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# Effects of rainfall on the use of emergency medical services

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**Abstract**

Emergency Medical Services (EMS) is an essential component of any healthcare system in the world, providing patients with medical care and a transfer system to hospitals. This system requires for an undisrupted and flawless provision of healthcare, considering factors that are controllable and uncontrollable. The aim of this study is to determine the effects of precipitation on the use of emergency medical services. This is a retrospective observational study, for which the precipitation data used was obtained from the Turkish State Meteorological Service. The daily number of cases transferred by EMS teams was obtained from the ASOS system of the Ankara Directorate of Emergency Medical Services. Data from 2002 days were included in the study. There were 198,816 cases on non-rainy days, while the total number of cases on rainy days was 94,407. While the median of the daily number of cases of non-rainy days was 140 (45), this value was 148 (49) for rainy days. There was a statistically significant difference between the two groups in terms of daily number of cases (p<0.001). There was also a statistically significant difference between the 4 groups (classified according to precipitation) in terms of daily number of cases (p<0.001). Considering that the need for EMS may increase, precautions may be taken on days with irregular or challenging weather conditions. Recognizing the request for prehospital emergency care may increase demands for advanced planning, which is of great importance for the cost-effective use, quality, and satisfaction of health services.

**Keywords:** Emergency care, prehospital healthcare, weather, rain, precipitation, emergency medical services

## Introduction

Emergency Medical Services (EMS) is an essential component of any healthcare system in the world, providing patients with medical care and a transfer system to hospitals. The continuous and undisrupted provision of this system is vital for the health and well-being of patients. Therefore, this system must always be regulated and checked for errors. When a complication occurs, it must be overcome rapidly and effectively. In this study, the aim was to determine the effects of precipitation on the use of emergency medical services. Once these effects are known, possible precautions may be undertaken in order to improve quality of service and allow for a cost-effective management.

Knowledge of the number of patients assessed by teams under EMS contributes to the effective use of all resources, including staff [1,2]. The possible effect of weather changes on the uses of EMS and emergency rooms has also been recognized, especially in terms of trauma cases [3]. It is believed that the number of hospital visits decreases in bad weather. Studies in this field have also shown a decrease in the number of emergency department (ED) visits on days with rain or snow [4]. Chen et al. found that there was no correlation between rainy weather and the traumatic, non-traumatic or pediatric patient volume of EDs [5]. Ou et al. found a negative correlation between rainy weather and ED visits. They also reported that the ambulance visits to EDs were not affected by weather variables [6]. According to a study examining the use of EDs by forensic cases in Turkey, 11.8% of such visits were on rainy days [7].

Turkey is a unique example in the world because of its annual number of ED visits that surpass its population. Emergency departments and EMS already care for a large quantity of patients as it is, without the addition of external factors like bad weather conditions that increase case numbers even more. It is therefore of great importance to predict the patient volume of EMS. Consequently, an increase in the quality of patient care, satisfaction with the services and efficiency is expected [8].

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Although Turkey is a unique country in the world with its EMS system, there is still a need to improve the quality in this field. In this study, we aimed to determine the effect of precipitation on the use of EMS. We believe that the results of our study will contribute to the planning of ambulance operations according to precipitation in our country.

## Materils and Methods

This study was designed as a retrospective study and was approved by the Ethical Committee of Clinical Research No. 1 of Ankara City Hospital (E1/068/2019). It also agrees with the principles of the Declaration of Helsinki of the World Medical Association.

With an altitude of 891 meters, the average annual temperature in Ankara was 11.8 °C and the amount of rain it received was 400.2 mm. The city has a continental climate, where spring is the rainiest season [9]. In this study, data regarding the Keçiören district, a metropolitan area of the capital city Ankara, was used. The population of Keçiören district was 909,787 in 2018. With this population, Keçiören district was the second most populous district in Turkey. One of the two reasons why this district was preferred in this study was due to its crowded population, while the other reason was because the main observation station of the Turkish State Meteorological Service was located there. Thus using data obtained from this district was highly convenient.

This study covered 2027 days from 1 January 2014 to 20 July 2019. The measurement data for 25 days during this time period were missing and were therefore excluded from study. Data from the remaining 2002 days were considered complete and were therefore included in the study. The precipitation data used was obtained from The Turkish State Meteorological Service. The precipitation sensors used by this institution were impulse counter measuring devices that operated with a precision of 0.2 mm and melt the snow or hail through the thermostat heater. The unit of measurement was the amount of water in kilograms per square meter. This was considered equivalent to a water height of 1 millimeter. In this study, precipitation amounts were recorded in millimeters. Like the study of Shah et al., precipitation was classified into 4 groups as "non-rainy (0 cm)", "low rainy (<1 cm)", "moderate rainy (≥ 1 cm)", and "very rainy (≥ 5 cm)" [10].

Ankara EMS provided medical care through 17 ambulance stations located in the Keçiören district. The daily number of cases attended by these teams was obtained from the ASOS system of Ankara EMS Administrative Office. Patient information and files were not used in the study, and so obtaining informed consents from patients were not required.

### Statistical analysis

The evaluation of whether data showed normal distribution was made by using visual (histogram, probability graphs) and analytical (Kolmogorov-Smirnov test) methods. Since the data did not show normal distribution, the Kruskal-Wallis test was used instead, which is one of the nonparametric tests. A value of $p<0.05$ was considered statistically significant. Since differences between the groups were observed, post hoc analyses were performed to find the cause of the difference. Paired comparisons were made using Mann-Whitney test and the Bonferroni Correction (p value <0.008 was considered significant). Median and interquartile range (IQR) were used for descriptive analysis. The data were analyzed using SPSS for Windows version 22.0.

## Results

Data from a total of 2002 days were included in the study. Of these, 629 days were rainy, while 1373 days were not. EMS teams encountered 198,816 cases on non-rainy days, while on rainy days, only 94,407 cases were seen.

While the median of the daily number of cases on non-rainy days was 140 (IQR=45), this value was 148 (IQR=49) for rainy days. There was a statistically significant difference between the two groups in terms of daily number of cases ($p<0.001$).

There was a statistically significant difference between the 4 groups (classified according to precipitation) in terms of daily number of cases ($p<0.001$) (Table 1).

**Table 1.** Comparison of daily number of cases according to precipitation

| Precipitation | Daily Number of Cases | P Value[a] |
|---|---|---|
| **Non-rainy (0 cm)** | 140 (45) | <0.001 |
| **Low rainy (<1 cm)** | 152 (48) | |
| **Moderate rainy (≥ 1 cm)** | 147 (52) | |
| **Very rainy (≥ 5 cm)** | 141 (49) | |

[a] Kruskal-Wallis test. Values are given as median (interquartile range - IQR)

In order to determine the cause of this difference, the Mann-Whitney test and the Bonferroni Correction were used, for which the results are shown in Table 2. According to this analysis, the differences between the groups were due to non-rainy, low rainy and moderate rainy days. In addition, there was a significant difference between very rainy days and low or moderate rainy days in terms of number of cases.

**Table 2.** Paired comparison of precipitation groups according to the daily number of cases

| Comparison | p valueb |
|---|---|
| **Non-rainy (0 cm) vs. Low rainy (<1 cm)** | <0.001 |
| **Non-rainy (0 cm) vs. Moderate rainy (≥ 1 cm)** | 0.003 |
| **Non-rainy (0 cm) vs. Very rainy (≥ 5 cm)** | 0.346 |
| **Low rainy (<1 cm) vs. Moderate rainy (≥ 1 cm)** | 0.613 |
| **Low rainy (<1 cm) vs. Very rainy (≥ 5 cm)** | <0.001 |
| **Moderate rainy (≥ 1 cm) vs. Very rainy (≥ 5 cm)** | 0.005 |

[b] Mann-Whitney test and the Bonferroni Correction

As a result, a significant increase in the number of cases on rainy days was observed compared to non-rainy days. The number of cases was higher on low and moderate rainy days compared to non-rainy days. Additionally, the number of cases on non-rainy days was similar to those on very rainy days.

## Discussion

As a result of this study, it was found that the daily number of cases increased statistically significantly on low and moderate rainy days compared to non-rainy days. However, there was no difference in the number of cases per day between very rainy days (rainfall of 5 cm or above) and non-rainy days. Thus, it was concluded that there is a similar number of EMS demand on very rainy days and non-rainy days. This outcome is similar to of Atherton et al., who stated that EMS usage decreased in bad weather conditions, however in their study daily rainfall did not directly affect the number of daily ED cases [3]. On the other hand, in a study by Lee et al., it was found that the number of pediatric cases seen in EDs on rainy and snowy days decreased. (4) In this study, no difference was found in the number of cases between very rainy and non-rainy days; however, more cases are observed on low or moderate rainy days than on non-rainy days. This is possibly related to the fact that patients do not prefer to use EMS on very rainy days for their non-urgent health problems. In addition, on such days, patients may have chosen to reach the EDs either by their own private vehicles or by private non-emergency transport ambulances.

According to a study by Wong et al. in Hong Kong, the need for ambulance service reached its highest level in the coldest and hottest months [11]. In contrast, Diehl et al. reported that more ED visits occurred during summer months, while if daytime rainfall was present, fewer ED visits would occur. (1) In this study, it was found that the request for ambulance services was the highest during low or moderate rainy days. One reason for this could be that traffic accidents are more likely to occur during low and moderate rainfall, whereas on days with heavy rain, people are more inclined to used public transport for safety reasons and do not use personal cars. The use of public transport could explain the lack of traffic and the decreased number of accidents as a consequence. Varying temperatures are also likely to have an effect on the use of EMS; however, temperature variables were not included in this study.

Lee et al. showed that traffic accidents increased by 10.5% in days when rain exceeded 3.5 mm [12]. Similarly and according to the results of this study, it is believed that the increase in EMS demand in low or moderate rainy days is due to the increase in trauma cases, especially traffic accidents.

Since EMS is completely free of charge and widespread enough to serve even the most remote areas in Turkey, patients also benefit from EMS ambulances for their non-urgent health problems to be transported to hospitals. Such patients could possibly use EMS more on days with low or moderate rain in order to facilitate their own transport to hospitals, whereas on days with no or heavy rain, they would either use public transport, or postpone their visit to the hospital. This is another factor that might have an effect on the results of the study.

Comparing various studies, a wide range of results can be seen. The reason of such dissimilarities in range could be due to differences in population distribution and density, a higher number of comorbid patients, or socio-economic and cultural differences.

In order to improve EMS quality and decrease the number of cases seen per day, the use of public transport should be encouraged. With the use of public transport, traffic is likely to be relieved, and the numbers of traffic accidents will decrease. Moreover, the uses of private or public non-emergency transport ambulances could be stimulated in order to decrease the workload of EMS.

## Limitations

The most important limitation of this study is that it was conducted in a single province. Ankara is a city far from the sea, dominated by terrestrial climate, and precipitation is between 0.1-25 mm [9]. Therefore, the results may vary in regions where unusual weather events occur. For example, on the landfall day of Hurricane Isabel the number of ambulances demands dropped significantly compared to the average of the last 6 months, but the number of demands increased by 35% a day later [13]. Furthermore, other factors such as temperature differences, seasons, or holidays also affect the regional population and thus the use of EMS. Such parameters were not accounted for, limiting the study.

## Conclusion

Since the need for emergency medical services will always be necessary, it is crucial that all components of the system operate flawlessly. Moreover, extra caution is needed on days with unpredictable and challenging weather conditions since the need for emergency medical services may increase on rainy days, thus increasing the need for staff and resources. The realization that need for prehospital emergency care may increase on rainy days demands for advanced planning according to weather conditions; and this is of great importance for the cost-effective use, quality, and satisfaction of health services.

## Key Message

Realizing that the need for EMS may increase on rainy days allows for advanced planning according to weather conditions and this is of great importance for the cost-effective use, quality, and satisfaction of health services. In this respect, we believe that the studies to be carried out in wider geographical areas and in regions with unusual weather events will contribute to the planning of EMS, thus contributing to the economic use of resources.

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**Conflict of interests**
*The authors have no conflicts of interest to declare.*

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*Ethics Committee of Clinical Research No. 1 of Ankara City Hospital (E1/068/2019).*

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