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Title: Impact of Temperature on Response Times in Emergency Medical Services

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Abstract

Background: Situations involving ambulance dispatch can be influenced by environmental factors such as weather and climate. Therefore, this study investigates how temperature impacts the response time of emergency medical services in Golestan Province.

Materials and Methods: A study was conducted to analyze the impact of temperature on EMS response times in Golestan Province, Iran, from 21 March 2019 to 20 March 2024. Data was collected from the pre-hospital care report (PCR) and the Golestan Meteorological Department using the convenience sampling method, and the variability in ambulance response time was examined in relation to the documented temperatures.

Results: Our research findings revealed that the highest rate of calls leading to ambulance dispatches occurred at an average temperature of 25–30 degrees Celsius (25.79%). In contrast, the lowest frequency of calls resulting in ambulance deployments was recorded at temperatures below 5 degrees Celsius (2.17%), a difference that is statistically significant. Additionally, we found that the response times at temperatures under 5 degrees and above 30 degrees Celsius were longer than at other temperature ranges and surpassed the national standard.

Discussion: Our research found that the highest number of calls resulting in ambulance dispatch occurred during times of increased average temperatures. Additional studies support our findings, indicating that EMS responses tend to rise with rising temperatures.

Conclusion: This study provides data-driven proof for planners to address the challenges presented by climate change. By predicting surges in service demands during climate fluctuations, we can strategize for effective resource distribution and reduce patient wait times**.**

Keywords: Climate change, Mortality, Temperature, Emergency medical Service, Response Time.

Introduction

Climate change represents one of the most significant public health challenges. Climate change has heightened the danger of encountering extreme temperatures, natural disasters, exposure to climate-sensitive illnesses, and their consequent impacts on public health. Research indicates that climate variability and change present significant threats to individuals living in both developing and developed nations globally(1, 2). Climate change has immediate effects that present the highest threat to the well-being of communities. These outcomes encompass death and illness (3-7). It is anticipated that as the extent of these changes expands during this century, additional repercussions will emerge for infrastructure (8). Certainly, preparedness can significantly contribute to minimizing these losses and averting deaths and illnesses. Achieving this preparedness necessitates collaborative efforts between local authorities and the community(9, 10). Organizations need to prioritize understanding risks, enhancing disaster risk governance, investing in disaster risk reduction, and strengthening disaster preparedness and response efforts as a national priority(11). This is particularly crucial in Iran, which has faced multiple instances of climate-related flooding in urban and rural areas, along with significant drought conditions affecting substantial regions of the nation (12, 13). Due to its arid and semi-arid climate, Golestan Province experiences drought and flooding events linked to climate change annually (14-18). Certainly, having access to evidence-based data regarding the existing and possible risks of climate change to the health of at-risk populations, as well as identifying effective adaptation strategies, is essential today to equip individuals and communities for the health consequences of climate change (19). Evaluating the effects of climate change and health vulnerabilities offers a crucial information framework for comprehending and tackling climate change-related risks within society(20). Consequently, mortality rates and disease occurrences linked to climate change have been the focus of numerous epidemiological investigations, with various studies documenting the adverse impacts of climate change on death rates and related complications(2, 21). Currently, as a health metric, calls to pre-hospital emergency dispatch centers have garnered increased focus in research examining the impact of climate change on health. Epidemiological research has found a link between temperature and emergency ambulance calls in various regions globally. Prehospital emergency services are the initial segment of the healthcare system that addresses medical emergencies across all levels, and several studies highlight a connection between prehospital emergency missions and weather factors like temperature(22, 23). Situations that necessitate ambulance deployment can be connected to environmental factors (such as weather and climate) and demographic traits. Data concerning ambulance dispatches in relation to the environment is essential for guiding emergency medical service planning and resource redistribution by officials(24). Researchers have focused on the elements that influence EMS response time in transportation, including obsolete road design, traffic congestion, a rising number of vehicles, and particular types of roads (such as city streets, interstates, and highways), leading to further response delays(25). Nonetheless, there has been minimal research investigating delayed response times in various temperature context and how these effects are distributed unevenly across different environments. Recognizing that contextual, geographic, and social factors in each area can affect the severity of these outcomes, this research investigates how temperature influences emergency medical services response times in Golestan Province.

Materials and Methods

An analytical study was carried out to investigate how temperature influences emergency medical services response times in Golestan Province of Iran from 21 March 2019 to 20 March 2024. Information was obtained from the prehospital care report (PCR). This data included the type of emergency and time of request. This study included patients who

received EMS during the four distinct seasons (spring to winter) from 2019 to 2024. Patients who could not be located or had incomplete information were excluded from the study. Illnesses in this study were defined according to diagnoses in the EMS database using the 10th revision of the International Classification of Diseases (ICD-10) version 2019. Reaction time was measured from when the dispatch center (Golestan command and control center) received the call to when the EMS team arrived at the scene. Total prehospital time was defined as the duration between receiving the call to dispatch and the ambulance's arrival at the hospital. The duration of each operational process was recorded in the EMS database. Data collected included demographic information such as diagnosis, EMS operation times, gender, age, and type of illness. Temperature data were provided by the Golestan Meteorological Department, with daily averages recorded temperature used for analysis.

Statistical Analysis

The participants' characteristics and demographics were the focus of a descriptive analysis. IBM SPSS for Windows was used for statistical analysis. Means and standard deviations were reported for continuous data, while percentages were used for categorical data. For univariate analysis, the Chi-squared test was used to compare groups, and the two-sample t-test was applied to numerical data.

Results

Throughout the study period, a total of 608,593 requests were recorded. since it's sensitive data, it does not include any personal or postcode information.

Step 1 (Descriptive): We organized all primary diagnoses of EMTs. The most common category of illnesses was associated with external causes of morbidity and mortality (V01-Y98), including accidents (34%). The following in rank were signs and symptoms associated with respiratory, circulatory, and digestive disorders (25.2%). Congenital anomalies and disorders before and during birth have the lowest amount of demand. Medical emergencies occur less frequently within city boundaries (49.674%) compared to on the out of city (50.326%).61.463% of the service recipients are male and 38.53% are female. Our study's findings indicated that during the year's months, August (9.8%), July (9.7%), and September (9%) represented the highest number of emergencies requiring ambulance dispatch.

Table1: Time Indicators in EMS				
Index	**place**	**N**	**Mean**	**Std. Deviation**
Reaction time	City	274846	0:00:08.75	0:00:06.420
	Out of City	271336	0:00:13.40	0:00:10.152
Total prehospital time	City	170186	0:00:31.82	0:00:13.639
	Out of City	193737	0:00:45.56	0:00:22.313

At this point, we analyzed the emergency time index within the city and out of city (Table1). Our study's findings indicated that reaction time in urban areas exceeds the national standard, while outside the city it falls within the standard range.

Step 2: At this point, we analyzed the correlation between the trend of emergencies resulting in ambulance dispatch and the trend of daily temperatures. We computed all logged temperatures as daily means and analyzed the patterns in daily temperatures alongside prehospital medical emergencies. Our study results indicate a direct correlation between temperature and the rise in prehospital medical emergencies, as verified by the Pearson correlation test(figure1).

Figure1: Trend Temperatures and Emergency Event
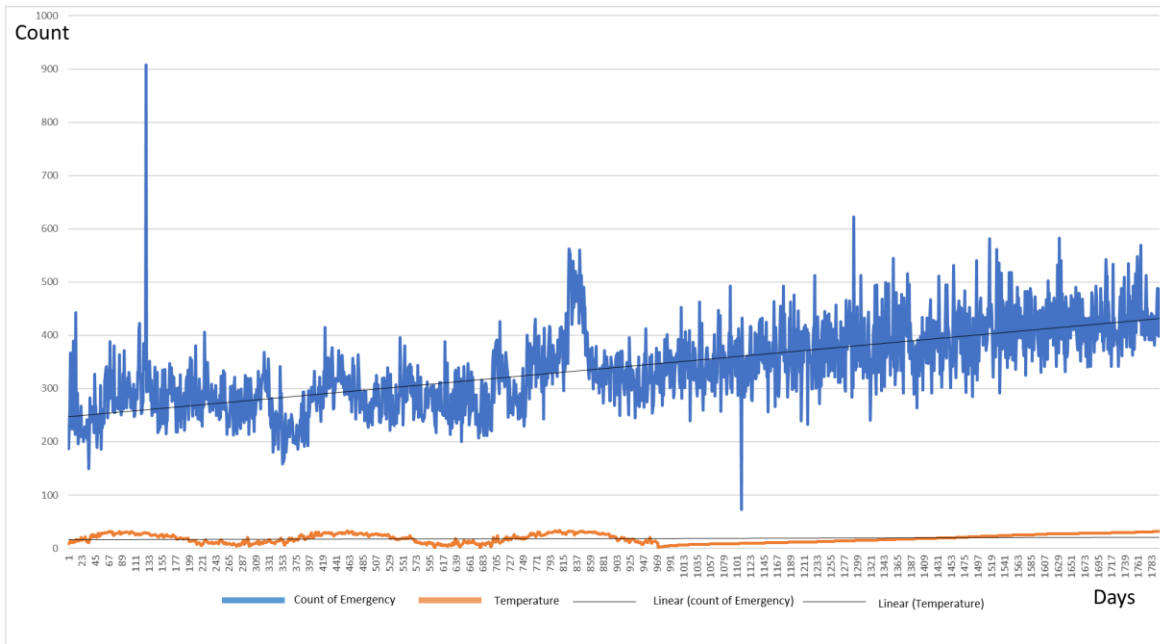
Table2: Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.316[a]	.100	.099	72.87170
a. Predictors: (Constant), VAR00005				
b. Dependent Variable: VAR00001				

The relationship between temperature and the frequency of emergencies is 0.316 (Table2) and is statistically significant. The R^2 value indicates that 10 percent of the variations in emergencies are influenced by temperature.

Table3: Regression analysis of the relationship between temperature and frequency of emergency

R	B	SE	Beta	T	P-value
μ0	283.556	4.294		66.031	0.00
Temperature	2.99	0.212	0/316	14.087	0.000

The results show that there is a regression relationship between the temperature variable and the frequency of emergencies(table3) (P-value<0.05).

Step 3: In this stage, we examined the pre-hospital response time at various temperatures. We conducted this analysis for reaction time and total pre-hospital time both within the city and in the out of city (Table4).

Table4: Relationship between temperature and EMS response time

| Air Temperature	Index	location	Frequency	Mean	Standard deviation	P-value
<5	Reaction Time	city	6255	0:00:09,06	0:00:06,555	<0.05
		Out of city	5941	0:00:14,15	0:00:12,023	
	Total prehospital Time	city	3678	0:00:33,45	0:00:13,811	<0.05
		Out of city	4118	0:00:46,42	0:00:21,972	
5-10	Reaction Time	city	41552	0:00:08,73	0:00:06,603	<0.05
		Out of city	39659	0:00:13,39	0:00:11,017	
	Total prehospital Time	city	25546	0:00:32,36	0:00:14,019	<0.05
		Out of city	28050	0:00:45,93	0:00:22,804	
10-15	Reaction Time	city	55156	0:00:08,85	0:00:05,838	<0.05
		Out of city	52087	0:00:13,34	0:00:09,664	
	Total prehospital Time	city	33582	0:00:32,17	0:00:13,717	<0.05
		Out of city	45527	0:00:08,65	0:00:05,697	
15-20	Reaction Time	city	43190	0:00:13,14	0:00:09,148	<0.05
		Out of city	28773	0:00:32,04	0:00:13,759	
	Total prehospital Time	city	68153	0:00:08,62	0:00:06,086	<0.05
		Out of city	72049	0:00:13,43	0:00:09,904	
20-25	Reaction Time	city	42533	0:00:31,19	0:00:13,389	<0.05
		Out of city	38445	0:00:08,61	0:00:06,717	
	Total prehospital Time	city	38602	0:00:13,24	0:00:10,361	<0.05
		Out of city	24246	0:00:31,40	0:00:13,638	
25-30	Reaction Time	city	68153	0:00:08,62	0:00:06,086	<0.05
		Out of city	72049	0:00:13,43	0:00:09,904	
	Total prehospital Time	city	42533	0:00:31,19	0:00:13,389	<0.05
		Out of city	51385	0:00:45,36	0:00:22,287	
>30	Reaction Time	city	19758	0:00:09,31	0:00:09,057	<0.05
		Out of city	19808	0:00:14,16	0:00:11,419	
	Total prehospital Time	city	11828	0:00:31,68	0:00:12,982	<0.05
		Out of city	13862	0:00:45,25	0:00:21,762	

1- Reaction Time

At this point, we analyzed the reaction time to emergencies both within the city and beyond. Our findings indicated that the Reaction Time at temperatures under 5 degrees Celsius and over 30 degrees Celsius is greater than at other temperatures and exceeds the national standard (Figure2,3). This is statistically meaningful in and out of city (P value <0.05).

Figure2: Trend Temperatures and Prehospital Reaction Time in city
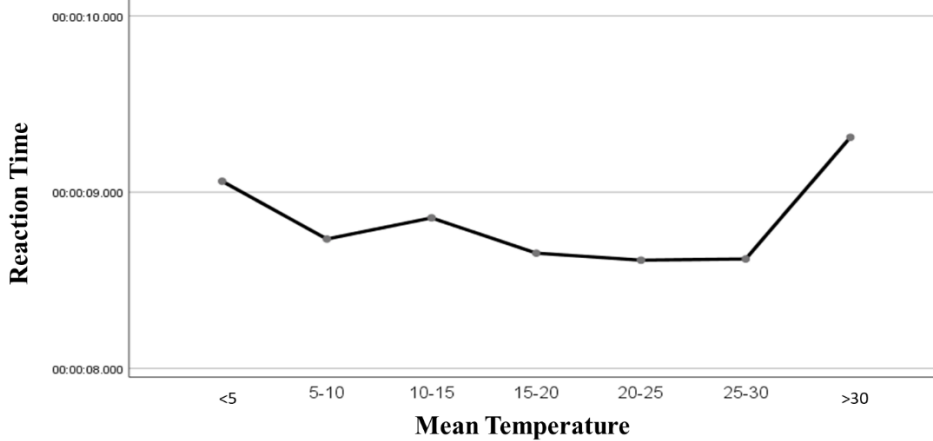
Figure3: Trend Temperatures and Prehospital Reaction Time out of city
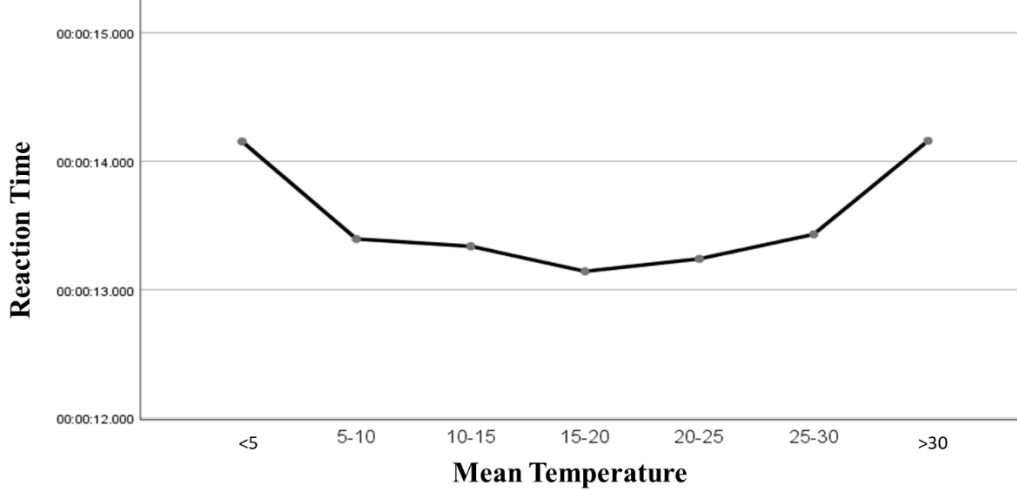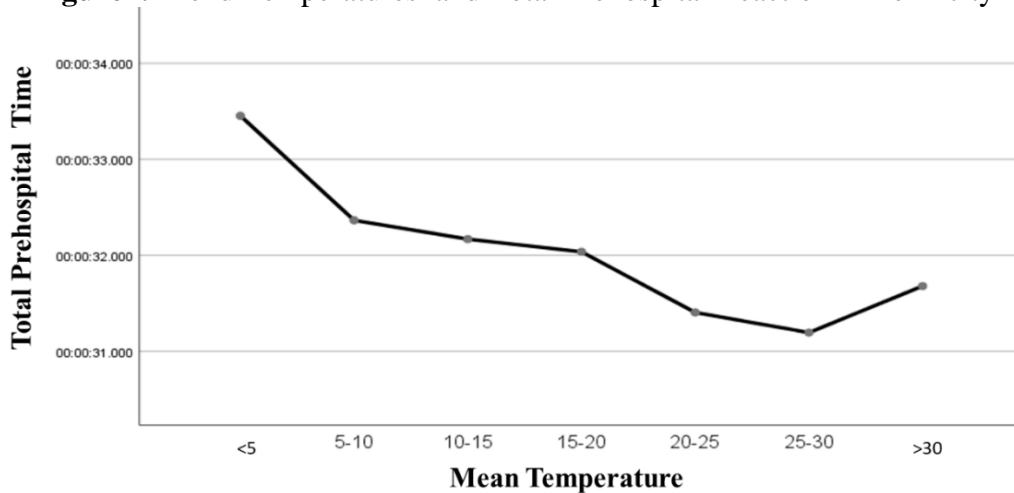


2- Total prehospital Time

Our findings indicated that the total prehospital time at low temperatures exceeded that at elevated temperatures (Figure4,5). The findings indicated a downward trend in time as temperature rose, which was statistically significant (P value=0).

Figure4: Trend Temperatures and Total Prehospital Reaction Time in city

Figure5: Trend Temperatures and Total Prehospital Reaction Time in out of city
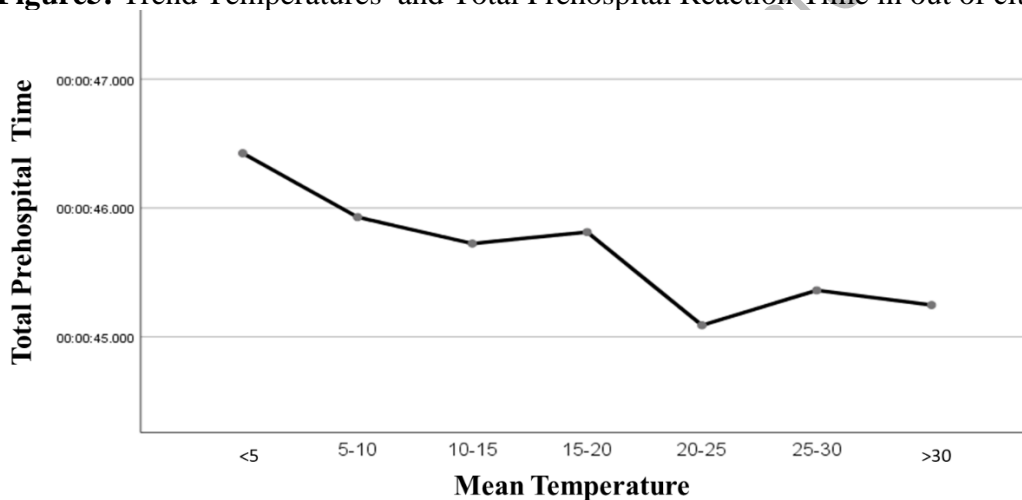
Discussion

In this research, we examined how temperature influences prehospital emergency response durations. Our study's findings indicated that the majority of calls prompting ambulance dispatch were due to external factors associated with morbidity and mortality, such as accidents. The second category of contacts includes ssymptoms, signs and abnormal clinical and laboratory findings. The study carried out by sangsefidi et al supports our results. Their research reveals that injuries and heart conditions rank among the primary reasons for calls that result in ambulance dispatch(26). We discovered a positive and direct correlation between temperature variations and the number of patients attended to. We observed that the patient count rose throughout the study, even though the temperature variations were minimal. This upward trend is statistically meaningful. Our findings indicated that the greatest number of calls resulting in ambulance dispatch happened at temperatures ranging from 25 to 30 °C, whereas the fewest calls leading to ambulance dispatch took place at temperatures lower than 5°C. The results of Ramgop al et al study confirm our findings. They found that the EMS response increases with increasing temperature(27). Kue et al study results also indicated that the number of emergency medical service calls rose significantly during the heat wave, but there was little change in the types of illnesses

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reported(28). In a research study, RUAN et al examined the link between temperature and prehospital emergency response in Chengdu. They discovered that the most common responses were related to the three primary causes of injury: traffic accidents, poisoning, and falls. They also discovered that when the average daily temperature surpassed 17.9°C, the amount of emergency medical services responding to injuries rose(29). It seems that variations in temperature can considerably affect the capacity of prehospital system to address the demands of patients. Through the examination of past data, we discovered a trend and temperature patterns indicating that emergency reaction times rose when temperatures fell below 5°C and exceeded 30°C. This indicates that patients needed to wait more time (beyond the established time standard) to obtain services. This connection was statistically relevant. On the other hand, as the temperature increases, the total pre-hospital time decreases.

Research conducted by Thornes et al. that analyzed daily air temperature alongside ambulance call data for Birmingham during a 5-year span (2007-2011) discovered a notable link between extreme weather and heightened ambulance call and response durations. For each 1°C drop in air temperature, there was a 1.3% decline in emergency department efficiency(30).Apiratwarakul's research additionally indicated that temperatures exceeding 35 °C prolong pre-hospital times(31). SEONG et al. examined the pattern of heat-related EMS response durations during weekdays peak hours. They discovered that EMS experienced comparatively longer response times during the morning and evening(32). According to the findings of Zhan et al., precipitation and temperature serve as risk factors for ambulance performance, and their delayed impacts on Ambulance Reaction Time (ART) are considerable. They discovered a linear connection between temperature and precipitation with ART(33).Forecasting the flow of service recipients in prehospital emergency departments under varying weather conditions can enhance managers' situational awareness and assist in addressing the challenges brought by climate change. By forecasting the rise in service demand across various climate periods, we can strategize the efficient distribution of resources and reduce patient waiting times.

Conclusion

This analysis shows that the response time in EMS increases when temperatures rise above 30 degrees or descend below 5 degrees. Conversely, as temperatures increase, the total prehospital time decreases. It is crucial for EMS policymakers to understand the changing patient trends and the growing demand for ambulances under varying weather conditions to provide adequate care. This study offers data-driven evidence for planners to tackle the challenges presented by climate change. By anticipating spikes in service demands during weather fluctuations, we can plan for better resource allocation and minimize patient wait times. We recommend that, in addition to climate forecasting, adaptive strategies be employed as a management tool to strengthen the resilience of emergency responses in extreme weather situations.

Limitations:

This study has a number of limitations. First, the retrospective design resulted in some data being either incomplete or insufficient. Additionally, because the research focused solely on a single EMS system, applying the findings to other contexts may prove difficult. Moreover, our study did not consider factors such as precipitation, air pollution, and traffic volume, which could affect response times. We suggest that future research should incorporate these variables.

Ethical Approvals: This article extracted of a Research project approved at Golestan University of Medical Sciences and was found to be in accordance to the ethical principles and the national norms and standards for conducting Medical Research in Iran. Code of Ethics: https://ethics.research.ac.ir/IR.GOUMS.REC.1402.449

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