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# Effect of Temperature on Gender-Specific All-Cause Mortality: A Study of the City in Northern India

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## Abstract

**Background:** The populations of developing nations are more vulnerable to high heat due to poor public health infrastructure and their sensitiveness towards changing climate. Excess mortalities caused by high temperatures have been reported from many parts of the world, including India. In the recent future, more warming and frequent hot days during summer are expected.

**Methods:** An analysis was carried out to study the effect of maximum temperature (Tmax) on gender-specific all-cause mortality during the summer months (May and June) of 2011 to 2015 in Chandigarh city of India. The mortality is calculated at different thresholds of temperatures of  $\leq 35^{\circ}\text{C}$ ,  $\leq 38^{\circ}\text{C}$ ,  $< 40^{\circ}\text{C}$ ,  $\geq 40^{\circ}\text{C}$  and  $\geq 42^{\circ}\text{C}$ . The average number of deaths at temperatures  $< 40^{\circ}\text{C}$  and  $\geq 40^{\circ}\text{C}$  were calculated at 99% significance. The Welch t-test is applied to test the significance.

**Results:** Tmax shows a high degree of association with all-cause mortality in both males and females. Male to female all-cause death ratio was found to be 1.67 for the study period. Daily Tmax of  $40^{\circ}\text{C}$  was found to be the point of inflexion as the number of mortalities at  $\text{Tmax} \geq 40^{\circ}\text{C}$  was significantly higher than those at Tmax below  $40^{\circ}\text{C}$ . The analysis also reveals an increase in the number of death among females at the threshold  $\text{Tmax} \geq 40^{\circ}\text{C}$  indicating higher vulnerability of females at higher temperatures of certain threshold.

**Conclusion:** A temperature of  $40^{\circ}\text{C}$  should be considered a threshold temperature for issuing heatwave alerts for Chandigarh, India. The increase in vulnerability at temperatures  $\geq 40^{\circ}\text{C}$  was more among the females.

**Keywords:** Heat, All-Cause Mortality, Chandigarh, Maximum Temperature.

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## 1. INTRODUCTION

Rising trends in temperatures and the increased incidence & severity of heatwaves have become more frequent and intense over the recent past. According to IPCC, the warming of the climate system is unequivocal. Since the 1950s, many of the observed changes are unprecedented over decades to millennia. The global mean temperature are expected to rise over the 21st century by 0.3°C to 4.8°C, based on concentration-driven different RCPs (Representative Concentration Pathways)<sup>1</sup>. Hence, it is expected to increase the intensity and frequency of warm days (heatwaves) during summertime across the globe. Unprecedented warming is impacting different sectors, including livelihoods. Developing regions, Africa, South America, the Middle East, and South Asia, may be highly affected primarily due to poor public health infrastructure and more vulnerable populations.<sup>2</sup> The warmer and/or frequent hot days and nights have increased over most land areas and are likely to expand further into the 21st century. In India, the temperature has been predicted to rise by 1.7-4.9°C by the end of the 21st century under the different RCPs<sup>3,4</sup>. More extreme temperature and heatwave events are expected in the near future in the Northern part of India too.

The heat caused mortality have been reported in the past across the globe.<sup>5–13</sup> Trends in India are also similar to those in many other parts of the world. More than 2,000 heat-related deaths were reported in India in 2015, with most deaths reported from Andhra Pradesh, Telangana, Punjab, Odisha and Bihar.<sup>14</sup> Further an increasing trend in the number of heatwave days and in maximum temperature (T<sub>max</sub> hereafter) above 90th, 95th and 98th percentile has been reported over several parts of India. Among all the five decades of understudy, the highest decadal frequency of heatwave days was observed during the latest decade (2001–10)<sup>15,16</sup>. Varying number of deaths ranging from 393 (in 1997) to 2422 (in 2015) due to heatwave with an increasing trend from the year 1992 to 2015 have been reported in India<sup>5,14,17</sup>.

In absence of information on cause-specific mortalities, all-cause mortalities are generally considered to study the associations between high temperatures and all-cause mortality in India and other parts of the world<sup>5,6,11,18–21</sup>. A significant relationship of high temperatures with increased mortality has also been

reported in developing nations from tropical regions<sup>22</sup>. Some of these studies have established that high temperature-induced mortalities increase markedly after the temperatures cross certain thresholds<sup>5,9,22</sup>. More frequent warmer days were suggested in the near future, leading to more heat-related outdoor and indoor deaths<sup>23</sup>. However, research linking mortality to heat during the summer months is limited to a few numbers of cities in the country. The present research is the first study for Chandigarh city to establish thresholds of T<sub>max</sub> for heat-related all-cause mortality. The literature survey is placed in section 1. Section 2 deliberates the study area, data & methodology; and results & discussion are placed in section 3 & 4, respectively.

## 2. STUDY AREA, DATA AND METHODS

### 2.1. Study Place

The current study was carried for Chandigarh, a Union Territory and combined capital for two states (Haryana and Punjab) in northern India (Figure 1). The city has a population density of 7900 persons per square km with 86.43% literacy. As per Census 2011, Chandigarh has a poor male to female sex ratio with 818 females per 1000 males, lower than all India figures of 940. The city experiences four seasons in a year, summer (mid-March to Mid-June), Monsoon or rainy season (late-June to September), post-monsoon autumn (September to November) and winter (December to February). During summer, May and June remain the hottest months with June being the warmest month ([http://chandigarh.gov.in/knowchd\\_general.htm](http://chandigarh.gov.in/knowchd_general.htm)). Chandigarh bears a Health Index (HI) of 63.62. It needs further improvement, as Kerala takes first place in India with an HI of 74.01<sup>24</sup>. The city, like many other parts of India, has registered increasing trend in temperature during the summer months<sup>25</sup>. More extreme temperature and heatwave events are expected in the near future in northern parts of the country<sup>23,26,27</sup> human health and has been a subject of prior considerable attention. Hence, for the sustainable development and adaptation of the urban population to climate change, it is essential to find the trend and magnitude of temperature and precipitation over Indian cities. An endeavor has been made in the present study to find the trend and magnitude of temperature and precipitation over 139 major Indian cities with respect to different Koppen climatic zones using Climatic Research Unit datasets of last 115 years (1901–2015).

The current study may provide a guideline for issuing of warning for heat-related health impacts. The same may be extrapolated to other parts of India based on data availability and comparable analysis. Need for more such studies to quantify the location-specific thresholds have also been emphasized<sup>17</sup>. Hence, the current study considers Chandigarh, a city from North India for analysis of relationship between temperature and all-cause mortality.

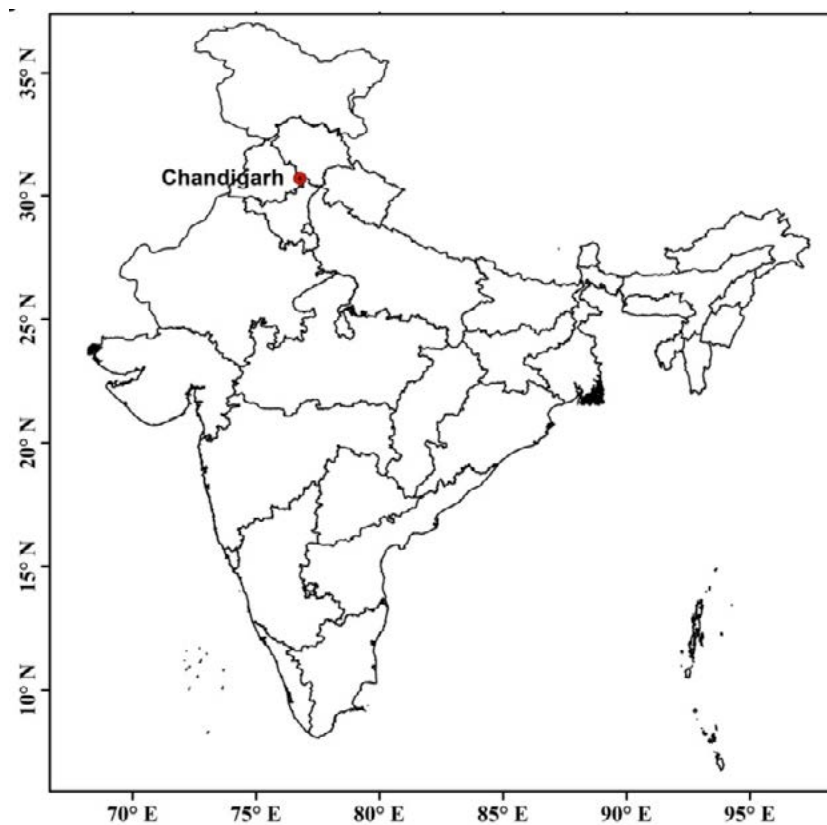
## 2.2. Study period and Data

Daily all-cause mortality data for May and June between 2011 and 2015 were obtained from the Registrar, Birth and Death, Chandigarh Administration office. The data were available for male and female mortalities only. The observed Tmax was obtained from the Meteorological Centre of India Meteorological Department (IMD), Chandigarh. Due to the unavailability of data on other factors such as exposure to sunlight, level of activity etc. which may influence mortality<sup>28</sup>, the current study was restricted to the relationship between temperature and all-cause mortality during the summer months.

## 2.3. Selection criteria

We limited the study to the summer season (May and June), when higher temperatures are expected over the city. Further, the mortality is calculated at different thresholds of temperatures of  $\leq 35^{\circ}\text{C}$ ,  $\leq 38^{\circ}\text{C}$ ,  $< 40^{\circ}\text{C}$  and  $\geq 40^{\circ}\text{C}$  and  $\geq 42^{\circ}\text{C}$ . The finding of different thresholds for Tmax and related death may help in issuing the early warning issues by the disaster managers.

**Fig. 1: Study area showing the geographical location of Chandigarh in India**

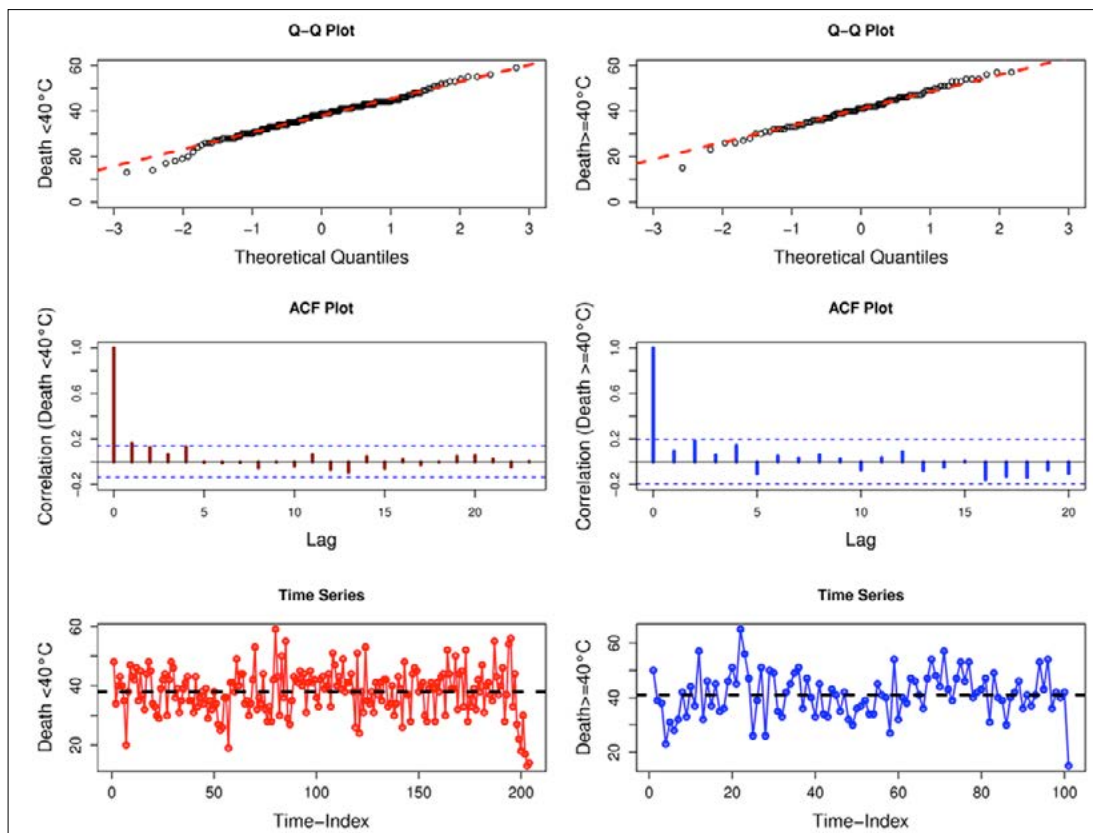


## 2.4. Methods for Analysis

The daily Tmax and all-cause mortality for the respective days were analysed to find the relationship during peak summer months (May and June) for the period 2011-2015. The data were analysed based on clustering methods. Further, the data were analysed to calculate the average number of mortalities (male and female, separately) per day for days with different Tmax thresholds. Simultaneously, the mortality rate per 0.1 million population is also calculated. The considered thresholds for the temperature were  $\leq 35^{\circ}\text{C}$ ,  $\leq 38^{\circ}\text{C}$ ,  $< 40^{\circ}\text{C}$ ,  $\geq 40^{\circ}\text{C}$ ,  $\geq 42^{\circ}\text{C}$ . Two independent samples considering the number of deaths at temperatures  $< 40^{\circ}\text{C}$  and  $\geq 40^{\circ}\text{C}$  were considered. The two thresholds have unequal sample sizes of 204 and 101, respectively. Quantile-quantile plot (QQ plot), autocorrelation function (ACF) and time series analysis were performed for both samples to assess whether the two groups are independent and fulfil the criteria for normality, stationarity and homogeneity. Figure 2 shows the theoretical quantile (Q-Q plot), ACF and time series plot for deaths at temperatures  $< 40^{\circ}\text{C}$  and  $\geq 40^{\circ}\text{C}$  to define whether the samples are independent or not. We plotted the theoretical quantiles, known as the standard normal variate (a normal distribution with mean equal to zero and standard deviation equal to one on the x-axis and the variables (number of death) on the y-axis). All points of both the samples lie on a straight line (evenly aligned with the standard normal variate) confirming it as a normal distribution.

A plot of the autocorrelation of a time series by lag, known as Auto Correlation Function (ACF) denoting the degree of correlation of the same variable between two successive time intervals was used for checking randomness in a data set. The randomness is ascertained by computing autocorrelations for data values at varying time lags (as shown in the x-axis of Fig. 4b). Further, the time series was plotted for death  $< 40^{\circ}\text{C}$  and  $\geq 40^{\circ}\text{C}$  concerning time (on the x-axis) which signifies that the time series is stationary. As the two samples were normally distributed and stationary, the significant test (Welch t-test) was carried at a 99% ( $p < 0.01$ ) confidence interval for both the samples.

**Fig. 2: Quantile-Quantile plot (first row), ACF (2<sup>nd</sup> row) and time-series (3<sup>rd</sup> row) plot for death  $< 40^{\circ}\text{C}$  (left panels) and  $\geq 40^{\circ}\text{C}$  (right panels). The theoretical quantile in the first panel of the Figure is standard normal variate and autocorrelation at different lags are shown in the second panel.**





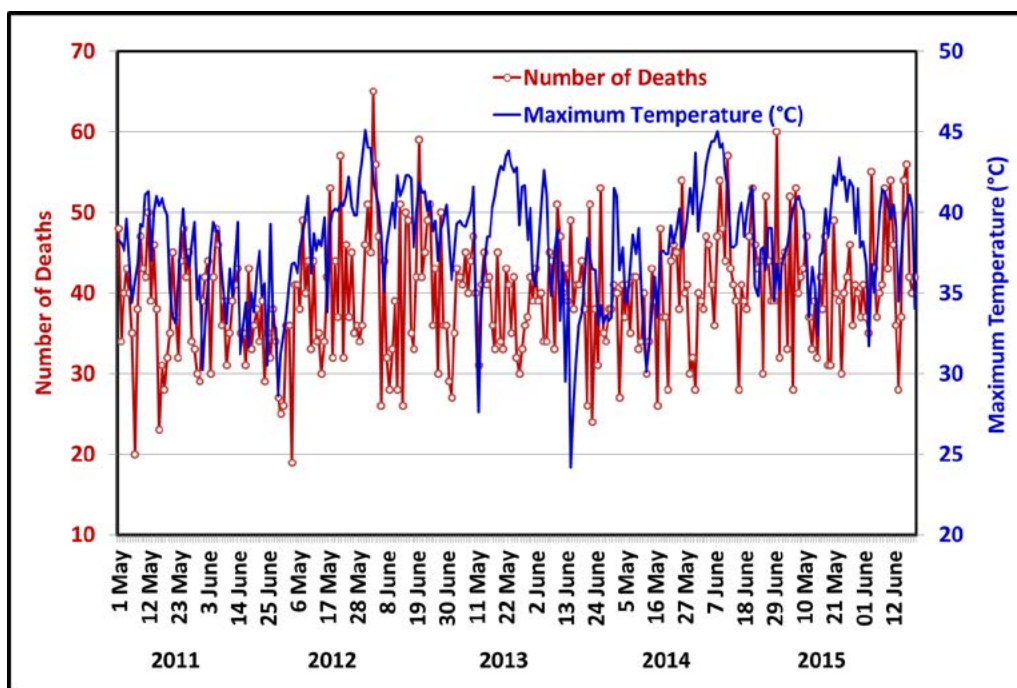
### 3. RESULTS

Daily all-cause mortalities in May and June for 2011 to 2015, along with Tmax, are shown in Figure 3. Average daily Tmax during different months and an average number of all-cause mortalities per day along with mortality rate per 0.1 million of the population are given in Table 1. Average Tmax of different months during the period varied from 35.0°C (June 2011) to 40.5°C (June 2012). The average number of deaths per day was also found to fluctuate with the temperature. On average, there had been 39 deaths per day during the study period which comes out to be 4.3 persons per 0.1 million. Higher mortality (overall) was reported among the male population in the city, with a male to female death ratio of 1.67 for the study period. The data were further analyzed to calculate the average number of daily deaths, along with mortality rate (per 0.1 million population) for days with different Tmax thresholds (Table 2 and Table 2A respectively). On average, 37-38 deaths were observed for the days when Tmax remains below 40°C with a mortality rate of 3.5-3.6. However, at  $T_{max} \geq 40^\circ\text{C}$ , the number of deaths count increased and was found to be 41-43 deaths (mortality rate of 3.9-4.1). The analysis was further performed for total death per day with the average of Tmax for the previous four days (including the day of death). A significant increase in the number of deaths (95% Confidence Interval, p-value = 0.0002462) was found when the average Tmax remained  $\geq 40^\circ\text{C}$  for four consecutive previous days.

### 4. DISCUSSIONS

The study found a positive relationship between Tmax and all-cause mortality in Chandigarh city of India. The number of daily all-cause mortalities generally increased or decreased with an increase or decrease in daily Tmax. However, there does not seem to be one to one relationship between the two. The hottest months during the study period (June 2012 and June 2014) recording the average Tmax above 40°C also recorded the highest number of deaths per day (43 each with a mortality rate of around 4.0 per 0.1 million of the population), which are about 10% higher than the average number of deaths during the entire period. Similar findings are reported for other cities in India<sup>5,11</sup>. Heatwave during 2015 were reported to cause 2248 numbers of deaths across India with 1677 deaths in the state of Andhra Pradesh alone<sup>17</sup>.

**Fig. 3. Daily maximum temperature and daily all-cause mortalities for May and June from 2011 to 2015**



**Table 1. Average daily Tmax and the average number of deaths per day for the months of May and June from 2011 to 2015.**

Year	Month	Mean Tmax	Average Number of Deaths per Day		
			Male	Female	Total
2011	May	38.0	24.0 (4.1)*	13.8 (2.9)*	37.8 (3.6)*
	June	35.0	22.9 (3.9)	13.8 (2.9)	36.6 (3.5)
2012	May	38.5	24.2 (4.2)	14.2 (3.0)	38.5 (3.6)
	June	<b>40.5</b>	27.1 (4.7)	15.5 (3.3)	<b>42.5 (4.0)</b>
2013	May	39.4	25.5 (4.4)	12.7 (2.7)	38.2 (3.6)
	June	35.3	26.2 (4.5)	13.2 (2.8)	39.4 (3.7)
2014	May	37.2	24.2 (4.2)	13.6 (2.9)	37.8 (3.6)
	June	<b>40.3</b>	<b>27.6 (4.8)</b>	<b>15.5 (3.3)</b>	<b>43.1 (4.1)</b>
2015	May	39.0	25.6 (4.4)	14.0 (2.9)	39.6 (3.8)
	June	37.9	22.3 (3.8)	14.2 (3.0)	36.4 (3.4)
Average			25 (4.3)	14 (2.9)	39 (3.7)

\*The figure in parenthesis shows mortality rate per 0.1 million of population.

**Table 2: Average number of deaths at the different temperatures in Chandigarh**

Tmax (°C)	Number of Deaths per day		
	Male	Female	Total
≤35	24	14	37
≤38	24	13	38
<40	24	14	38
≥40	26 (7.5)*	15 (9.5)*	41 (8.2)*
≥42	27 (12.5)**	16 (14.3)**	43 (13.2)**

Figures in parenthesis with \* and \*\* show an increase in the number of deaths at temperatures ≥40 and ≥42°C, respectively, compared to the number of deaths at temperatures <40°C

**Table 2(A): Same as Table 2 with mortality rate (per 0.1 million population)**

Tmax (°C)	Mortality rate (per 0.1 million)		
	Male	Female	Total
≤35	4.1	2.9	3.5
≤38	4.1	2.7	3.6
<40	4.1	2.9	3.6
≥40	4.5	3.2	3.9
≥42	4.6	3.4	4.1

A significant increase in deaths was found when daily Tmax exceeded 40°C. A higher increase in number of female mortalities was found at Tmax ≥40°C than in the male population. The percentage increase in male, female and total mortalities, respectively at Tmax ≥40°C, was 7.5%, 9.5% and 8.2%; and that at Tmax ≥42°C was 12.5%, 14.3% and 13.2%. The average number of deaths at temperatures <40°C and ≥40°C were further subjected to statistical significance. The significance test (Welch t-test) found the two means statistically different at a 99% confidence interval (p<0.01, p-value = 0.001784), indicating a significant increase in the number of deaths at temperature ≥40°C. These findings are consistent with the study from India reporting an increase in death by 10 -13% in different cities<sup>5,22</sup>.

Further analysis reveals that the average Tmax for all the days with number of deaths one standard deviation more than the average number of deaths was 39.7°C which further indicates that 40°C seems to be the point of inflexion above which significantly higher number of deaths are reported. Hence, a temperature of 40°C should be considered a threshold temperature for issuing heatwave alerts for the city. An intervention like an early forecast of heatwaves based on established thresholds, community awareness, health care capacity-building etc. may reduce mortality at higher temperatures<sup>29</sup>.

The number of deaths among the males was higher at all the temperature thresholds (Table 2). This could, partially, be attributed to frequent and prolonged exposure of the male population to outdoor activities connected with their livelihood. Larger increase in female mortalities at temperatures ≥40°C and ≥42°C compared to male mortalities indicates an increase in vulnerability of the female population at higher temperatures. A study based on sex-stratified mortality due to heatwaves revealed that older women are at higher risk than men<sup>22,30</sup>; intense and longer-lasting heat waves which can have severe health outcomes. The elderly are a high-risk population for heat-related mortality and some studies suggested that elderly women are more affected by extreme heat than men. This study aimed to review the presence of sex-specific results in studies performed on mortality in elderly (> 65 years old). Further, in developing nations like India,

females stay indoors and perform household activities with poor infrastructures. They even suffer from a dearth of continued electricity, indoor sanitation and proper ventilation.

## 5. CONCLUSIONS

Current research analyses the effects of Tmax on daily all-cause mortality in the Chandigarh city of India for the period 2011-2015 during the summer months of May and June. The average number of deaths for all days with temperatures ≥40°C was found to be statistically higher than the average number of deaths for all days with temperatures <40°C indicating that 40°C is the point of inflexion for a higher number of all-cause mortalities; and could, therefore, be considered a threshold temperature for issuing heatwave alerts for the city. However, the increase in the number of deaths among the female population at temperatures ≥40°C was higher than that among the male population. This analysis shows the higher vulnerability of the male population on account of their higher outdoor exposures. However, the increase in vulnerability at temperatures ≥40°C was more among the females. The National Meteorological Service of the country- India Meteorological Department- issues the forecast for temperature on short, medium, extended, and seasonal periods. Based on the forecast of Tmax, the obtained threshold from the current research outputs may be applied to issue impact-based heatwave warnings. The disaster managers may use the same to disseminate for public use. For similar settings, the study may be replicated for determining the threshold for heatwave warnings of a place or a region. Further, more detailed data may be recorded by the concerned authority for detailed study.

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# Association between Meningococcal Meningitis and Santa Ana Winds in Children and Adolescents from Tijuana, Mexico, a need for Vaccination.

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## Abstract

**Background:** Based on several previous studies (regional and national), Tijuana, Baja-California, Mexico (across the border from San Diego, California, USA), has shown the highest rate of Meningococcal Meningitis (MeM) in the country, however, the reason for this has not yet been known. In the "African Meningitis Belt", the Harmattan seasons are associated with MeM outbreaks. The Santa Ana winds seasons (SAWs) are hot and dry winds (similar to Harmattan seasons) that occur seasonally in southwestern California, USA, and North of Baja-California, Mexico. Objectives: Our aim was to demonstrate, as a short communication, a potential association of SAWs with MeM in Tijuana, Baja-California, Mexico, which in turn, may partially explain the high rate of this disease in the region. Methods: Based on own previously published data obtained from thirteen years of active surveillance of MeM, and a 65 years review showing the occurrence of SAWs, we estimated the risk ratio (RR) of total cases number by MeM vs. bacterial non-MeM (bacterial meningitis not caused by *Neisseria meningitidis*) during seasons with and without SAWs. Results: We found an association of SAWs seasons with MeM, but not with bacterial non-MeM (RR = 2.06, p = 0.02 (95% CI 1.1 to 3.8)), which may partially explain the high endemicity of this deadly disease in this part of the globe. Conclusion: This study shows a new potential climatic association with MeM, and provides more information that justifies universal meningococcal vaccination in Tijuana, Mexico.

**Running title:** Santa Ana winds and Meningococcal Meningitis.

**Keywords:** Meningococcal meningitis, Climate, Weather, Children, Meningococcal Vaccine.

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## INTRODUCTION

Meningococcal meningitis (MeM) is a contagious disease transmitted from individual to individual by airborne droplets of respiratory or throat secretions. The highest burden of the disease occurs in the 'African Meningitis Belt', a region stretching from Senegal to Ethiopia with an estimated population of 400,000 million people [1]. While *Neisseria meningitidis* serogroup A was the main cause for large epidemics before monovalent conjugate serogroup A meningococcal vaccine was universally administered, serogroups W, C and X are also responsible for localized outbreaks [1]. Increase in incidence is typically observed during the core of the dry season, from January to March, characterized for the presence of these dry and hot winds called Harmattan. These winds blow from the northeast and carry high dust loads from January to March, before rainy seasons start [2]. These dusts mostly originate from Bode'le' (Chad) causing weekly incidence rates reaching up to 100 per 100,000 population in individual communities [2]. Even with appropriate treatment, the mortality rate fluctuates around 10%, and 10–15% of survivors suffer long-term neurological sequelae [1,2].

Similarly, the Santa Ana Winds seasons (SAWs) are episodic pulses of easterly, downslope, offshore flows over the coastal topography of the California Border Region: Southern California and Northern Baja-California (Mexico), occurring mostly from October to April, and are associated with very dry air, often with anomalous warming at low elevations, similar to the Harmattan winds associated with MeM outbreaks in Africa [3].

Furthermore, SAWs have been associated with episodes and/or exacerbations of asthma and/or allergies [4], and maybe with Coccidiomycosis [5].

Meningococcal universal vaccination (MUV) has never been part of the Mexican National immunization Program (NIP).

The Tijuana, Baja-California, Mexico, and San Diego, California, USA -border, is considered to be the most transited in the world.

Based on our active national surveillance studies, Tijuana has the highest incidence of MeM in Mexico,

with annual attack rates varying from 2.6, 4.2 and 7.6 /100,000 in children < 16, 5, and 2 years of age, respectively, being *Neisseria meningitidis* the leading cause of all bacterial meningitis in the region [6-8]. Meningococcal serogroup C is predominant (61%), followed by Y (23%).

In addition, a binational San Diego, California, USA, and Tijuana, Mexico study between 2005-2008, showed that MeM was more frequent only at the General Hospital of Tijuana when compared to the whole San Diego County in children < 16 years old (16 vs. 13 cases, respectively) [9], however, MUV at 11 years of age started in the USA since 2005, and as mentioned, is not part of the Mexican NIP.

Moreover, a serogroup C, MeM (clonal complex 11) outbreak with 19 cases occurred in 2013, and was associated with a high mortality of 36.8% [10].

In this short communication, we hypothesized that the high incidence of MeM in Tijuana may be, in part, associated with the occurrence of SAWs in the region. This association has never yet been described.

## METHODOLOGY

In one a peer-reviewed publication from our group based on 13 years of active/prospective surveillance (2005-2018), in children > 7 days and < 16 years of age at the General Hospital of Tijuana, we identified 51 cases of MeM (25% lethality), and 30 bacterial non-meningococcal meningitis (NMeM) among which *S. pneumoniae* was predominant (42%), followed by *S. agalactiae*, *S. pyogenes*, *Enterobacteriaceae*, and others [8].

A SAW episode was then defined as periods with at least 12 hours of continuous selected winds that exceed the local wind speed threshold for at least 1 hour, and from the available data between 1948-2012 (65 years summary review), 2056 SAWs episodes were detected, with an average of 32 occurrences per year, hence, a mean annual frequency of SAWs was estimated [3].

In order to only compare MeM with NMeM with/without SAWs, we did not include cases of meningococcal disease without meningitis, however, 92% of all meningococcal disease cases developed meningitis [7,8].

Total number of cases of MeM and bacterial but non-MeM (NMeM) per month (from our 13 years of active/prospective surveillance data [8]) were compared with/without SAWs seasons from a 65 year review [3], and followed by Risk Ratio (RR) estimation.

The reason for comparing MeM with NMeM was basically to see whether only MeM, but not NMeM, was associated with SAWs, as with meningococcal outbreaks associated with the Harmattan condition in the African meningitis belt [2].

A z test was also used to compare proportions of MeM during SAWs seasons vs. non-SAWs seasons.

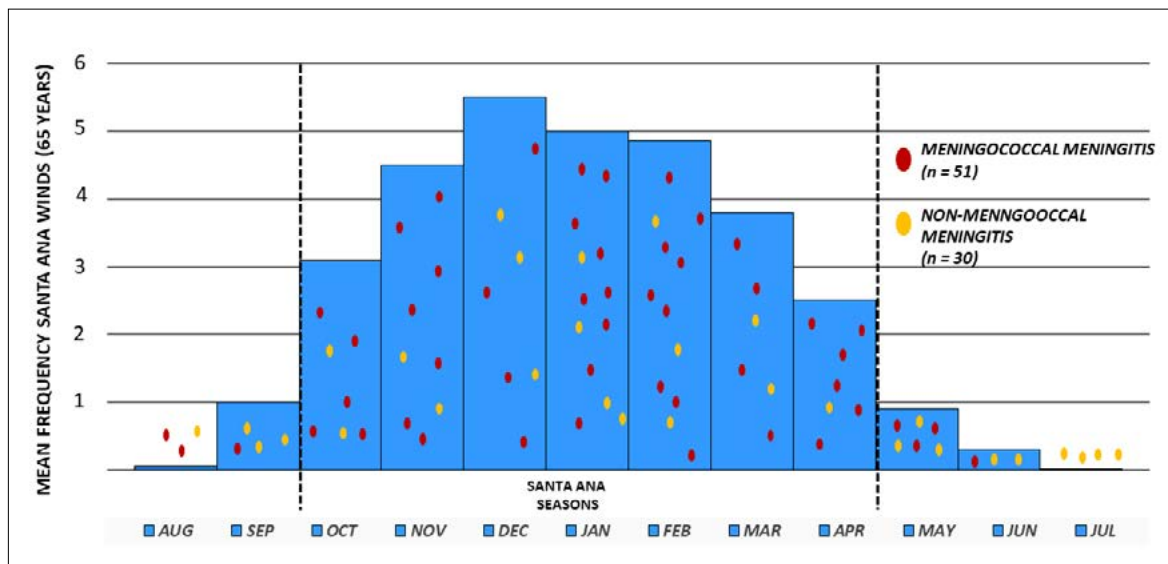
## RESULTS

The RR of MeM and NMeM with/without SAWs is shown in Table 1, showing a clear statistically significant association of MeM with SAWs.

Figure 1 shows individual cases per month of MeM (red dots) and NMeM (yellow dots) obtained from our 13 years active surveillance, and, between the dotted lines, in blue bars, months with the highest mean annual frequency of SAWs, based on 65 years (1948-2012), summary review [3].

Additionally, from 51 MeM, 44 (86.27%) occurred during SAWs seasons (z test = 7.32, p<0.0002).

**Figure 1: Association of Mean Annual Frequency of Santa Ana Winds (1948-2012) and Meningococcal Meningitis in Tijuana, Mexico, 2005 – 2018.**



**Table 1: Risk Ratio Estimation of Meningococcal (Mem) and Bacterial-Non-Meningococcal Meningitis (Nmem) With Santa Ana Winds (Saws) Seasons**

	SAWs seasons	Non-SAWs seasons
<b>MeM</b>	44 cases	7 cases
<b>NMeM</b>	17 cases	13 cases

RR = 2.06, p = 0.02 (95% CI 1.1 to 3.8)

## DISCUSSION

This is the first study that clearly associates Meningococcal Disease and a climatological condition other than the Harmattan condition.

Both Harmattan and SAWs share similarities: 1. Both are seasonal and cyclic. 2. Are associated with dry winds, and, in the case of Harmattan seasons, lead to dust loads that allow *Neisseria meningitidis* to spread [2,3]. The latter has never been described with SAWs. However, its impact on triggering allergies and asthma has been well described [4], and there is evidence that strongly suggests that these episodes of very dry air maybe associated with higher transmission of Coccidioidomycosis, a mycotic disease that typically spreads during dry air turbulences [5].

In our study, we have shown, based on many years of prospective/active surveillance that *Neisseria meningitidis* is not only the leading cause of bacterial meningitis in Tijuana, Mexico [7,8], but similarly proved, based on the same surveillance system in nine hospitals within the country, that MeM has much higher endemicity in Tijuana than other geographic regions in Mexico [6], from which an explanation of this phenomena is mandatory. Our elevated rates of MeM (2.69/100,000 in < 16 years of age [7]) in a city of two million people may be seen not concordant with 51 cases in thirteen years, nonetheless, as we described this when we published our studies [7,8], in the state of Baja-California, Mexico, during the time of our active surveillance, there were mainly five different health care systems: "Instituto Mexicano del Seguro Social" (IMSS), "Seguro Popular", "Instituto de Seguridad Social para Trabajadores del Estado" (ISSSTE), "Instituto de Seguridad Social para Trabajadores de Baja-California" (ISSSTECALI), and "PEMEX" [11]. The General Hospital of Tijuana was the only one attending patients belonging to the "Seguro Popular" health care system, therefore, attack rates by age groups were estimated by using that "Seguro Popular" population as a denominator, with the potential disadvantage that maybe some patients with MeM belonging to "Seguro Popular" were hospitalized in the private sector, potentially leading to under estimation. In addition, even though MeM is of mandatory report in Mexico, no other hospital than the General Hospital of Tijuana has established well

active surveillance system including both clinical and laboratory trained personnel and resources. All of the latter was explained and accepted in our publications [7,8].

The main limitation of our study is indeed the lack of data from other places where SAWs also occur, and this association is coming only from one hospital. In Baja-California, Mexico, the General Hospital of Tijuana, where all cases of bacterial meningitis were obtained for this study, is the only hospital that actually performs active surveillance in the State (as mentioned), hence, information from other hospitals where SAWs occur in the region is practically absent. In Southern California there are no studies of this association, moreover, since MUV is part of the NIP in the USA (started in 2005), trying to make an association of MeM with SAWs could now be very difficult to estimate. Additionally, as we mentioned in the Introduction section, we have published a binational (Tijuana, Mexico-San Diego, California) study between 2005-2008, with more MeM cases only at the General Hospital of Tijuana when compared to all the San Diego County [9].

We are aware that other factors can be associated with higher endemicity of MeM in our region, such as a potential higher nasopharyngeal carriage in the population (studies never performed to date), high rate of migration from Central and South America, many areas of people congregation, among others.

## CONCLUSIONS

This short report showed a statistically significant association of MeM during the SAWs seasons when compared to bacterial but non-MeM, strongly suggesting that this hot, dry SAWs may intervene in a higher transmission and occurrence of this potentially deadly disease. Nonetheless, our results do not prove causality, but rather a hypothesis that, along with previous data showing a higher rate of MeM in Tijuana, Baja-California, Mexico, urges serious consideration for universal vaccination against *Neisseria meningitidis* in this region.

## Declarations

This study was accepted for presentation at the Infectious Diseases Society of America Meeting – 2020



(IDSA-IDWeek-2020), abstract number 879656, but never been submitted to any Journal.

This study was approved during the period of active surveillance from the “Comite de Etica en Investigacion del Hospital General de Tijuana” (Ethics Committee in Research of the General Hospital of Tijuana), number CONBIOETICA02CE1001-20170526.

No additional authorization was needed since this study is showing an association from two previous publications, and, coming from those same approved and published data, an association to Santa Ana winds. No conflicts of interest need to be stated, neither a written consent form, since, again, this study is showing an association of a previous publication to a climatic condition. There are no names, neither samples saved from any subject from those previous publications, and this study was 100% self-funded.

All authors need have contributed to this study based on the following:

1. Made a substantial contribution to the concept of the work; as well for data interpretation.
2. Revised the article critically for important intellectual content,
3. Approved the version to be published,
4. Each author participated sufficiently in the work to take public responsibility for appropriate portions of the content.

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The paper should be typed on paper with A4 dimensions, leaving 2.5 cm space from the top, below, right and left edges, with double line space, without hyphenation at line end, by using font size 10 Times New Roman character font.

The tables, figures, graphs and similar that are included should not exceed an area of 10 x 17 cm for preventing exceeding of page borders and for using with convenience. Thus, smaller font sizes and single line space may be used for objects such as tables, figures, images, graphs etc. The tables, figures, images, graphs etc. should be inserted into the text.

Papers should not exceed 20 pages. Sending a copy of the paper produced through MS Word to the Journal's e-mail addresses or submitting the same online from the website is sufficient for the editorial process to commence. An electronic mail message confirming its receipt is sent at the latest in a week after the paper was sent.

For any clinical or experimental studies on humans and animals that require ethics board approval to be used in the research studies, separate ethics board approvals have to be obtained, such approval should be referred to in the paper, and duly documented.

For Turkish papers, the grammar rules in TDK Spelling Book (Yazım Kılavuzu, 2009, Turkish Language Association) or on the address [www.tdk.gov.tr](http://www.tdk.gov.tr) (online version) should be complied with in respect to both the text and the references sections.

References (For both the text and the references sections, the grammatical rules defined in the book named Publication Manual of American Psychological Association and published by American Psychological Association should be implemented).

Journal names should be abbreviated in accordance with Index Medicus or Ulakbim/Turkish Medical Index.

The papers submitted should include the sections presented in bold characters below:

- Turkish Title Page (should include paper title, full names and titles of author(s), the institutions they are employed in, and their address, telephone, fax and electronic mail addresses)
- Turkish Abstract (between 150 and 200 words)
- Keywords (between 5 and 8 words)

- Main Text (quantitative and qualitative studies should include introduction, methodology, findings and discussion sections)
- English Title Page (should include the paper title, full names and titles of author(s), the institutions they are employed in, and their address, telephone, fax and electronic mail addresses, and their "ORCID" data with international validity)
- Abstract (between 150 and 200 words)
- Keywords (between 5 and 8 words)

English Main Text (quantitative and qualitative studies should include introduction, methodology, findings and discussion sections)

### NOTES TO AUTHORS ON THE PROCESS OF PUBLISHING

Considering the studies conducted on the impacts of climate change, it is observed that the year 2018 became a milestone. The World Health Organisation published a special report in the year 2018. The special report requested further involvement on the impacts of climate change on health. Such involvement should be supported with academic evidences. The health related impacts of climate change should be placed as the focus in international, national and local climate change adaptation studies.

"Climate and Health" journal is prepared with the aim to bring together the studies conducted, and the evidences and experiences gathered on the field of climate and health by researchers expert in their fields.

### In this regard, it shall be;

1. An international peer reviewed journal that aims to serve as an effective tool for the academicians and researchers working on the fields of climate, climate change, public health, environment and other related fields, and researchers expert in their fields within non-governmental organisations (NGOs), public sector organisations and international organisations to share their scientific assessments, research findings and analyses.
2. The publishing languages of the journal are Turkish and English.
3. For papers with several authors, the person with whom editorial correspondence is to be made should be defined and indicated clearly.
4. Author(s) are responsible for any falsification, faults, copyright violation, plagiarism etc. issues that may exist within the content or references in the papers published.
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