The Trend of Prehospital Emergency Medical Care Services after the COVID-19 Pandemic: A Time Series Analysis

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Abstract:

Introduction: The COVID-19 epidemic in 2019 directly or indirectly had an impact on the healthcare system of hospitals. Iran was among the countries whose hospitals and especially the emergency system were affected by the outbreak of Coronavirus. The main objective of this study is to compare the number of emergency services, including heart and respiratory diseases, accidents, drowning, and CO poisoning, after the coronavirus pandemic in Chaharmahal and Bakhtiari provinces.

Methods: In this study, after obtaining the necessary permissions, an attempt was made to analyze the data on the most common Emergency Medical Services (EMS) extracted monthly by the city from the ASAYAR system during 2020-2023 using time series and Auto-regressive Integrated Moving Average (ARIMA) model.

Results: The number of emergency services related to accidents had an upward trend and was based on seasonal changes. Examination of seasonal effects shows that most emergency services occurred in the months of June through September; the number of emergency services related to heart disease was relatively constant. In addition, the number of emergency services related to respiratory diseases was constant on average despite many fluctuations in the observations. During the COVID-19 pandemic, the number of interventions and emergency calls increased.

Conclusion: Therefore, emergency services should increase their response capacity in these cases by modifying their programs and approaches, increasing response capacity and the number of staff, and providing appropriate training.

Keywords: Emergency, Emergency services, COVID-19, Coronavirus, Time series, Trends.

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1. INTRODUCTION

In December 2019, a disease called Coronavirus (COVID-19) was identified in Wuhan, China, and it quickly spread around the world. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic. The pandemic directly and indirectly impacted healthcare systems worldwide. Iran was among the hard-hit countries, and healthcare systems, such as EMS, were

also affected. EMS of Iran is one of the organs under the Ministry of Health and this organization includes emergency medical and pre-hospital services and air ambulance [1, 2].

This system, which relies on the initial data from the patient's history, known as the main emergency services, and includes the symptoms and problems generally reported by the patient, is effective in helping physicians create a diagnostic model [3]. The most common medical emergencies requiring EMS services are related to cardiac and respiratory illnesses and traffic accidents, and the provision of services in these cases has changed due to the coronavirus pandemic.

In Iran, cardiovascular diseases are the leading cause of death, accounting for 39.3 percent of all deaths [4]. Trauma caused by vehicle accidents is also another important cause of death in the world, especially in developing countries [5]. For example, the World Health Organization reported in 2018 that around 3,400 people died every day in low- to middle-income countries due to vehicle accidents [6]. Iran is also a middle-income country with a high percentage of accident-related deaths [7]. Injuries and trauma caused by traffic accidents are the third leading cause of death worldwide [8], while their magnitude in Iran is above the world average and is the second leading cause of death after cardiovascular diseases, with an annual mortality rate of 32 percent [9]. The number of traffic accidents in Iran is twenty times higher than in other countries in the world, and in only four countries is this rate higher than in Iran [7]. Respiratory diseases are also reported as the fourth leading cause of death in the world and are predicted to reach third place by 2030 [10].

During an epidemic, the detour of non-emergency patients is very important to maximize EMS and hospital resources and reduce disease transmission [11]. While previous studies on EMS have often focused on primary care abuse and less urgent health problems, the avoidance of urgent medical calls has been particularly evident during this epidemic.

In 2020, a study was conducted on the impact of the COVID-19 epidemic on emergency medical services in Tehran, where the coronavirus disease significantly affected the medical service system. The number of calls to emergency services increased by 347% compared to the period before the coronavirus outbreak, and the number of emergency interventions increased by 21%. In addition, after the epidemic, there was a significant increase in the main emergency services, fever, and infectious diseases (211% increase) and respiratory symptoms (245% increase) [12]. In 2021, a study was also conducted on the evolution of emergency services during the COVID-19 outbreak and analyzed the number of emergency calls for all diagnoses used during 121 days between January and the end of April 2020. The results showed an increase in calls for symptoms, such as cough, fever, and sore throat, and the trend of calls not referred to the hospital, calls for psychological or psychiatric reasons, and calls related to cardiovascular problems and pneumonia decreased [13].

In the study of Theodorus *et al*. in 2021, missions related to respiratory problems increased significantly in 2020, but in terms of non-emergency missions, it did not show much change. In addition, the concern caused by the risk of getting infected with the Coronavirus caused patients to visit the hospital less, especially for conditions that were less medically urgent. This is consistent with the reduction of transfer to the hospital and the increase of on-site outpatient treatment missions [12]. The research results of Yasin *et al*. in 2021 showed a significant decrease in the number of accidents and injured people in traffic accidents. In other studies, the traffic volume during the COVID-19 pandemic decreased drastically, accompanied by a significant decrease in accidents worldwide and a decrease in deaths. The most important factors affecting this number were the reduction of traffic volume and congestion [14].

The main purpose of this study is to investigate and compare the trend of the number of emergency missions (heart diseases, respiratory diseases, accidents, drowning, and CO poisoning) based on the most common main emergency services in the number of emergency medical (EMS) calls and activities in the Chaharmahal Bakhtiari province during the COVID-19 epidemic. The results will help determine the need of patients for emergency services in critical situations so that better planning can be done in case of similar crises.

2. MATERIALS AND METHODS

This study is an ecological study, and after obtaining the necessary permits from the hospital to receive information on the number of calls and emergency medical services, the data related to the most common emergency services in the pre-hospital emergency every month were extracted from the ASAYAR system, which is responsible for managing and controlling the process of providing services in the emergency organization of Iran. The data used in this study include the number of the most common emergency services in the medical emergency of Chaharmahal Bakhtiari province during the years 2020 to 2023.

For data analysis, time series methods and, specifically, autoregressive Integrated Moving Average (ARIMA) have been used.

Time series data is a sequence of data obtained over time. The statistical methods used to analyze such data are time series analysis. Time series analysis is used to identify a model and forecast the future values of the series. Time series can be decomposed into four components: trend, seasonal variations, cyclic variations, and irregular movements [15, 16].

One of the common time series models is the ARIMA, and if there are seasonal patterns in the data, this model is converted to the seasonal ARIMA or SARIMA, and the components of seasonal changes are also considered [17, 18].

In this research, a time series plot was drawn for each variable to investigate, and the best model was determined using the "auto.arima" function in the "forecast" package in R software and the forecasts for the

next 15 months for each of the emergency services (heart diseases, respiratory, traffic accidents, drowning, and carbon monoxide poisoning) were obtained based on this model.

3. RESULTS

The best models for each variable are shown in Table **1**. Three variables related to accidents, carbon monoxide poisoning, and drowning had seasonal variations, which is why the best model determined for these is SARIMA. For each of the models, AIC and RMSE criteria were used for goodness of fit, which are the lowest in the determined models (Table **1**).

Table 1. The best time series model for each variable.

Variable	Best Model	AIC	RMSE
Accident	SARIMA (0,1,1) (0,1,0)	345.55	72.39
Heart Diseases	ARIMA (0,1,1)	434.47	45.28
Respiratory	ARIMA (0,0,1)	447.87	46.29
CO	SARIMA (0,0,0) (0,1,0)	247.26	12.18
Drowned	SARIMA (0,0,0) (1,1,0)	139.99	1.65

Table 2. Five common emergency medical care from march to october 2023 (incidence per 100,000, 95% CI).

| City	Accident	Heart Diseases	Respiratory Diseases	Carbon Monoxide Poisoning	Drowning
Shahrekord	604 (577-632)	142 (129-156)	100 (90-112)	0.9 (0.1-2)	0.3 (0.08-1)
Boroojen	798 (749-849)	191 (168-218)	113 (95-133)	11 (6-19)	2 (0.5-7)
Farsan	445 (403-489)	67 (51-86)	67 (51-86)	2 (0.2-7)	2 (0.2-7)
Lordeghan	695 (660-731)	124 (109-140)	89 (77-103)	2 (0.5-4)	3 (1-7)
Ardal	512 (450-580)	200 (162-244)	77 (54-106)	10 (3-24)	0 (-)
Koohrang	512 (445-586)	109 (80-146)	43 (26-69)	2 (0.6-13)	4 (0.5-17)
Kiar	684 (614-759)	252 (211-300)	166 (133-206)	2 (0.4-10)	2 (0.4-10)
Saman	911 (813-1018)	323 (265-389)	108 (76-149)	44 (24-72)	26 (12-50)
Ben	485 (407-574)	278 (220-347)	175 (129-231)	0 (-)	10 (2-31)
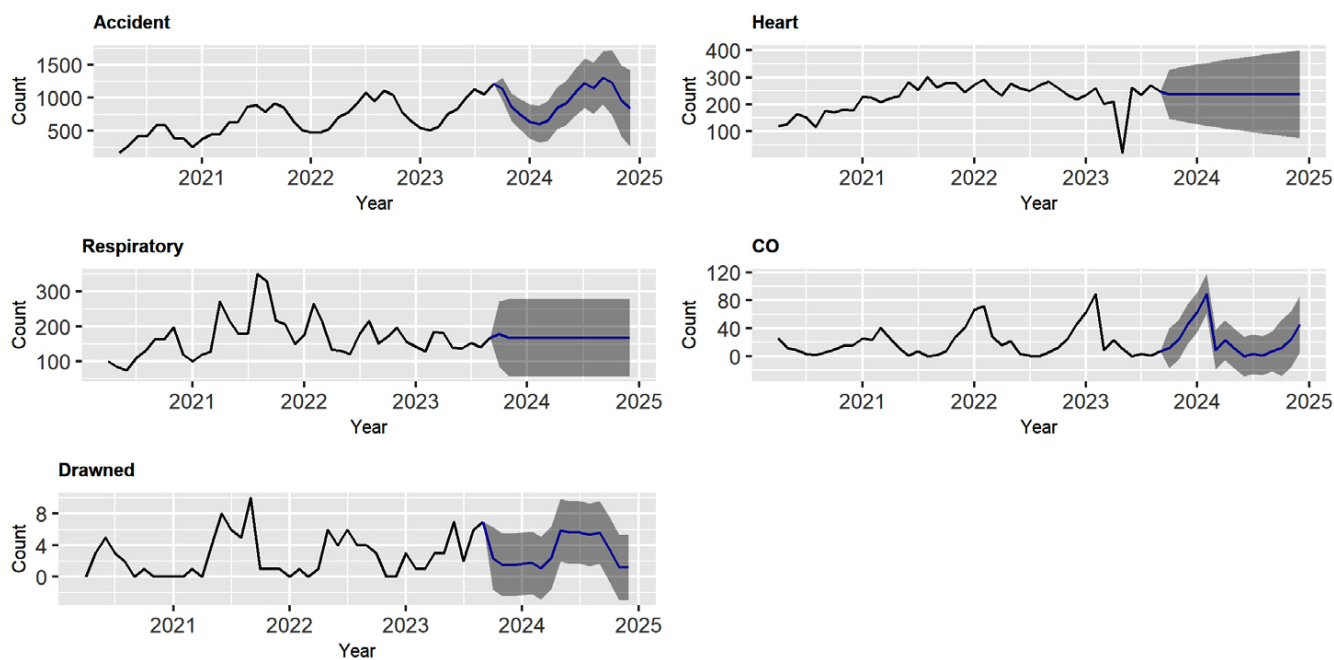
Fig. (1). The time series plot of each variable and the forecast for the next 15 months.

Moreover, according to the time series graphs of each variable, the trend of number of emergency services related to accidents is ascending from 2020 to 2023 and has seasonal variations. In such a way, the investigation of seasonal effects shows that most cases occurred from June to September, and it reached 838 cases in December 2024, and the highest frequency of accidents occurred in September 2024 with 1304 cases. On average, the number of accidents from October 2023 to December 2024 reached 947 (Fig. **1**, Table **2**).

The number trend of heart disease cases was relatively constant, although the trend of the time series graph of this variable has been relatively ascending from 2020 to before 2023. In general, no particular trend is observed, and the number of predicted cases in the next year will be 238 cases.

The number trend of respiratory diseases, despite the large fluctuations in observations, has been constant on average, and the future forecast also shows that the number of cases of this disease reached 168 in 2023.

The number of carbon monoxide poisoning cases also has a seasonal trend, according to the time series plot and the best model determined for this data. The most cases are in December, January, and February.

Moreover, according to forecasts, the number of such cases in December 2024 was 46. Over the next year, the number of cases of carbon monoxide poisoning will be an average of 25.

4. DISCUSSION

This study aims to investigate the trends of the most common Emergency Medical Services (EMS) after the COVID-19 pandemic in Chaharmahal and Bakhtiari Province. According to the results, the number of emergency services related to accidents, carbon monoxide poisoning, and drowning also had seasonal patterns. The time series plot of each variable showed that the trend of the number of cases related to accidents increased from 2020 to 2023 and showed seasonal changes, which may be due to the fact that people were at home for a long time during the Covid-19 period and the travel restrictions were a reason for the low number of accidents in 2020, which was the peak of Covid-19, and that the number of accidents increased afterwards.

Moreover, in this study, the number of cases related to heart diseases was relatively constant; however, this trend ascended from 2020 to 2023, which is consistent with the research results of Ahmadi *et al*. (2023) in Mashhad and their increase of 1.1% compared to before the outbreak of Coronavirus. Meanwhile, the same study shows a 40.8% increase in respiratory emergencies in the period before and after the epidemic [19], which is consistent with the results of our research. In general, the trend is ascending, but from 2020 to 2022, when the prevalence of COVID-19 in Iran was high, according to Fig. (**1**), the trend of heart disease cases also increased, which can be justified due to the increase in restrictions and home quarantine and lifestyle changes and reduced mobility and increased anxiety, which are risk factors for heart diseases. After 2022, when restrictions were reduced over time and people's awareness of the disease increased, the trend of heart emergencies also decreased.

In the study of Theodorus *et al*. in 2021, missions related to respiratory problems increased significantly in 2020, but in terms of non-emergency missions, it did not show much change in the way the concern caused by the risk of getting infected with the Coronavirus reduced the visits of patients to the hospital, especially for conditions that are less medically urgent. The results of our study also show that from 2020, the peak of corona in Iran, to the end of 2022, the trend of calls and emergency services for respiratory patients increased. The trend plot also shows that this number increased in some hot months of the year, indicating that the high temperatures also affected the severity of respiratory illnesses and the need for emergency care. Therefore, under the conditions of the respiratory disease epidemic, increasing the capacity of treatment staff and emergency service in the respiratory disease department, especially in the hot season, as well as the many recommendations on social media to drink plenty of water, stay at home except for important work in the hot seasons, may help reduce the number of respiratory patients [11, 20].

In some studies, the number of emergency calls increased significantly after the epidemic [21]. The results of the study conducted in 2020 in Saudi Arabia, like this study, showed a significant increase in emergency cases during the COVID-19 period compared to before the epidemic, except for trauma cases. Meanwhile, the demand for medical emergencies increased significantly during this period [22], which is in line with the findings of our research.

In some countries, trends show that the use of emergency services decreased during the corona epidemic, which may be due to the reluctance of patients to visit hospitals as corona spreads [23, 24]. This is despite the fact that for some diseases, such as respiratory disease, heart disease, and even accidents in general, the number of emergency calls and emergency service utilization increased during this period in our study.

The results of the research conducted by Yasin *et al*. in 2020 showed a significant reduction in the number of accidents and injuries in traffic accidents, and in other studies, the traffic volume during the COVID-19 pandemic decreased significantly, which was accompanied by a significant decrease in accidents worldwide, and a decrease in deaths. The most important factors affecting this number were the reduction of traffic volume and congestion [14]. The results of our study also show that the number of accidents was low in 2020, the peak year of COVID-19 and intercity traffic restrictions in Iran, but this trend has increased over time as restrictions have been reduced. Of course, we do not have data for the period before 2020, but definitely the number of accidents before Corona was higher than in 2020 because there were no restrictions.

In 2020, a study was conducted on the impact of the COVID-19 epidemic on emergency medical services in Tehran, in which the Coronavirus disease significantly affected the medical service delivery system in Tehran. The number of calls to the EMS department increased by 347% before the outbreak of the Coronavirus, and the number of emergency missions increased by 21%. Moreover, after the epidemic, there was a significant increase in the main emergency services, fever and infectious diseases (211% increase), and respiratory symptoms (245% increase) [24], and these results are similar to the results of the present study.

One of the limitations of this study is that the data were collected monthly and recorded on a daily basis. Further, more observations would be available, and we could use more complex models, such as neural networks, for modeling.

CONCLUSION

The current research results showed that the trend of the number of cases related to accidents, compared to heart and respiratory diseases, which generally had a relatively constant trend, has been increasing during these years, and therefore, researchers and policymakers should pay serious attention to these cases. In addition, carbon monoxide poisoning in autumn and winter has not decreased during these years, which makes it necessary to spread advertisements and seriously deal with the prevention of these cases. Moreover, our results show that the COVID-19 pandemic and social restrictions led to changes in the use of emergency medical services. These findings emphasize the importance of developing new strategies and protocols in response to upcoming outbreaks and epidemics.

AUTHORS' CONTRIBUTIONS

M.K., M.T.S., and M.H.: Study conception and design contributed; M.M.: Data collection was performed; M.M., M.T.S., and F.J.: Analysis and interpretation of results were performed; H.T. and R.M.: The draft manuscript was prepared. All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

CM = Carbon Monoxide

ARIMA = Autoregressive Integrated Moving Average

WHO = World Health Organization

EMS = Emergency Medical Services

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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