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Original

Climatic Parameters and Outdoor Workers Safety and Health: A Case Study of Sabzevar City (2011-2017)

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Abstract

Background: Climate change and global warming present a significant threat to outdoor workers. Climatic parameters change has increased the risk of outdoor workers' safety and health. The objective of this paper was to examine the hypothesis of an association between six years data of climatic parameters and outdoor workers' safety and health. **Methods**: A variety of approaches have been produced to assess and measure workers' occupational heat exposure and the risk of heat-related disorders. In this study, maximum, mean, and minimum daily temperatures were used in the heat wave models to compare the sensitivity of predictions according to different climatic parameters in the case study of Sabzevar, settled in the north east of Iran, Khorasan Razavi Province. In this perusal, we used a 6-year data (from March 2011 to June 2017) on medical attendance because of outdoor workers disorders and also daily values of different climatically parameters to investigate the hypothesis of an association between heat indices and outdoor workers disorders. **Results**: Mean temperature in the case study period was 18.95(0.21) °C. The minimum and maximum recorded temperature in the perusal period was -11.2 °C and 45.4 °C, respectively. The highest and lowest number of outdoor workers disorders was observed for the 11th (max daily air temperature > 35°C for ≥ 1 day) and 4th (mean daily air temperature > 99th percentile for ≥ 2 sequential days) definition of the heat wave in 16 definitions (17.75(4.80) and 0, respectively). **Conclusion**: This study found that extreme temperature was associated with outdoor worker disorders in Sabzevar. Research into the future likelihood, existence and magnitude of safety and health consequences of global warming and climate change represent an important input to national policy debates.

Keywords: Climate parameters; Global warming; Outdoor workers; Health

Introduction

Workers in many occupational categories already experience climate- hazards in their jobs. Many occupations require employees to be outdoors for at least part of the time. Increased temperature threats will impact many groups of workers. Because of financial pressures and work requirements in Sabzevar city with a young population, many workers may not be able to avoid these threats. The NIOSH (National Institute for Occupational Safety and Health) appraisals that up to 10 million workers in the USA are exposed to a hot working situation, including

high air temperatures and radiant heat sources.[1] High air temperatures are associated with an estimated

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5.3% reduction in outdoor manual labor productivity worldwide.[2] Since 1906, the mean temperature has increased by 0.74 °C, and this trend is predicted to intensify during the next decades.[3] As climate change and global warming continues, extreme heat events are increasing globally, which is closely associated with human safety, health and activity. The climate varies from place to place, and it has a direct impact on one's activities in society. Climate change and Global warming endangered life humans. The impending weather-related experience and change of the heat wave in Europe area in 2003, which terminated in an increase of about 44,000 deaths in the summer, has led more papers to focus on heat indices and its harmful effects.[4]

New continent models also predict that mean world air temperatures over the range of 1.4–5.8 °C will increase in this century. Weather-related change is rapidly increasing, and these changes are causing extreme phenomena, including floods, storms, heat waves, frosts, and more. The incidence and intensity of heat waves have been increasing in recent years.[5] New definitions for heat wave are defined mathematically. Deviations from daily mean temperature,[6] temperature rise with decreasing rainfall,[7] and several days of summer with temperatures above 30 °C[8] are examples of these definitions. Despite the importance of climate change and its adverse safety effects on human beings, unfortunately, there are a few researches from the viewpoint of occupational health and safety of workers in outdoor workplaces. In this paper, a 6-year data (from March 2011 to June 2017) was used on medical attendance because of outdoor workers disorders and also daily values of different climatically parameters to investigate the hypothesis of an association between heat indices and outdoor workers disorders.

Method

Sabzevar is located in the northeastern Islamic Republic of Iran, with a habitant population of 231,557, according to the latest census. Sabzevar is located in the arid and very hot region (coordinates: 36°13′N 57°41′ E, elevation: 977.6 m) with an arid climate (BWh) according to the Köppen climate classification with four distinct seasons.[9] Figure1 shows the position of the study area (Sabzevar) in I.R. Iran.

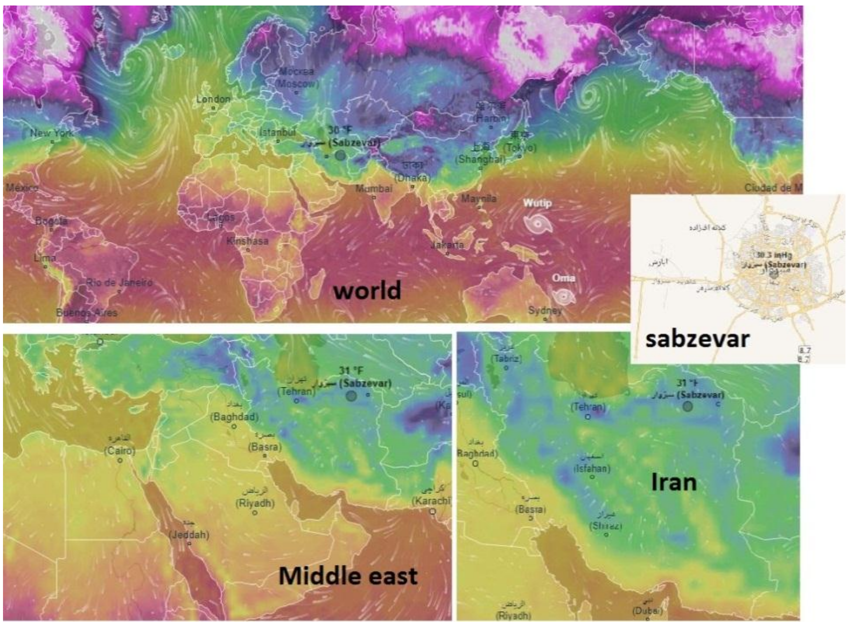

Figure 1. Location of Sabzevar in Iran [10]

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Table 1. Heat wave definition[11]

Code	Heat wave definition
H01	daily mean air temperature > 95th percentile for ≥ 2 sequential days
H02	daily mean air temperature > 90th percentile for ≥ 2 sequential days
H03	daily mean air temperature > 98th percentile for ≥ 2 sequential days
H04	daily mean air temperature > 99th percentile for ≥ 2 sequential days
H05	daily Minimum air temperature > 95th percentile for ≥ 2 sequential days
H06	daily Maximum air temperature > 95th percentile for ≥ 2 sequential days
H07	daily Maximum air temperature ≥ 81st percentile every day, ≥ 97.5th percentile for ≥ 3 non sequential days, and sequential day average ≥ 97.5th percentile
H08	daily Maximum apparent temperature (AT) > 85th percentile for ≥ 1 day
H09	daily Maximum AT > 90th percentile for ≥ 1 day
H10	daily Maximum AT > 95th percentile for ≥ 1 day
H11	daily Maximum air temperature > 35°C (95°F) for ≥ 1 day
H12	daily Minimum air temperature > 26.7°C (80.1°F) or daily max air temperature > 40.6°C (105.1°F) for ≥ 2 sequential days
H13	daily Maximum HI* > 80°F for ≥ 1 day
H14	daily Maximum HI > 90°F for ≥ 1 day
H15	daily Maximum HI > 105°F for ≥ 1 day
H16	daily Maximum HI > 130°F for ≥ 1 day

*Heat index is a subordinate of temperature and relative humidity, parameterized to take account of other environmental factors.

Sabzevar is not an industrial city. There are few factories and industrial units in Sabzevar. Most people in the city have a job in animal husbandry and agriculture. People appropriate to their jobs are exposed to direct sunlight and weather parameters. Sabzevar city has experienced considerable changes in weather and climate over the past years. In this case study, a 6-year data (from March 2011 to June 2017) was used on medical attendance because of outdoor workers disorders and also daily values of different climatically parameters to investigate the hypothesis of an association between heat indices and outdoor workers disorders.

Meteorological and climatically data including daily maximum, mean (average of 24-hour temperature), and minimum temperature (°C) were prepared from records of the Sabzevar meteorological synoptic station (coordinates: 36°12′ 27″ N 57°38′ 55″ E). The outdoor workers' disorders data in Sabzevar were prepared according to the HIS data (health information system) from March 2011 to June 2017. All records in this study were coded according to the ICD-10 (International Classification of the Diseases 10th version). The outdoor workers' disorders in this study were physical hazards to outdoor workers, including extreme heat, extreme cold, and sun exposure. Extreme heat can cause heatstroke, heat cramps, heat rash, heat exhaustion and other problems. Extreme cold can cause frostbite, hypothermia and other problems. In this study, 16 definitions of heat wave were used to explain climate change effect [5]. Table 1 shows this definition. All analyses were managed using the R software (version 3.3.0). The paper was approved by the Ethics Committee (approval number: IR.SSU.SPH.REC.1396.121) of the Shahid Sadoughi University of Medical Sciences.

Results

The mean air temperature in the research period was 18.95(0.21) °C. The maximum and minimum recorded air temperature in the research period was 45.4 °C and -11.2 °C, respectively. In total, 12,136 medical attendances due to outdoor workers disorders were noted in Sabzevar city during the research period. In this study, minimum mean temperature was recorded in January (5.92(3.54) °C), and the maximum mean temperature was found in July (31.82(2.25) °C). Maximum and minimum mean relative humidity in this study was 2017 (41.35(19.53) %) and 2011 (34.73(20.14) %), respectively. The maximum

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mean velocity in the research period was in June (11.94(3.52) m/s), and the minimum mean velocity was in December (7.59(2.93) m/s). Table 2 shows Descriptive statistics on the temperature and relative humidity (2011-2017) in different month and year.

Table 2. Descriptive statistics on the temperature and relative humidity (2011-2017)

Variable		Temperature (°C)		Relative Humidity (%)		
		Average Maximum temperature (Mean (SD))	Average Minimum temperature (Mean(SD))	Average Maximum RH (Mean(SD))	Average Minimum RH (Mean(SD))	Average Mean RH (Mean(SD))
Year	2011	28.24(10.73)	15.06(9.01)	50.11(24.58)	19.35(17.55)	34.73(20.14)
	2012	24.08(11.29)	11.44(9.49)	55.00(25.31)	23.92(17.53)	39.46(20.73)
	2013	25.77(10.64)	12.44(9.42)	52.82(23.10)	20.20(14.04)	36.51(17.72)
	2014	25.01(11.45)	12.04(9.64)	53.16(26.11)	21.07(16.15)	37.12(20.06)
	2015	25.59(10.82)	12.71(9.10)	52.99(23.83)	22.34(15.53)	37.66(19.05)
	2016	26.02(10.26)	12.68(8.95)	53.53(22.29)	18.62(12.15)	36.08(16.36)
	2017	22.73(10.86)	10.03(9.15)	62.23(21.93)	22.82(17.40)	41.35(19.53)
Month	January	11.42(4.32)	0.41(3.37)	75.06(15.28)	34.35(13.48)	54.71(13.24)
	February	13.11(5.72)	1.87(4.57)	71.56(16.46)	33.71(16.54)	52.63(15.63)
	March	18.64(5.16)	6.47(4.41)	70.23(16.58)	28.40(13.41)	49.31(13.16)
	April	26.19(4.96)	12.01(3.89)	60.50(19.49)	19.11(11.84)	39.66(14.65)
	May	32.69(3.62)	18.26(3.10)	50.18(19.07)	13.76(7.97)	31.43(12.83)
	June	37.24(3.02)	22.94(2.85)	33.22(14.06)	9.35(5.44)	21.02(9.10)
	July	38.67(2.56)	24.97(2.40)	27.79(10.20)	9.12(3.95)	18.45(6.56)
	August	37.03(2.73)	22.34(2.60)	27.23(10.35)	9.16(4.96)	18.20(7.22)
	September	33.80(3.20)	19.09(2.65)	34.95(13.46)	10.69(5.48)	22.82(8.92)
	October	26.19(4.88)	12.42(3.84)	49.52(17.84)	18.32(10.97)	33.92(13.56)
	November	16.18(5.27)	5.28(3.83)	70.88(18.32)	33.88(18.03)	52.38(17.13)
	December	11.48(4.18)	0.90(3.54)	75.62(16.66)	36.75(16.56)	56.18(15.57)

Table 3. Summary of data on the daily number of outdoor workers disorders and heat wave indices during 2011-2017

Code	Heat wave definition	Number of days in the definition	Number of outdoor workers disorders (Mean (SD))
H01	daily Mean air temperature > 95th percentile for ≥ 2 sequential days	19	15.21(3.20)
H02	daily Mean air temperature > 90th percentile for ≥ 2 sequential days	74	15.79(4.33)
H03	daily Mean air temperature > 98th percentile for ≥ 2 sequential days	4	11.25(2.51)
H04	daily Mean air temperature > 99th percentile for ≥ 2 sequential days	0	-
H05	daily Minimum air temperature > 95th percentile for ≥ 2 sequential days	12	15.83(3.88)
H06	daily Maximum air temperature > 95th percentile for ≥ 2 sequential days	4	17.75(4.80)
H07	daily Maximum air temperature ≥ 81st percentile every day, ≥ 97.5th percentile for ≥ 3 consequential days, and sequential day average ≥ 97.5th percentile	4	11.25(2.88)
H08	daily Maximum AT > 85th percentile for ≥ 1 day	16	15.75(3.40)
H09	daily Maximum AT > 90th percentile for ≥ 1 day	11	14.90(4.12)
H10	daily Maximum AT > 95th percentile for ≥ 1 day	4	11.25(2.79)
H11	daily Maximum air temperature > 35°C (95°F) for ≥ 1 day	625	13.90(3.55)
H12	daily Minimum air temperature > 26.7°C (80.1°F) or daily maximum air temperature > 40.6°C (105.1°F) for ≥ 2 sequential days	37	16.83(4.41)
H13	daily Maximum HI* > 80°F for ≥ 1 day	84	15.92(4.27)
H14	daily Maximum HI > 90°F for ≥ 1 day	60	16.90(4.19)
H15	daily Maximum HI > 105°F for ≥ 1 day	19	15.73(4.80)
H16	daily Maximum HI > 130°F for ≥ 1 day	12	15.91(4.61)

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Depending on the version of heat wave, between zero (04 heat wave definitions) to 625 days (11 heat wave definition) with heat wave were recorded during the research period in Sabzevar city. The average daily number of outdoor workers disorders in most of the heat wave definitions were significantly higher than non-heat wave days (Table 3). The highest and lowest number of the heat wave days was observed for the 11th (daily maximum air temperature > 35°C for ≥ 1 day) and 4th (mean daily air temperature > 99th percentile for ≥ 2 sequential days) definition of the heat wave in 16 definitions. The highest daily number of outdoor workers disorders was observed in the conditions that the maximum daily temperature was higher than the 95th percentile for ≥ 2 sequential days (17.75(4.80)).

Discussion

This paper reported precise evidence from Sabzevar on the relationship between heat indices and outdoor workers' health and safety. The highest daily number of outdoor workers disorders was observed in the conditions that the maximum daily temperature was higher than the 95th percentile for ≥ 2 sequential days (17.75(4.80)) in 4 days. The resultant risks to health and safety are anticipated to compound over time as global warming and climate change along with other large scales social and environmental changes continues.[12] There are many studies on climate change and global warming. These researches have begun to focus on the effect of extreme heat on hospital admissions and emergency room visits for various kinds of patients, including respiratory and cardiovascular diseases.[13, 14] It was observed that heat stress is an occupational and environmental hazard. Exposed workers may suffer heat-related illness, reduced productivity and increased injuries. This result is consistent with the results of the previous studies.[15]

Many studies were conducted in Europe with a moderate area and low studies conducted in an arid and warm area. Sabzevar is located in an arid and very hot region. A cohort study in Sweden showed that employment in outdoor works was associated with elevated rates of cerebrovascular disease mortality. The rate ratio estimate for outdoor environment work ≥25 years compared with 0–4 years was 3.45 (95 % CI 1.55–7.65; 11 deaths: ≥25 years).[16] HWIs are defined using air temperatures alone or air temperatures with other climatically data, such as relative humidity, rainfall and wind speed, that must be transgressed for a specified period, ranging from one to several sequential days.[17] Although the maximum of the reviewed papers reported an increase of disorders and accidents during increased air temperatures, several methodological limitations preclude definite statements on the relationship between outdoor workers disorders and heat waves. All reviewed studies used routinely prepared data to measure the outcome or databases set up to record occupational health and safety outcomes.[18]

In this study, it was observed that the exceptional nature of the heat wave in terms of the high temperatures and the duration of the heat wave combined in some way to produce the strong observed effect. One of the specifications of heat waves was the lack of evidence of substantial short-term disorders displacement. The finding appears to be a unique characteristic of the France heat wave. The summer of 2003 was determined by exceptionally warm weather in France with the average temperature exceeding that of any previous summer over the last 500 years.[19] Depending on the definition of heat wave, between zero (definition: daily mean air temperature > 99th percentile for ≥ 2 sequential days) to 625 days (definition: daily maximum air temperature > 35°C for ≥ 1 day) with heat wave were recorded during the study period. Different definitions for heat wave have been used in recent researches. Bell and Anderson reported that comparing the 90th and 99th percentile temperatures for the community in the USA, heat-related mortality was most associated with a shorter lag, with an average increase of 3.0% in mortality risk.[20] Different heat waves definitions resulted in significant differences in associations between disorders and heat waves. Heat waves defined as ≥ 4 sequential days with daily average air temperature > 98th percentile had the best model fit and were associated with an increase of 24.6% (95% CI: 15.6%, 34.3%) total mortality, 32.0% (95% CI: 8.5%, 60.5%) respiratory mortality, 46.9% (95% CI: 33.0%, 62.3%) cardiovascular mortality, 63.4% (95% CI: 41.5%, 88.8%) ischemic heart disease mortality, 51.3% (95% CI: 23.4%, 85.6%) stroke mortality and 47.6% (95% CI: 14.5%, 90.3%) chronic obstructive pulmonary disease mortality at lag day 2.[21]

To decrease the consequences of future heat waves, identifying the mechanisms of heat waves, developing their meteorological systems, forecasting and discovering ways to reduce the effects of heat waves on the general health and the identification of harmful areas are essential.[22] Modern epidemiology studies have focused on risk factors for non-communicable diseases in humans, not populations. Meanwhile, there have been occasional researches examining deaths due to heat waves, preterm births, cardiovascular disease, and hospital admission. Overall, the health and safety risks of climate-related heat stress have been the most amenable to epidemiological studies. Previous physiological studies show that high air temperatures, as well as increased relative humidity, heighten the risk of thermal diseases.[23, 24] However, findings in this research suggest that HWIs including relative humidity and other climatically data may not be more predictive of adverse thermal-related health and safety effects, which is consistent with the previous studies.[25] Despite its uniqueness because of the span of days considered in this study, several limitations should be highlighted. First, improved housing HVAC can reduce the influence of outdoor air temperature and unfavorable climate and weather. Second, in this paper, investigate the effects on individual characteristics and sensitive subgroups, including gender, age, cultural conditions, race, and socioeconomic variables, were not investigated. The results of this study complement the results of other similar researches on the effects of heat indices and climate change on preterm births and cardiovascular diseases.[10, 11]

Conclusion

It was observed that thermal stress or heat stress is an occupational and environmental hazard. Exposed workers may suffer thermal-related illness, increased injuries, disease intensification and reduced productivity. In estimating the safety and health effects of climate parameters, the proper indicator should be selected. The effect of climatic parameters on health and safety of outdoor workers might be separate from other parameters such as air pollution.

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Conflict of interest statement

None declared.

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