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Emergency Department Visits, Hospitalizations, and Mortality: The Effects of Heat Stress in Israel, 2010–2023

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Taub Center Research and Policy Initiative for Environment and Health

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Taub Center for Social Policy Studies in Israel

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Emergency Department Visits, Hospitalizations, and Mortality: The Effects of Heat Stress in Israel, 2010–2023

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Background

The rise in average global temperature is reflected, among other things, in an increase in the number of very hot days and nights each year. Studies have found that extreme heat events cause physiological stress in all bodily systems, and especially in the cardiovascular system (Anderson & Bell, 2011; Masselot et al., 2025). The growing physical and mental distress increases the demand for healthcare services during heat waves (Mason et al., 2022). The Eastern Mediterranean basin is considered one of the regions most affected by global warming. Between 1980 and 2024, the average daily maximum temperature in Israel in July rose by about 3 degrees Celsius (Figure 1). This trend is expected to continue. In the coming decades, for every one-degree rise in global temperature, the temperature in the eastern Mediterranean basin is expected to rise by 1.4–1.8 degrees (Cos et al., 2022).

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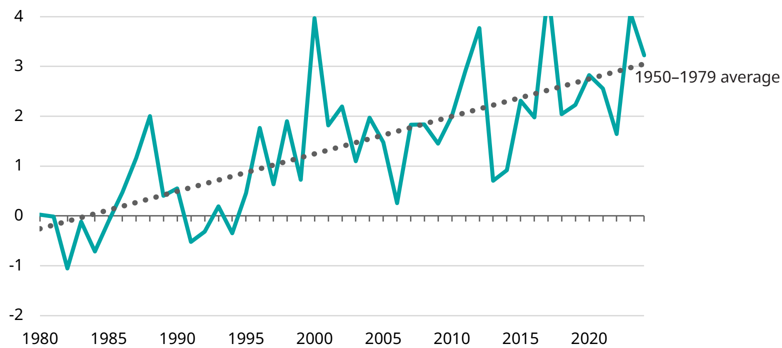
Figure 1. Average daily maximum temperature in Israel in July, 1980–2024, compared with the July average in 1950–1979



Source: Alex Weinreb, Taub Center | Data: The Israel Meteorological Service

The effect of heat on the demand for healthcare services

Exposure to extreme heat increases blood flow to the skin to facilitate heat loss and cool the body, accompanied by increased sweating; the heart rate rises, the burden on the cardiovascular system increases, and intensified cardiac output comes at the expense of other systems. In addition to the direct effect on the cardiovascular system, higher oxygen consumption also impairs the ability to regulate the respiratory rate; impaired regulation causes, among other things, hyperventilation and a worsening of the condition of patients with asthma and chronic obstructive pulmonary disease. Exposure to heat can also weaken the immune system and increase exposure to respiratory infections.

The total effect of extreme heat stress depends on the duration of exposure and on health status. Heat stress accompanied by relatively high humidity makes sweating even more difficult, which reduces the body's ability to dissipate the heat that has accumulated in it (Kenney et al., 2014). Since the ability to sweat is also impaired at older ages, in part because of the use of certain age-related medications, the effects of heat stress are particularly strong among the elderly. Heat stress also affects the kidneys, mainly because of dehydration and fluid loss, which reduce blood flow to the kidneys and cause kidney failure. In extreme cases, these physiological phenomena can lead to death (Sorensen & Hess, 2022).

A study conducted in Palma de Mallorca, which has a Mediterranean climate similar to Israel's, found significant results: during extreme heat events, diagnoses of pulmonary embolism increased by 55%, among the highest in all the diagnoses examined (after heatstroke and kidney failure) (Bujosa Mateu et al., 2024). Substantial increases were also documented in diagnoses of hypertension (47%) and stroke (26%).

The effect of demand for healthcare services on quality of care

The intensification of physiological stress leads to a substantial increase in demand for emergency medical services, including visits to emergency departments (Adélaïde et al., 2022; Mason et al., 2022; Panagiotakos et al., 2004; Tong et al., 2021), demand for ambulatory services (Turner et al., 2013; Xu et al., 2023), and hospitalizations (Knowlton et al., 2008). Hospital crowding, in particular, has secondary effects on the quality of care, even when they are not directly exposed to heat. It has been found to be associated with an increased risk of contracting various infections (Kaier et al., 2012); longer visits to emergency departments and longer waits for tests and treatments (Hoot & Aronsky, 2008); and an increased probability of mortality (Cameron, 2006).

A study conducted in Mexico examined about 70 million emergency department (ED) visits and about 22 million hospitalizations in 916 EDs and 857 public hospitals[1] over eight years (Aguilar-Gomez et al., 2025). The researchers found that on days when the daily maximum temperature exceeded 34 degrees Celsius, the number of ED visits and the number of hospitalizations increased. Although the severity of diagnoses among hospitalized patients did not change, there was an increase in the severity of the condition of patients who arrived at the ED. The burden on hospitals also led to the discharge of more seriously ill patients to their homes, to an increase of about 6% in mortality both within hospitals (explained by overcrowding and not by a more severe condition among hospitalized patients) and in the overall population explained by heat stress (that is, also outside the hospital).

1 The hospitals of the Mexican Ministry of Health, which mainly serve Mexico's poor population (the lower-middle part of the income distribution).

This negative relationship between hospital crowding and quality of care also exists in Israel. A study that examined the effect of COVID-19 on hospital burden in Israel found an association between patient load and mortality. The odds of mortality among patients hospitalized for up to 14 days in months characterized by a high patient load were 27.2% higher than the odds in months characterized by a moderate patient load, after adjustment for the hospitalized patient's clinical condition (Rossman et al., 2021).

Heat stress, morbidity, and mortality in Israel

Although the rate of air conditioner ownership in Israel is high, standing at nearly 97% in 2022 (CBS, 2024),[2] studies on Israel and comparative studies that include Israel largely confirm the negative effect of heat events on health. A study comparing mortality associated with heat stress in countries in the Middle East and North Africa found that Israel ranked second among 18 countries, with a mortality rate of 3.74 per 100,000 people (Hajat et al., 2023). Another study examined the relationship between mortality rates and the heat stress index and estimated that by the end of the century there are expected to be 330 excess deaths in Israel each summer (Wedler et al., 2023). By contrast, a global study that examined the probability of mortality due to heat stress in different countries estimated that in countries such as Israel, where income per capita is relatively high, the rise in temperature will increase adaptation expenditures (for example, spending on air conditioning) that will help the country avoid meaningful increases in heat-related mortality (Carleton et al., 2022).

In Israel, an association has also been found between heat stress and an increase in specific health-related outcomes. For example, a temperature of 32 degrees was found to be associated with a 32% increase in the risk of stroke relative to a temperature of 27 degrees (Negev et al., 2026); a 5-degree temperature increase in summer months increased the probability of a suicide attempt by 59% (Yarza et al., 2020); and exposure to heat above the 90th temperature

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2 However, entire populations in Israel live in localities that do not have a regular electricity supply. In addition, about 13% of households in Israel in 2023, about 368,000 households, live in energy poverty (Kuperak & Kosman, 2023), and some experience electricity disconnections that prevent them from heating or cooling their homes (Latet, 2024).

percentile was found to be associated with an increase in the probability of out-of-hospital cardiac arrest (Kranc et al., 2021). A preliminary data analysis by the Ministry of Environmental Protection, which examined mortality in eight cases of heat stress that the Israel Meteorological Service defined as heat waves, found that each heat wave led to the deaths of 45 people on average (Yamin & Shmueli, n.d.).

Within this emerging scholarly literature on Israel, only a few studies have focused on the relationship between heat stress and the use of healthcare services.[3] A study conducted in four medical centers in the Tel Aviv metropolitan area found that a one-degree increase in the average daily temperature was associated with only a small increase of 1.5% in ED visits (Novikov et al., 2012). Another study found a 50% increase in the rate of hospitalizations due to ventricular fibrillation at the 95th temperature percentile relative to the rate at the median (Yarza et al., 2023). Associations have also been found between high temperatures and the use of psychiatric healthcare services (Shiloh et al., 2005) and worsening conjunctivitis (Levanon et al., 2023).

An extra factor increases the salience of this topic in Israel. Not only does the high rate of population growth — averaging 1.9% per year in the period under study — drive rapid construction. The manner of construction in Israel, without sufficient shade, with few green spaces, and usually at the expense of open areas that serve as natural air conditioners, causes the formation of urban heat islands (Illustration 1). As a result, the number of residents exposed to exceptional heat stress is rising, usually, but no longer only, in the summer months.[4]

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3 Based on a literature review by Prof. Keren Agay-Shay of Bar-Ilan University (unpublished).

4 See the Planning Authority website, A Planning Guide for Moderating Urban Heat.

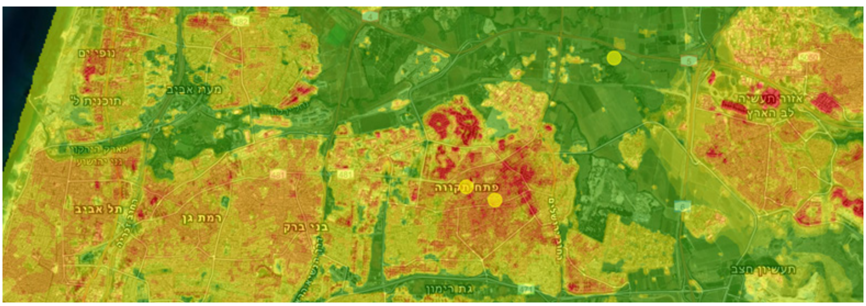
Illustration 1. The difference between temperatures within localities and open areas around them

Temperature exposure in August at 9:00 pm in localities relative to exposure in open areas in the vicinity

2.0 – 2.7 Positive difference in temperature in degrees celsius

1.8 – 2.0 | 1.8 – 1.5 | 1.5 – 1.0 | 1.0 – 0.5 | 0.5 – 0.0 | 0.0 – -0.1

-0.1 – -0.2 | -0.2 – -0.3 | -3.0 – -4.5 Negative difference in temperature in degrees



Source: Climate risk mapping, Ministry of Environmental Protection

Study goals

The goals of this study are: (1) to examine the association between extreme heat events and the use of hospital healthcare services, with an emphasis on chronic diseases that are most sensitive to heat stress; (2) to examine whether excess demand for healthcare services during heat events affects two distinct hospital treatment outcomes — length of stay and probability of death; and (3) to estimate the health and economic burden of extended hospital stays.

Data

Health outcomes

Core data on health outcomes are provided by the Ministry of Health through TIMNA (its Big Data Research Infrastructure). The data include individual-level information on ED visits, hospitalizations and final outcomes (release or death) for people admitted to EDs or inpatient departments in Israel during the summer weeks in the 2010–2023 period, conditional on those people being diagnosed with a respiratory disease, cardiovascular disease, kidney disease, or diabetes (for the full list of diseases according to ICD-9 classification, see Appendix Table 1). By summer weeks, we refer to weeks 17–38 of each year, broadly corresponding to mid-May to late September.

The data on ED visits include the week of the ED visit, primary and secondary diagnoses (ICD-9 code), year of birth, sex, and locality of residence. These data also include the outcome of the ED visit (discharge, referral for hospitalization, death, referral to another institution) and primary ethnic group (Jewish, Arab, Druze). Data on subsequent hospitalization add date of hospitalization, the date of discharge or death, and an indicator of hospitalization urgency (planned/ emergency).

Models also control for the age composition (in five-year age groups).

Exposure variables

Heat stress. To estimate exposure to heat stress in each locality, we used the Israel Meteorological Service's heat stress index (sometimes also called the discomfort index). This is calculated as the average of the dry-bulb temperature and the wet-bulb temperature (humidity index[5]) (Israel Meteorological Service, 2022) in each of Israel's eight climate zones. Borders between the latter are based on regulations regarding the thermal insulation of buildings (SI 1045). Appendix Illustration 1 maps these zones. Within each of them, the weekly heat stress index was calculated by averaging hourly temperature data over seven days, then flagging weeks in which temperatures were one standard deviation higher than the historical seasonal average within that climate zone — this is detailed below.

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5 The temperature to which air is cooled by the evaporation of water from a wet source, such as a thermometer wrapped in wet cloth. For further discussion, see Stull, 2011.

National air pollution. Existing studies indicate a correlation between air pollution and urban heat islands and a correlation between high air pollution and heat stress (for example, Rainham & Smoyer-Tomic, 2003). It is therefore possible that the association between heat stress and excess ED visits and hospitalizations is explained by the increase in air pollution. To examine this relationship, and also prevent possible confounding (specifically omitted variable bias) affecting the estimated relationship between heat stress and health outcomes, we calculated the average weekly value of concentrations of particles smaller than 2.5 micrometers (PM2.5), which are emitted by industrial plants and motor vehicles. The calculation was based on the air quality index of the Ministry of Environmental Protection.[6]

Methodology

To estimate the effect of extreme heat stress on Israel's healthcare system, we linked individual-level data on ED visits, hospitalizations, and mortality with data on heat events and air pollution, as well as with demographic characteristics. Analysis proceeded in two discrete stages. In the *first stage*, we examined whether there was a change in the number of ED visits due to heat events. We focused on individuals diagnosed with respiratory diseases, cardiovascular diseases, kidney diseases, or diabetes. In the *second stage*, we estimated the effect of extreme heat events on the health outcomes of hospitalized patients, and in particular on average length of stay and survival probability. This was based on the assumption that the functioning of the healthcare system, which is already affected by very high occupancy rates compared with other wealthy countries, will be affected even further by an additional increase in demand for its services due to heat stress. Finally, we estimated the morbidity and excess hospitalization burden during extreme heat events and the economic burden of excess hospitalization days.

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6 The PM2.5 data were collected from Ministry of Environmental Protection monitoring stations. In localities with several stations, the average value was calculated. Locality data were averaged to the national level.

The study population

The study consists of two populations. The first comprises all ED patients in localities with more than 25,000 residents who were aged 60 or older between 2010 and 2022[7] and were diagnosed with one of the following diseases: respiratory diseases (all diseases, lung diseases, pneumonia), cardiovascular diseases (all diseases, heart disease, stroke), diabetes, and kidney disease. Since the individual-level data available to us include only those who arrived at the ED and not the entire population exposed to heat, we cannot directly estimate rates of ED visits — there is no clear denominator. The statistical modeling in this part of the study is therefore not based on individual-level data but on fluctuations in the relative share of ED visitors in the total population in each locality, controlling for differences between localities in the age of the population and for changes in the age of the population in each locality over time. To augment the validity of this approach, the sample is also limited to localities with a population of 25,000 or more — that reduces the influence of random variation from much smaller localities on our estimates. The final sample in this part of the study therefore includes the sum of ED visits with one of the four target conditions from 73 cities and localities over 22 summer weeks across 13 years (2010–2022), yielding a sample size of almost 21,000 observations per condition.

The second population is all hospitalized patients aged 60 or older who were diagnosed with heart disease or a respiratory disease and were hospitalized for up to 21 days during the summers of 2010–2023 (about 22,500 individuals). This sample was limited to people aged 60 and older, since they have been found to be especially vulnerable to heat stress (Belmin et al., 2007; Fouillet et al., 2006).

Table 1 presents the characteristics of ED visits. The main differences between ED visits due to respiratory diseases and visits due to cardiovascular diseases are as follows: the average age of visitors due to respiratory diseases is higher than the age of visitors due to cardiovascular diseases; the average temperature at the time of ED visits due to respiratory diseases is slightly higher than the average temperature at the time of visits due to cardiovascular diseases; 71% of ED visitors due to respiratory diseases are hospitalized, compared with 55% of visitors due to cardiovascular diseases; 0.23% of heart disease patients

7 Due to data quality issues the ED data for 2023 were not used.

who arrived at the ED died during hospitalization, compared with 0.17% of patients with respiratory diseases; the weekly average number of ED visits due to respiratory diseases (415) is almost three times greater than the weekly average number of visits due to cardiovascular diseases (158); the number of men visiting the ED due to respiratory diseases is equal to the number of women, whereas most visitors due to heart disease and kidney disease are men (see Appendix Table 2).

Table 1. Characteristics of ED visits due to heart diseases and respiratory diseases among people aged 60 and older: Number of visits, means, and standard deviations, 2010–2022

	Respiratory diseases (ICD-9: 460–519)			Cardiovascular diseases (ICD-9: 390–498)		
Characteristic	N	Average	Standard deviation	N	Average	Standard deviation
Week (20–31)	1,912,886	28.02	6.32	725,150	28.19	6.23
Age (> 60)	1,912,886	77.15	10.30	725,150	75.32	9.34
SES (1-10)	1,678,717	5.36	2.14	646,546	5.86	1.94
Sex (Female = 1)	1,912,886	0.50	0.50	725,150	0.56	0.50
Jewish (Yes = 1)	1,912,886	0.80	0.40	725,150	0.81	0.39
Heat stress rating (weekly average)	1,904,385	22.88	2.43	721,756	23.05	2.33
Temperature (weekly average)	1,904,385	25.69	2.48	721,756	25.86	2.38
Hospitalization (%)	1,912,886	0.71	0.45	725,150	0.55	0.50
Died in emergency department (%)	1,912,886	0.002	0.041	725,150	0.002	0.048

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Exposure to heat stress

The highest average weekly temperature was measured in Eilat, the Jordan Valley, and the Arava, and the lowest was measured in the Upper Galilee and the Golan, followed by Jerusalem, where the temperature was less than one-tenth of a degree higher (Table 2). In terms of the combination of temperature and humidity, heat stress (see Table 3) was lowest in Jerusalem and highest in Eilat.

In the northern coastal plain, heat stress was higher than in the southern coastal plain. In the southern Shfelah and the Negev, lower values were measured than in the northern Valleys region.

The heat stress exposure variable in this study is a binary variable that takes the value 1 if the week is defined as having any heat stress (one standard deviation above the seasonal average in the climate zone) and the value 0 otherwise.[8] One standard deviation is about 2.5 degrees and several heat stress units above the weekly average. In this study, 13% of the weeks in the four months examined were found to be especially hot weeks (Figure 2), and the heat stress index in the hottest weeks corresponds to the definition of moderate to heavy heat stress; only in Eilat, the Jordan Valley, and the Arava were there weeks in which extreme heat stress was measured.

Table 2. Temperature and heat stress index by climate zone in Israel: Mean, minimum, and maximum in the summer months (May–September), 2010–2023

	Heat stress index				Temperature			
Climate region	Average	Standard deviation	Maximum	Minimum	Average	Standard deviation	Maximum	Minimum
Center, Coastal strip	23.47	2.52	28.11	16.22	25.68	2.53	29.86	18.26
North, Coastal strip	23.84	2.41	28.72	16.41	26.36	2.42	30.54	18.99
Inner valleys	23.30	2.44	28.31	15.84	26.07	2.50	31.32	17.78
Shfelah	22.89	2.36	27.25	15.77	25.17	2.29	29.32	17.73
Negev	22.54	2.24	27.35	15.88	25.67	2.19	30.57	18.53
Upper Galilee, Golan	20.80	2.45	26.10	13.42	23.30	2.59	30.00	14.61
Jerusalem	20.53	2.22	25.39	13.64	23.37	2.37	29.09	15.30
Jordan Valley to Eilat	25.80	2.31	30.75	18.99	30.09	2.43	35.00	22.06

Note: The method used to calculate the heat stress index was explained above.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service

8 When examining the association between heat stress and emergency department visits, the heat stress variable is binary. When examining the association between heat stress and length of hospitalization and in-hospital mortality, this variable is continuous.

Table 3. Heat stress index of the Israel Meteorological Service

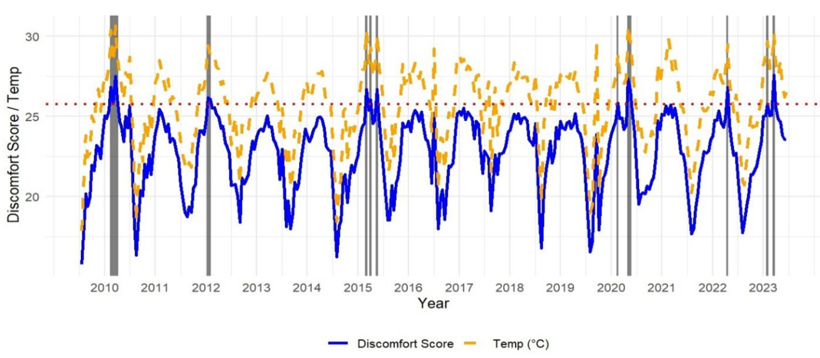
Category	Heat stress index
No heat load	< 22
Light heat load	23–24
Moderate heat load	24–26
Medium heat load	26–28
Heavy heat load	28–30
Extremely heavy heat load	> 30

Note: The values are rounded; in practice, the value "up to" does not include the next threshold.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service

Figure 2 describes heat stress (the blue line) and average temperature (the dashed yellow line) in May–September in 2010–2023. The horizontal dotted line marks the national heat stress threshold. The vertical lines in the figure represent weeks characterized by high heat stress.

Figure 2. Exposure variable: Heat stress index and average weekly temperature over time



Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service

Data limitations

Week of admission to the ED. In the absence of the exact date of admission to the ED, we use data on week of ED visit. On one hand, this makes it more difficult to identify an effect of heat stress, since it is not possible to use time-series methods such as distributed lag models, where the possible impact of heat stress on ED visits or hospitalization occurs over the course of days. On the other, aggregating these data to weeks smooths out day-to-day fluctuations, allowing us to identify larger and more sustained effects. The bottom line here is that our estimates are conservative — erring on the side of underestimating the effects of heat stress — because they likely miss very short-term impacts that do not sufficiently raise weekly averages.

No hospital identifier was provided. Because the dataset lacks hospital identifiers, we cannot disentangle stable institutional characteristics from acute temporal variations. Specifically, we cannot control for baseline differences in patient volume and case complexity across facilities, nor can we observe how individual hospitals cope with the operational strain of heat-stress days relative to routine days. While hospitals likely account for their steady-state patient loads when making staffing decisions, a sudden weather-induced surge may trigger localized capacity bottlenecks that alter hospitalization lengths and ED outcomes. Because our data obscures the specific treating institution, these facility-level baselines and heat-responsive dynamics are absorbed into a single geographic average. Consequently, this study focuses entirely on how heat-stress health outcomes vary by the patient's locality of residence rather than hospital-specific effects.

No information was provided on other reasons for ED visits. We focus on respiratory diseases, cardiovascular diseases, kidney diseases, and diabetes (for the full list of diseases according to ICD-9 classification, see Appendix Table 1). It is possible that identifying other reasons for ED visits (external injuries, hospitalizations on mental health grounds) would have allowed a more comprehensive assessment of the scope of ED visits and hospitalizations.

Our model also addresses the fact that over the 13 years of observation, there may have been some correspondence between patterns of population growth, changes in age composition or other sociodemographic change, and the frequency of heat waves. To address this problem, the dependent variable in models looking at the association between heat stress and ED visits was defined as the ratio of the total number of ED visitors in each locality in a given week of admission with one of the primary diagnoses of interest (cardiovascular diseases and respiratory diseases) relative to the total population of the locality in that year. Using this ratio, rather than the number of visitors, builds in a control for population growth. It also makes it possible to control for confounding variables at the locality level. To address the change in age composition at the locality level, models include the percentage of the population in each age group in the locality in each year. Models also include fixed effects for week and year. These capture potential fluctuations in the number of ED visits associated with seasonal events that can affect activity or food consumption but are not related to climate (e.g., receipt of payments, holidays, the start of the school year, vacations).

ED visits

As noted, in the first stage of the study we sought to examine whether there was a change in the number of ED visits due to heat events. To estimate changes in ED visits during weeks of high heat stress, a negative binomial (NB) regression was used;[9] the dependent variable is the ratio of ED visitors in each locality, week, and year, and the heat stress exposure variable is a binary variable that takes the value 1 if the week is defined as having any heat stress (one standard deviation above the annual average in the climate zone) and the value 0 if there is no heat stress. The estimated regression is formulated as follows:

$$(1)\ \mathrm{NB} = \left(\mathrm{Rate}^{j}_{cwy} \sim \alpha_y + \beta_{\mathrm{w}} + \gamma_1 \mathrm{discomfort}_{zwy} + \gamma_2 \sum_{60-65}^{75+} \mathrm{Age\ group}_{cy} + \gamma_4 \mathrm{pollution}_{wy} + \gamma_4 \mathrm{ses}_c + \varepsilon_{cwy}\right)$$

where Rate^{j}_{cwy} is the relative share of ED visitors with primary diagnosis j in locality c, week w, and year y out of the total population in the locality (in 2015); $\mathrm{discomfort}_{cwv}$ is a binary variable for a week characterized by heat stress in climate zone Z; $\mathrm{Age\ group}_{cy}$ is the relative share of each age group in the locality in each year (age groups 60–65, 65–70, 70–75, 75+); $\mathrm{pollution}_{wy}$ is the national air pollution index (PM2.5); ses_c and is the socioeconomic ranking of the locality. In addition, the regression included fixed effects for calendar time (year and week).

9 Negative binomial regression is more appropriate for probabilities composed of positive discrete numbers (such as the number of visits), and unlike Poisson regression, it does not assume equi-dispersion (i.e., that the mean and the variance of the outcome variable are equal).

Health outcomes after hospitalization

The second stage of the study estimates the association between heat stress and length of hospitalization and probability of in-hospital mortality at the individual level (rather than the association between heat stress and ED visits at the locality level). To ensure that the estimated health effect of heat stress on length of hospitalization and probability of in-hospital mortality does not include the effect of the increase in the number of ED visits, a variable was added to these outcomes (EDChange), representing the change in the number of ED visits by week compared with the average number of visits (over all years), by Ministry of Health subdistrict. We used the number of ED visits, rather than the number of hospitalized patients, as a measure of hospital burden because the decision to hospitalize a patient may be endogenous, that is, dependent on the hospital's current burden.

The analysis focused on patients in the main categories: cardiovascular diseases and diseases related to the respiratory system. The estimated regressions are formulated as follows:

$$(2)\ duration_i^j$$
$$= \alpha_m + \beta_y + \delta_w + \gamma_1 \text{discomfort}_{zwy} + \gamma_2\, ERChange_{nwy}^j + \gamma_3 \text{pollution}_{wy} + \gamma_4 \text{discomfort}_{zwy} * \text{pollution}_{wy}$$
$$+ \gamma_4 \text{Sex}_i + \gamma_5 \sum_{60-65}^{75+} Age\ group_i * \text{Sex}_i + \gamma_7 \text{ses}_c + \gamma_8 \text{Urgent}_i + \varepsilon_{cwy}$$

$$(3)\ death_i^j$$
$$= \alpha_m + \beta_y + \delta_w + \gamma_1\, ERChange_{nwy}^j + \gamma_2 \text{pollution}_{wy} + \gamma_3 \text{discomfort}_{zwy} + \gamma_4 \text{discomfort}_{zwy} * \text{pollution}_{wy}$$
$$+ \gamma_3 \sum_{60-65}^{75+} Age\ group_i + \gamma_4 \text{Sex}_i + \gamma_5 \sum_{60-65}^{75+} Age\ group_i * \text{Sex}_i + \gamma_7 \text{ses}_c + \gamma_8 \text{Urgent}_i + \varepsilon_{cwy}$$

where $death_i^j$ and $duration_i^j$ are, respectively, the probability of in-hospital mortality and length of hospitalization with diagnosis j; $ERChange_{nwy}^j$ is the relative change (relative to the subdistrict average) in the weekly number of people arriving at the ED (at the Ministry of Health subdistrict level) compared with the multi-year weekly average number of people arriving at the ED over all years (at the Ministry of Health subdistrict level); and Urgent_i is an indicator of hospitalization urgency (taking the value 1 if the case is urgent and 0 if it is not urgent). In addition, variables for age group and gender at the individual level were included. In both cases, the regressions were estimated linearly; the probability of mortality was also estimated using logistic regression; and the association with length of hospitalization was also estimated using Poisson regression. In the second stage, the sample included hospitalized patients with a primary diagnosis of cardiovascular diseases or respiratory diseases, aged 60 and older, who were hospitalized for no more than 21 days.[10]

Results

The effect of heat stress on ED visits

The tests we conducted found a positive correlation between the rate of ED visits and the heat stress index in the summer weeks for almost all medical diagnoses. The strongest association was measured for diagnoses of lung diseases and respiratory diseases (see Appendix Figure 1).

We found that in weeks of high heat stress, there was a significant increase in ED visits due to respiratory diseases, cardiovascular diseases, and kidney diseases, compared with weeks of lower heat stress (Table 4). The largest increase, about 41%, was found among patients diagnosed in the ED with lung disease, compared with patients diagnosed with kidney disease (28%) and cardiovascular disease (27%). No association was found between heat stress and ED visits due to diabetes. For stroke, an increase was found in hot weeks, but it was not statistically significant. The regression results describing the association between heat stress and ED visits are presented in Appendix Table 3.

10 To neutralize the effect of outlier observations involving especially long hospitalizations.

Table 4. The association between a one-standard-deviation increase in the heat stress index (2.33 heat stress units) and ED visits, during the summer months, by illness, 2010–2022

Diagnosis	Beta (β)	Standard error	IRR= exp(β)	Confidence interval 95% for IRR (lower limit)	Confidence interval 95% for ITT (upper limit)
All respiratory diseases	0.20	0.03	1.20	1.13	1.27
Pneumonia	0.19	0.00	1.17	1.08	1.26
Lung diseases	0.33	0.06	1.41	1.24	1.59
All cardiovascular diseases	0.13	0.05	1.18	1.07	1.30
Heart diseases	0.22	0.07	1.27	1.09	1.48
Stroke	0.10	0.08	1.13	0.95	1.33
Diabetes	0.02	0.10	1.12	0.90	1.38
Kidney diseases	0.12	0.01	1.28	1.15	1.43

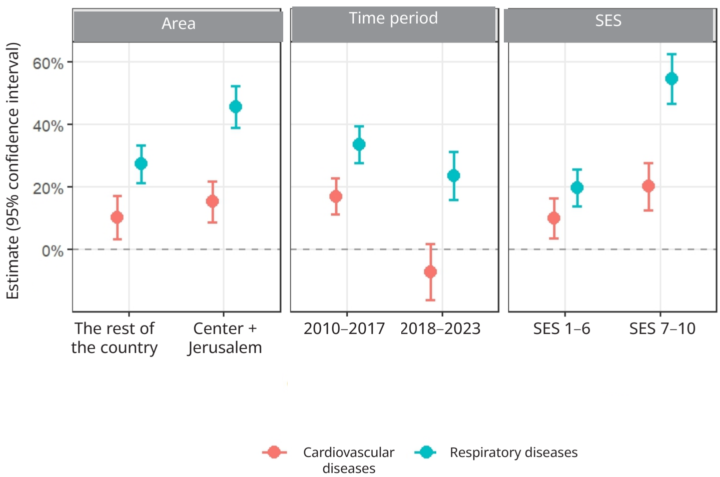
Note: The increase in ED visits was estimated using negative binomial regression. To convert the negative binomial regression coefficients into growth rates, we converted the coefficient from the logarithmic scale, for example, exp(0.34) = 1.41. IRR is the incidence rate ratio.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: TIMNA, Ministry of Health

The increase in the number of ED visits due to respiratory diseases and cardiovascular diseases (Figure 3) as a result of heat stress in 2010–2017 was greater than in 2018–2023. No significant association was found between heart disease and heat stress in the latter period. In addition, we found that ED visits during periods of high heat stress, compared with lower heat stress, increased more in localities with a high socioeconomic ranking (7–10) than in localities with a low socioeconomic ranking. In the Tel Aviv and Central districts (including Jerusalem), the increase in ED visits due to heat stress was greater than in the other districts in Israel, especially for respiratory diseases.

Figure 3. Change in the number of ED visits in weeks of high heat stress compared with other summer weeks, by region, time period, and socioeconomic ranking

Percent



Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

The association between heat stress and hospitalization outcomes

In the second stage, examined using Equations (2) and (3), we evaluated whether heat stress is associated with longer hospitalization and higher mortality during hospitalization, controlling for hospital burden (by adding the variable for excess ED visits) and additional variables. The characteristics of hospitalized patients are detailed in Table 5. Full regression results from model are presented in Appendix Tables 4 and 5.

Table 5. Characteristics of hospitalized patients with heart diseases and respiratory diseases among people aged 60 and older, by diagnosis, 2010–2023

Characteristic (average [standard deviation])	Respiratory diseases (N = 299,370)	Cardiovascular diseases (N=583,540)
Age	77.9 (9.2)	79.3 (9.6)
SES (1-10)	5.4 (2.2)	5.6 (2.0)
Length of hospitalization (days)	4.6 (3.8)	4.9 (4.2)
Female	54%	46%
Died in hospital	23,950 (8%)	70,024 (12%)
Urgent	239,496 (80%)	525,186 (90%)

Note: The sample includes patients hospitalized for 1–21 days. Continuous variables are presented as mean and standard deviation; binary variables are presented as number and percentage.

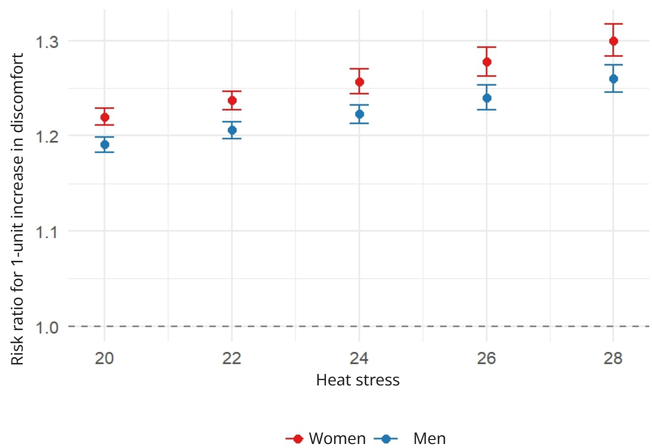
Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: TIMNA, Ministry of Health

An overarching, though somewhat surprising, result is that the association between heat stress and length of hospitalization is quite different across the two major categories of medical conditions that we focus on here.

Figure 4 summarizes the relationship among patients hospitalized with respiratory diseases, based on model in Appendix Table 4. Among both male and female patients, the higher the heat stress, the longer the hospital stay. For example, a one-unit increase in heat stress from 20 to 21 degrees lengthens the average hospital stay due to respiratory diseases by 19% for men and 22% for women, whereas an increase from 25 to 26 degrees lengthens the hospital stay by 24% for men and 28% for women. The increase in length of stay among women is greater than the increase among men across the entire observed range of heat stress (between 20 and 28 units), controlling for the other variables. Given the average length of stay of a hospitalized patient with a respiratory disease was 4.6 days, this heat-related increase would therefore extend hospitalization by between 0.9 days to 1.3 days. Hospitalization also becomes longer with increasing age, though it was shorter for patients from localities with a socioeconomic ranking of 8–10 (15% shorter than counterparts from localities with a socioeconomic ranking of 1–3).

The association between heat stress and length of hospitalization is quite different in the case of heart disease (model results in Appendix Table 5). Here, the average length of stay decreased by 3%, equivalent to a decline of about 0.15 days for each heat stress unit. This decline was uniform across the entire range of heat stress. As in the case of respiratory diseases, the length of stay for women with heart disease was 7.5% longer than that of men. However, unlike the case of respiratory diseases, patients from localities with a socioeconomic ranking of 1–3 were hospitalized for a shorter period than their counterparts from higher SES localities. The increase in ED visits lengthened the hospital stay for both diagnoses by 0.1%.

Figure 4. Marginal effect of discomfort score on days of hospitalization, by sex and discomfort level

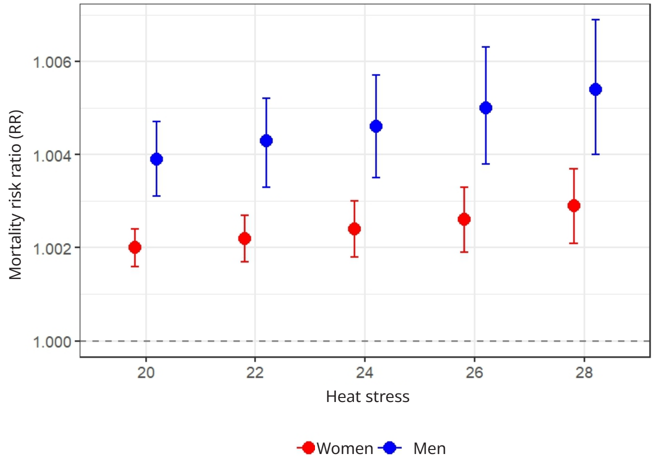


Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

The relationship between heat stress and in-hospital mortality

Full regression model results appear in Appendix Table 6. Among patients hospitalized with a diagnosis of respiratory disease, a linear, albeit small, increase in in-hospital mortality was observed as heat stress rose. As depicted in Figure 5, a one-unit increase in heat stress raises the probability of in-hospital mortality by 0.2%–0.3% among women and by 0.4%–0.5% among men. The probability increases with age, except among those aged 65–75, for whom it decreases compared to those aged 60–65. Unlike length of stay, women's probability of in-hospital mortality is lower than that of men. The probability of in-hospital mortality among patients from the highest SES localities (8–10) is higher than that of patients from the middle and lowest SES localities (1–3).

Figure 5. Change in mortality for each one-unit increase in the heat stress index among patients hospitalized with a diagnosis of respiratory diseases



Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Among patients diagnosed in the ED with cardiovascular diseases (regression model results in Appendix Table 7), no increase in in-hospital mortality was observed as heat stress rose. In fact, a negligible decrease of 0.3%–0.5% was observed. The probability of mortality among those aged 65+ is higher than among those aged 60–65, and women's probability is more than 60% higher than that of men. The relationship to SES is also generally negative: the probability of in-hospital mortality is lowest for patients from the highest SES localities and highest for patients from localities whose SES ranking is classified as unknown[11]. In fact, it is 3.2 times higher among the latter than among the former.

The health and economic burden of heat stress

The estimated health and economic burden was defined as excess mortality in weeks characterized by extreme heat stress and the cost of total excess hospitalization days during these weeks due to heat stress.

Number and cost of excess hospitalization days

The cost of excess hospitalization days (EDHC) is equal to the change in hospitalization days attributable to heat stress multiplied by the average weekly number of hospitalized patients in the summer months (AHW), ($\frac{\partial(duration * AHW)}{\partial heat}$), multiplied by the cost per hospitalization day (CoD), and by the 22 summer weeks (HW, heat weeks). The change in length of stay associated with heat stress is calculated using the regression presented in Equation (4) below. Since this study did not examine the change in the number of hospitalized patients due to heat stress, in this calculation we assume that the change in annual hospitalization days stems from the change in average length of stay and from natural population growth. In this case, we can write:

$$(4)\ EDHC = HW * CoD * \frac{\partial duration}{\partial heat} * AHW * \Delta heat$$

11 Unknown socioeconomic ranking, which served as the reference category for comparing the association with socioeconomic ranking in the regressions of heat stress, length of stay, and in-hospital mortality, mainly characterizes the Bedouin population living in unrecognized villages and small rural localities that belong to regional councils. The population living in unrecognized villages is characterized by a low socioeconomic ranking.

The final calculations were carried out for a 10-year period after assuming discount rates of 3% and 7% and an annual growth rate of 4.5% in the older population. The increase in hospitalization days was quantified for increases of 0.5, 1, 1.5, and 2 heat stress units relative to the weekly average during the summer weeks.

The results of these calculations are presented in Table 6. A one-unit increase in heat stress appears to result in about 5,500 excess hospitalization days per year. The 10-year cost, based on a 3% discount rate and a two-unit increase in heat stress, is estimated at about NIS 380 million (confidence interval [hereafter CI]: NIS 325–411 million). From 2014 to 2025, there was an average increase of about two heat stress units in the hottest summer months (July–August).

Table 6. Number of excess hospitalization days due to respiratory diseases or cardiovascular diseases and their 10-year cost, based on a 3% discount rate, for each increase of 0.5, 1, 1.5, and 2 heat stress units relative to the weekly average during the summer weeks

Change in heat stress (in heat stress units)	Average excess hospitalization days each summer associated with an increase in heat stress	10-year cost (NIS) based on a 3% discount rate	10-year cost (NIS) (95% confidence interval)
0.5	2,755 days (≈ 2,435–3073)	89,943,272	79,499,609–100,338,993
1.0	5,553 days (≈ 4,906–6,197)	181,258,196	160,172,357–202,299,405
1.5	8,394 days (≈ 7,414–9,372)	274,001,137	242,010,919–305,934,839
2.0	11,625 days (≈ 9,958–12,594)	379,445,539	325,042,513–411,084,491

Note: With a 7% discount rate, the excess cost of length of stay over 10 years ranges from NIS 68 million for an increase of 0.5 heat stress units above the weekly summer average to NIS 280 million for an increase of two heat stress units.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Although heat stress was found to shorten the length of stay of patients with heart problems, its overall effect on hospitalization days is positive because of its effect on extending the hospitalization of patients with respiratory diseases. The overall burden on Israel's hospitalization system therefore appears to be relatively small, since the estimated annual addition of hospitalization days due to heat stress is negligible relative to the total number of hospitalization days per year in Israel, which stands at about 15 million. Moreover, the shortage of hospital beds in Israel is generally felt during the winter months, when occupancy in some hospitals reaches more than 100%, whereas in the summer it is 10%–15% lower.

Even though these effects are relatively small, it should be remembered that they do not take into account the possibility that the growth in the older population may exceed the growth in hospital bed capacity, or that the increasing frequency and intensity of heat waves will increase demand for hospitalization services.

Calculating excess mortality in hot weeks

To calculate excess mortality, we multiplied the difference between mortality in weeks with extreme heat stress (one standard deviation above the mean = an increase of 2.33 heat stress units, about 2.2 weeks per year) and mortality in an average summer week by the coefficients for the association between heat stress and mortality:

$$AM = WM * \frac{\partial death}{\partial heat} * HW * \Delta Heat$$

where AM is excess mortality, WM is the weekly number of deaths in the ED, $\frac{\partial death}{\partial heat}$ is the rate of change in mortality for each one-unit increase in the heat stress index, HW is the average number of weeks per year with extreme heat stress (2.2), and $\Delta Heat$ is the average difference in heat stress units between a week with extreme heat stress and an average summer week (2.33 units).

This study found that excess mortality due to heat stress among hospitalized patients is small, amounting to fewer than two excess deaths per year, compared with about 40,000–53,000 annual deaths in Israel during the 2010–2023 period. Of course, this misses heat-related deaths outside hospitals. Nonetheless, it suggests an overall successful management of health-related spikes by Israel's formal healthcare system, at least in relation to the respiratory diseases and heart conditions. The question to which we now turn is what is driving that apparently successful management.

Discussion

In our study, we found an association between heat stress and ED visits due to heart disease (an increase of 18%, CI: 7%–30%), respiratory diseases (20%, CI: 13%–27%), and kidney disease (28%, CI: 15%–43%). No association was found between heat stress and ED visits due to stroke or diabetes.[12] Heat stress was found to be associated with a 19%–28% increase in the length of stay of patients with respiratory diseases, but with a small decrease in the length of stay of heart patients (3%). Only a small increase, of about 1%, was found in the length of stay of patients with respiratory diseases due to increased hospital burden; therefore, the longer length of stay in these diseases can be attributed to the interaction between biological factors and heat stress, rather than to a decline in quality of care resulting from the increased burden. A small increase was found in mortality from respiratory diseases and a small decrease in mortality from heart disease.

Heart patients and patients with respiratory diseases respond differently to heat stress

The study findings reveal two notable patterns: (1) the increase in ED visits due to respiratory diseases is slightly greater than the increase in visits due to cardiovascular diseases, mainly because of lung diseases (41%, CI: 24%–59%); (2) among patients with respiratory diseases, a substantial increase in length of stay was observed, whereas among heart patients no increase was observed, but rather a slight decrease. This is likely related to the fundamental difference between respiratory injury mechanisms and cardiovascular injury mechanisms under heat stress. In the respiratory system, heat stress triggers a chain of physiological processes that begin at the moment of exposure and continue

12 Recently published findings of Negev et al. (2026), found an excess of about 30% in stroke cases on hotter days. This difference stems from differences in methodology and in the exposure window. Our study uses weekly temperature averages and compares hotter weeks with less hot weeks, with broader cardiovascular diagnosis codes and a coarser exposure assignment (a heat stress index by natural region), whereas the study by Negev et al. used data from the National Stroke Registry at daily resolution and included patients' residential address data. The weekly averaging in our study smooths the acute same-day heat effect found by Negev et al. (lag 0–1) and "dilutes" it over the entire week, including days on which the risk returns to baseline or even declines (lags 3–4) due to the harvesting effect.

to develop in the days that follow, not necessarily within a few hours: airway irritation, hypersensitivity and bronchoconstriction, breathing difficulties and worsening of asthma and COPD; decline in lung function, respiratory tract inflammation, and increased susceptibility to acute respiratory infections; and worsening of the condition of chronic lung disease patients, sometimes requiring antibiotic treatment, oxygen, and even prolonged intensive care (O'Lenick et al., 2025; Zhu et al., 2025). The patient arrives at the ED after the condition has already worsened, and requires gradual stabilization, monitoring, and ongoing treatment. Respiratory hospitalizations therefore tend to become longer as heat stress increases. In Hong Kong, for example, a clear increase was found in the length of stay of patients with respiratory diseases on especially hot days (Long et al., 2024). A study from Spain showed that in-hospital mortality from respiratory diseases also rises in the summer on especially hot days, increasing by about 16% in Madrid and about 22% in Barcelona when the daily temperature is at the 99th percentile relative to the mortality-optimal temperature (Achebak et al., 2023).

The effect of heat stress on the cardiovascular system is fundamentally different and is characterized by an immediate and dramatic response to heat stress, including life-threatening cardiac events within only a few hours of exposure. The direct mechanisms include an increase in cardiac output and heart rate, a decline in blood pressure, and hypovolemia. These effects may lead to especially fatal acute events that occur outside the hospital (Chaseling et al., 2025). As early as 2004, a study on heat waves and ED visits in London found that during heat waves, the overall increase in mortality was considerably greater than the increase in ED visits (Kovats et al., 2004). An Israeli study found an association between heat stress and excess mortality from myocardial infarction outside the hospital (Kranc et al., 2021). A 2022 meta-analysis also found that the association between heat stress and hospitalizations for heart disease is weaker than the association between heat stress and overall mortality from heart disease, both during hospitalization and outside the hospital (Liu et al., 2022). Exposure to heat stress may also bring forward mortality among the most vulnerable heart patients, a phenomenon referred to in the scientific literature as the "harvesting effect" (Zhen et al., 2015). It is possible that the heart patients who reach hospitals are the less severe cases, and therefore their average length of stay is slightly shorter and mortality is slightly lower.

The effect of burden on the healthcare system on health outcomes during heat stress

Another explanation for the possibility of increased mortality outside the hospital, and for the absence of an association with increased in-hospital mortality, is that during periods of high heat stress hospitals manage the burden through accelerated discharge of patients. A study from Mexico found that as temperatures rise, ED visits increase; the share of ED patients who are admitted declines, while the share discharged rises; and the rate of deaths outside hospitals increases faster than the rate of deaths inside hospitals (Aguilar-Gomez et al., 2025).[13] The same study also found excess mortality among hospitalized patients who had been admitted before the heat wave and argued that the cause of in-hospital mortality may not be the heat itself but rather the patient burden. Similar to the findings of our study, the increase in mortality during heat stress was very small and was observed only for respiratory diseases, whereas for heart disease, a small decrease was even observed.

Vulnerable populations and geographic differences

Our study found that the increase in ED visits is higher in localities with a high SES ranking than in localities with low and medium SES rankings, and in the central region and Jerusalem than in the northern and southern regions. This finding contrasts with findings reported in some of the international literature, according to which weaker populations actually seek medical care at higher rates during heat stress than stronger populations (Gronlund, 2014; PoshtMashhadi et al., 2025; Schwarz et al., 2021).

The high rate of ED visits due to respiratory diseases among populations in high SES areas may be related to these populations' prolonged stay in closed, air-conditioned spaces. Staying in air-conditioned spaces may increase exposure to cold, allergens, and pollutants in the indoor environment and exacerbate respiratory diseases (D'Amato et al., 2018). Studies show that working and staying in air-conditioned buildings are associated with higher rates of chronic cough, sinusitis symptoms, and respiratory symptoms compared with working and staying in naturally ventilated buildings (Graudenz et al., 2005).

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13 For details on the findings of this illuminating study, see the VoxEU website.

Use of air conditioning at low temperatures at night may cause airway hyperresponsiveness and worsen asthma symptoms and chronic lung diseases among vulnerable populations. In addition, geographic proximity to hospitals in the central region may encourage patients from more affluent populations to go to the ED when symptoms appear, whereas patients from peripheral areas and low socioeconomic backgrounds may avoid going to the ED and rely instead on home care. Lower length of stay found among affluent populations compared to less affluent populations may strengthen this possibility.

Another possible factor is the degree of adaptation to heat stress. Long-term exposure to air-conditioned environments may weaken thermal adaptation capacity (Yu et al., 2012). It is possible that stronger populations, who spend most of their time in air-conditioned spaces, are less acclimatized to extreme heat and may therefore develop adverse health effects even after a relatively short stay outdoors, whereas weaker populations, who are more exposed to the outdoor environment, show greater resilience. Finally, there is evidence that in affluent and dense urban areas, mortality due to heat stress is higher than in affluent but less dense areas, since heat exposure in urban environments is greater because of the formation of urban heat islands (Paniello-Castillo et al., 2026).

From the geographic perspective, there are several possible explanations for the excess ED visits in the central region, which is more densely populated, compared with the northern and southern regions. One is that dense urban areas are characterized by extensive asphalt and concrete cover, which absorb solar radiation during the day and release it as heat throughout the night. As a result, nighttime temperatures are high and the body has difficulty "recovering" from daytime heat without artificial cooling. A study conducted in California showed that during heat waves, heat stress in dense urban areas, where urban heat islands tend to form, is greater than in urban suburbs characterized by less dense construction (Taha, 2017). Another explanation is that dense urban centers are also characterized by high traffic-related air pollution, which is known to exacerbate respiratory diseases.

Overall, our findings may reflect a combination of different exposure profiles (urban heat islands, air pollution, and prolonged stays in closed indoor spaces), patterns of access to and use of healthcare services, and a healthcare system in which the traditional effect of socioeconomic differences may be more limited, while geographic and cultural gaps in access and use still remain.

Adaptation?

Our analysis of the subperiods shows that ED visits during weeks of heat stress in 2018–2023 were somewhat fewer than in 2010–2017. This finding may point to improved adaptation to heat stress at the population level, for example due to an increase in the share of households with air conditioning, or to effective adaptation policy, such as Ministry of Health warnings ahead of heat waves and guidance on appropriate behavior under such conditions. However, these explanations need to be tempered by other recent findings in the literature, in particular studies showing that rising life expectancy is disguising some of heat-related excess mortality (Huber et al., 2025; Vicedo-Cabrera et al., 2021). Systematic reviews point to associations between certain adaptation measures and reduced heat-related mortality, but more specific information is needed in order to reduce morbidity (Das et al., 2025).

Study limitations and strengths

Some limitations of this study need to be acknowledged. The study period, 2010–2023, does not include the first two decades of major increases in average temperature (Figure 1 above). The analytic focus is only on respiratory diseases and cardiovascular diseases and limited to the older population. The absence of a hospital identifier in the data prevented a deeper understanding of the burden in specific medical centers and areas. Finally, heat stress was measured at the weekly level, which reduces the identification of short-term spikes.

On the other hand, the study has distinct strengths. It is based on comprehensive individual-level administrative databases that include detailed information on diagnoses of heat-sensitive chronic diseases, including cardiovascular diseases, respiratory diseases, kidney diseases, and diabetes, as well as demographic and socioeconomic indicators, air pollution measures, and heat stress measures. There is careful delineation of climate zones. In addition, the two-stage analytic approach distinguishes the effect of heat stress on ED visits from subsequent effects on length of hospitalization and mortality, while also allowing us to infer the effects of heat on system burden and possible harm to quality of care. Finally, adding direct estimates of the economic burden of extra hospitalization makes the results relevant for health policy planning and system preparedness.

Summary and policy recommendations

Like its counterparts in many countries around the world, Israel's healthcare system is contending with the health effects of climate change. This study shows that even in a high-income country accustomed to heat stress, as is the case in Israel, there are notable effects on older adults and patients with chronic diseases. The study's findings indicate an increase in emergency department visits and in the duration of hospitalization during the summer period, primarily among patients suffering from respiratory diseases, but also among patients with heart and kidney diseases. Furthermore, it was found that the increase was approximately 20% higher among affluent populations compared to economically weaker populations, and also higher in the Central and Jerusalem regions compared to the North and South. It is important to continue researching these gaps and their origins, and to guide health authorities accordingly. Additionally, although we did not address this directly in this study, it is important to investigate the impact of urban heat islands on the health of residents in Israel and to act to mitigate heat loads, especially in areas where weaker populations reside.

In terms of mortality, while our findings point to only a minor increase in the death rate during weeks of heat stress, this refers only to patients who passed away within hospitals; other studies conducted in Israel and around the world, which have included out-of-hospital mortality, find significant excess mortality during heatwaves, particularly from cardiac events (Kranc et al., 2021). This suggests that during weeks of exceptional heat stress, health services should increase their preparedness, and community medicine activities — part of the current effort to strengthen the medical services network provided outside of hospitals — should be focused more on preventing heat-related effects.

Our study is also conservative in a few ways. We have not addressed direct injuries from heat stress, such as dehydration and heatstroke. Nor have we considered the impact of heat stress on pregnant women, though it is known to increase the risk of preterm birth, and consequently, low birth weight — this seems particularly important given Israel's unusually high fertility rate. Nor have we considered the impact on mental health issues, though other research points to a significant uptick in mental health-related admissions and psychiatric emergencies during prolonged heat events (Basagaña et al., 2021; Bekkar et al., 2020; Nori-Sarma et al., 2022). Any preparation for the health impacts of heat stress should anticipate effects on these measures, too.

Finally, the absence of a hospital identifier has prevented us from tracking effects of heat stress across specific medical centers: it is crucial to obtain this information in order to provide tailored responses, whether for the specific medical conditions covered here, or those that we did not address.

According to the World Health Organization, a resilient health system is one that anticipates risks, prepares, responds, recovers, and adapts, while at the same time reducing its contribution to the climate crisis. The Israeli healthcare system, accustomed to functioning in emergency situations, is applying those skills to extreme climate events. The Ministry of Health has a climate change preparedness plan and has allocated dedicated personnel for this purpose. Work is being conducted on reducing emissions, developing healthy and sustainable institutional nutrition, and preparing staff for emergency climate-related events in general. Now, the central challenge is to ensure that these plans are translated into operational action on the ground. Alongside existing achievements, there is a need to expand control and monitoring mechanisms at the hospital level, implement dedicated early warning systems for healthcare institutions, and formulate standard requirements for resilient infrastructure. Concurrently, there is a need to develop climate-adapted community services, including the deployment of mobile clinics in peripheral areas. In order for us to cope with climate change in an optimal manner, it is essential to invest resources in advancing these strategic plans and bringing them to fruition.

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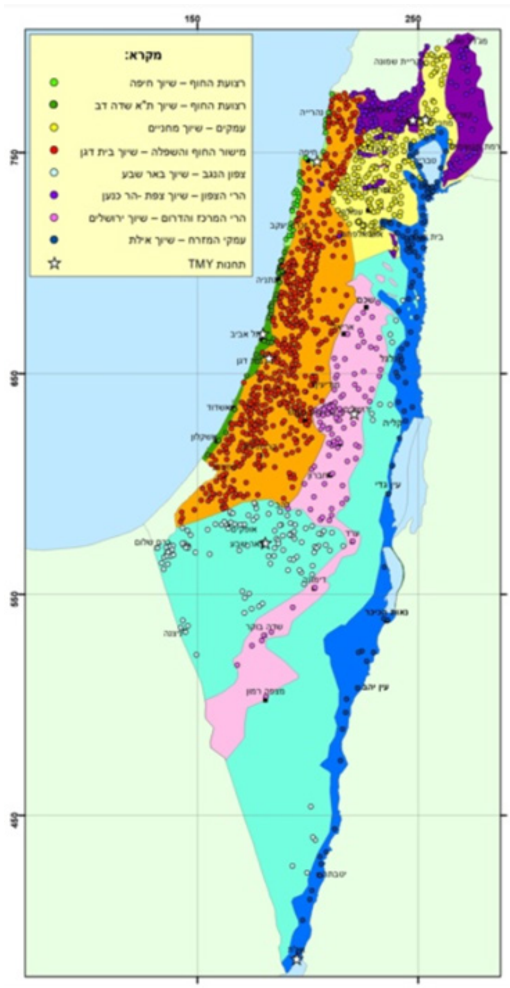
Appendix

Appendix Illustration 1. Climate regions in Israel



Source: Israel Meteorological Service

Appendix Table 1. Diseases included in the study by International Classification of Diseases, Ninth Revision (ICD-9) code

Diseases included	ICD code
Disorders of the kidney: nephritis, nephrotic Syndrome, and nephrosis; acute kidney injury — 584, infections of the kidney, hydronephrosis, calculus of kidney and ureter (kidney stone), other disorders of kidney and ureter	
All circulatory system diseases	390–459
Hypertension	401–405
Ischemic heart disease	410–414
Dysrhythmia	427
Congestive heart failure	428
Ischemic stroke	433–437
All respiratory system diseases	460–519
Pneumonia	480–486
Chronic obstructive pulmonary disease	491, 492, 496
Asthma/wheeze	493 or 786.07
Diabetes	249–250

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center

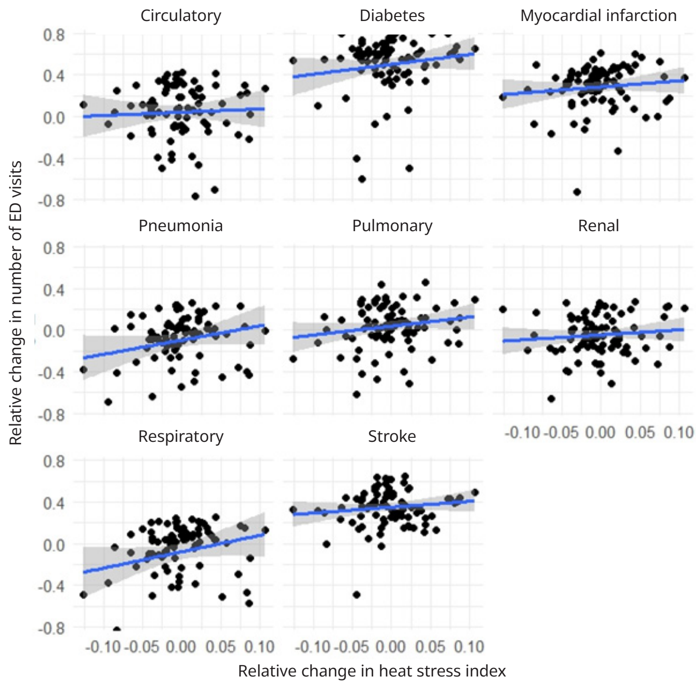
Appendix Table 2. Mean (standard deviation) weekly ED visits, by diagnosis (primary and secondary) and sex

Disease	Full sample	Women	Men
Kidney diseases	87.2 (23.8)	37.2 (11.1)	50.0 (14.6)
Cardiovascular diseases	157.7 (62.3)	88.4 (36.2)	69.3 (27.6)
Heart diseases	44.8 (20.4)	19.0 (9.9)	25.8 (11.7)
Stroke	35.5 (15.8)	17.4 (8.2)	18.1 (8.7)
Respiratory diseases	414.9 (105.7)	205.4 (55.6)	209.5 (52.4)
Respiratory infections	233.0 (65.3)	111.6 (33.4)	121.4 (34.1)
Lung diseases	73.2 (23.7)	28.9 (10.6)	44.3 (14.7)
Diabetes	22.3 (16.5)	11.4 (8.5)	10.9 (8.8)

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Ministry of Health

Appendix Figure 1 describes the association between the relative change in the heat stress index in each locality (horizontal axis) and the relative change in the number of ED visits by diagnosis in each locality. The changes are relative to the multi-year average of visits in the same week and under the same heat stress level.

Appendix Figure 1. Correlation between the heat stress index and the relative change (by week and locality) in ED visits, by disease



Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Appendix Table 3. Regression model results: The association between heat stress and ED visits

	Respiratory diseases			Cardiovascular diseases			Other	
Diagnosis	Lung diseases	Lung infections	All respiratory diseases	Stroke	Heart diseases	All cardiovascular diseases	Kidney diseases	Diabetes
Heat stress (Yes = 1)	0.340***	0.154***	0.183***	0.118	0.240**	0.165**	0.248***	0.109
	(0.063)	(0.040)	(0.030)	(0.084)	(0.079)	(0.050)	(0.060)	(0.110)
Air pollution PM2.5	-0.007**	0.000**	-0.004**	0.003	-0.004	-0.001	0.002***	-0.002
	(0.003)	(0)	(0.001)	(0.004)	(0.004)	(0.002)	(0)	(0.005)
Age 60–64	2.767	6.906***	-5.338***	-2.178	0.758	-6.633**	12.129***	-4.232
	(2.55)	(0.219)	(1.139)	(3.482)	(3.239)	(2.029)	(0.332)	(4.547)
Age 65–69	0.676	12.434***	5.780***	-0.551	2.358	8.312***	10.144***	0.284
	(3.12)	(0.267)	(1.397)	(4.27)	(3.964)	(2.485)	(0.4)	(5.556)
Age70–74	9.457**	-8.518***	-4.643***	-10.772**	7.211*	-0.202	4.272***	-4.303
	(3.115)	(0.249)	(1.395)	(4.269)	(3.964)	(2.487)	(0.371)	(5.551)
Age 75+	3.398**	8.222***	10.022***	9.139***	9.177***	7.579***	2.631***	2.848
	(1.421)	(0.088)	(0.635)	(1.937)	(1.806)	(1.133)	(0.133)	(2.53)
SES fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year, week fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table presents results from negative binomial regressions measuring the association between heat stress, defined as one standard deviation above the mean summer heat stress index at the weekly level, and ED visits. The data were taken from 38 cities in Israel over 13 years (2010–2023) during the summer season (weeks 19–38). The dependent variables are the weekly sum of ED visits for each medical condition, defined by primary or secondary ICD-9 diagnosis. All specifications include year, week, and metropolitan-area fixed effects. Observations are clustered at the subdistrict level.

Significance levels: *p < 0.10; **p < 0.05; ***p < 0.01.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Appendix Table 4. Poisson regression results: Length of stay of patients with respiratory diseases

Variable	Coefficient	Standard error	Significance level
Age *(Reference category: 60–65)*			
65–70	0.212	0.008	<0.01
70–75	0.265	0.008	<0.01
75–90	0.327	0.006	<0.01
90+	0.455		<0.01
Sex *(Reference category: male)*			
Female	0.054	0.007	<0.01
SES *(Reference category: Unknown)*			
1–3	0.000	0.007	
4–7	0.006	0.006	
8–10	-0.157	0.008	<0.01
ED admission *(Reference category: selective)*			
Urgent	0.861	0.008	<0.01
Heat stress index *(for every increase of 1°C)*	0.041	0.002	<0.01
PM2.5 (*for every increase of 1 microgram/µm*)	0.005	0.002	<0.10
Relative change in ED visits	0.001	0.000	<0.01
60–65 × Female	0.076	0.013	<0.01
65–70 × Female	-0.129	0.011	<0.01
70–75 × Female	-0.008	0.011	
75–90 × Female	0.075	0.008	<0.01
PM2.5 × Heat stress index	0.000	0.000	<0.01

Model statistics	
Dependent variable	Days
Fixed effects, weekly	Yes
Fixed effects, yearly	Yes
Number of observations	299,703
BIC	1,683,873.80

Notes: For patients hospitalized for up to 21 days.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Appendix Table 5. Poisson regression results: Length of stay of patients with cardiovascular diseases

Variable	Coefficient	Standard error	p value
Age ***(Reference category: age 60–65)***			
65–70	0.069	0.001	<0.01
70–75	0.093	0.001	<0.01
75–90	0.206	0.009	<0.01
Sex ***(Reference category: male)***			
Female	0.073	0.007	<0.01
SES ***(Reference category: unknown)***			
1–3	0.050	0.005	<0.01
4–7	0.178	0.004	<0.01
8–10	0.141	0.005	<0.01
ED admission ***(Reference category: selective)***			
Urgent	0.436	0.003	<0.01
Heat stress index *(for every increase of 1°C)*	-0.009	0.001	<0.01
PM2.5 (*for every increase of 1 microgram/μm*)	-0.005	0.001	<0.01
Relative change in ED visits	-0.001	0.000	<0.01
60–65 × Female	-0.120	0.0100	<0.01
65–70 × Female	-0.097	0.0100	<0.01
70–75 × Female	-0.185	0.0090	<0.01
75–90 × Female	0.000	unknown	
PM2.5 × Heat stress index	0.000	0.000	< 0.10
Model statistics			
Fixed effects, weekly	Yes		
Fixed effects, yearly	Yes		
Number of observations	583,549		
BIC	3,174,094.6		

Note: For patients hospitalized up to 21 days.

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Appendix Table 6. Logistic regression results: The association between heat stress and in-hospital mortality among patients with respiratory diseases

Variable	Coefficient (log RR)	Standard error	p value
Intercept	-6.69	0.25	<0.01
Age ***(Reference category: age 60–65)***			
65–70	-0.65	0.03	<0.01
70–75	0.57	0.02	<0.01
75–90	0.79	0.02	<0.01
Sex ***(Reference category: male)***			
Female	-0.32	0.03	<0.01
ED admission ***(Reference category: selective)***			
Urgent	0.97	0.04	<0.01
SES ***(Reference category: 1–3)***			
4–7	-0.14	0.04	<0.01
8–10	0.15	0.04	<0.01
Unknown	0.18	0.03	<0.01
Heat stress index *(for every increase of 1°C)*	0.19	0.01	<0.01
PM2.5 (*for every increase of 1 microgram/μm*)	0.17	0.01	<0.01
Respiratory ED visits	0.00	0.00	<0.01
Heat stress index × PM2.5	-0.01	0.00	<0.01
Model statistics			
Fixed effects, weekly	Yes	—	—
Fixed effects, yearly	Yes	—	—

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health

Appendix Table 7. Poisson regression results: The association between heat stress and in-hospital mortality among patients with respiratory diseases

Variable	Coefficient (log RR)	Standard error	p value
Intercept	-10.21	0.27	<0.01
Age ***(Reference category: age 60–65)***			
65–70	-0.15	0.03	<0.01
70–75	-1.31	0.03	<0.01
75–90	-0.70	0.03	<0.01
Sex ***(Reference category: male)***			
Female	0.50	0.03	<0.01
ED admission ***(Reference category: selective)***			
Urgent	3.49	0.11	<0.01
SES ***(Reference category: unknown)***			
1–3	-0.92	0.02	<0.01
4–7	-0.48	0.02	<0.01
8–10	-1.16	0.03	<0.01
Heat stress index *(for every increase of 1°C)*	0.13	0.01	<0.01
PM2.5 (*for every increase of 1 microgram/μm*)	0.24	0.01	<0.01
Relative change in ED visits	0.00	0.00	<0.01
Heat stress index × PM2.5 (*for every increase of 1 microgram/μm*)	-0.01	0.00	<0.01
Model statistics			
Fixed effects, weekly	Yes		
Fixed effects, yearly	Yes		

Source: Siman-Tov, Weinreb, Rogozovsky, and Sadeh, Taub Center | Data: Israel Meteorological Service; TIMNA, Ministry of Health