This is particularly true in the Arab population, where smoking is considered a social activity, such as water-pipe (narghile) smoking, and therefore more common (Keinan-Boker & Bar-Zeev, 2019). Therefore, those living smaller Arab households could be expected to have lower exposure to smoking.

Jewish women with up to three children, on the other hand, have a higher risk of lung cancer-related mortality. Previous studies in Israel indicate that religious level is associated with number of children, and religious women, especially ultra-orthodox women, are less likely to smoke (Kalter-Leibovici et al., 2016; Levi, 2016). Further, the percentage of Arabs who have tried smoking even while in elementary school is 26.3%. almost three times the percentage for Jews so there is likely a greater risk of second-hand smoke exposure to Arabs with larger families (Geva Hospil & Education, 2020).

One aspect to consider in looking at these disparities is religious level. Traditional or religious Jews and Arabs are less likely to smoke compared to their secular counterparts (Bayram & Donchin, 2018; Kalter-Leibovici et al., 2016). Studies comparing ultra-orthodox Jews to non-ultra-orthodox Jews and Arabs found that ultra-orthodox Jews have much lower smoking rates (Bayram & Donchin, 2018). One study showed an association between ethnicity, religious level, and smoking among men; secular Arab men were more likely to smoke compared to secular Jewish men. However, religious Arab men were less likely to smoke compared to religious Jewish men (Kalter-Leibovici et al., 2016).

There are also potentially important policy implications to these findings. The significant difference between Jews and Arabs in Israeli society in SES, a gap that may be related to health inequalities, is well known (Averbuch et al., 2020; Daoud et al., 2018). Efforts should be made in general to improve SES, which we found associated with greater respiratory cancer mortality, as well as other health inequalities, such as better access to healthcare services, especially for minority groups such as Arabs (Baron-Epel et al., 2007; Daoud et al., 2018).

However, our study found gaps between Jews and Arabs even after adjusting for socioeconomic status as well as other key demographic variables. The differences found between Jews and Arabs in the context of these factors points to the fact that one size may not fit all and that there is a need to tailor appropriate interventions for different subgroups.

As noted, previous studies have shown that SES is linked to smoking, an important cause of incidence and mortality from respiratory cancer (Siegel et al., 2015) and therefore part of a causal pathway that links ethnicity to mortality in Israeli society. Moreover, when analyzing the population by sex, we found higher mortality rates among Arabs and among men. This is consistent with literature showing that men and in particular Arab men had the highest smoking rates in Israel (Geva Hospil & Education, 2020; Kalter-Leibovici et al., 2016). Therefore, they should be especially targeted in efforts to reduce smoking and respiratory cancer mortality.

Access to care should also be improved among Arabs and other minority groups in order to reduce health inequalities related to respiratory cancer inequality and in general (Baron-Epel et al., 2007; Daoud et al., 2018). Although Israel has made efforts in recent years to try to improve access to care and reduce health inequalities between Jews and Arabs as well as other groups, further efforts should be made. Activities to reduce accessibility gaps can include improving the cultural and linguistic accessibility of the health system and adapting it to all citizens of the country, while strengthening its ability to provide medical services to residents from all cultures (Averbuch et al., 2020; Schuster et al., 2016).

4.2. Limitations/additional research

There are several limitations to this study. First, we did not have access to smoking data; this could have ramifications on our ability to understand study outcomes. Additionally, we did not have access to the education data of the participant's spouse. This could potentially affect a person's socioeconomic status, particularly among more traditional communities.

We do not have data for people who emigrated from Israel and did not return by the end of the follow-up period. However, we chose to include their contribution of life-years up until they left in order to get a more robust picture of the risk rate. However, different emigration rates and the difference in the health characteristics of emigrating nationals between Israeli Jews and Arabs could potentially affect the results.

As noted in the discussion, religion has been found to be associated with rates of smoking. As this study does not include a 'religious observance' variable, we were unable to determine the effect of this association in our study.

The data utilized in this study were exclusively administrative, and therefore we were unable to verify cause of death. The marital status variable was based on marital status at the beginning of the study

period; this could potentially effect results. We were not able to separate the cause of death by type of cancer, which could have contributed to a more detailed analysis.

It is not clear to what extent these findings are generalizable to cancers less connected to smoking and also to Jews and Arabs in other counties. Further research about this is needed.

Surprisingly, we found no association between mortality and marital status or number of children among Jewish men. The reasons for this are not clear and warrant additional research.

5. Conclusions

Our study analyzed data for 1,667,650 Israelis born between 1940 and 1960, following them for a 21-year period to analyze respiratory cancer-related mortality. Different predictive factors for mortality from respiratory cancer (and most likely smoking) affect ethnic groups differently. Therefore, when studying health outcomes, different ethnic groups in a given population should be studied separately, by sex, in order to better understand these health outcomes. These separate analyses can lead to a deeper understanding of what affects disparities between groups and can assist in creating more effective interventions. Additional studies should be done to understand the effect of predictive factors on other health outcomes among ethnic groups.

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Author agreement statement

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We understand that the Corresponding Author is the sole contact for the Editorial process.

Declaration of competing interest

None.

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