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Road Traffic Injuries in Iran: Epidemiology and Equitable Distribution of Emergency Services

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ABSTRACT

Objective: This study emphasized the importance of providing equal access to rescue and emergency services for all individuals involved in road accidents, regardless of their geographical location or socioeconomic status.
Methods: This study involved gathering data on the number of Iranian Red Crescent Society (IRCS) and Emergency Medical Services (EMS) stations in 31 provinces of Iran. It entailed calculating the Gini coefficient and creating the Lorenz curve to assess the station distribution. To present road traffic injuries (RTIs) mortality, Disability-Adjusted Life Years (DALYs), and prevalence in Iran from 1990 to 2019, the Global Burden of Disease (GBD) 2019 estimates were utilized.
Results: The findings revealed that Tehran, Khorasan Razavi, Isfahan, Fars, and Khuzestan provinces were equipped with the most stations; whereas, Ilam, Semnan, and Kohgiluyeh and Boyer Ahmad had the fewest. The Gini coefficient for the distribution of RCS and EMS stations was found to be 0.23 and 0.38, respectively. Additionally, the study examined the prevalence, DALYs, and mortalities caused by road injuries across the 31 provinces and presented the findings in the form of a geographical representation.
Conclusion: The results of this study highlighted the importance of ongoing efforts to ensure the equitable allocation of RCS and emergency services, with a particular emphasis on road accidents and disaster management scenarios.

Keywords: Gini coefficient, Lorenz curve, Equity, Red crescent society.

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Introduction

The World Health Organization defines an emergency as any sudden occurrence or incident that necessitates immediate intervention, such as road injuries, severe illnesses, or natural disasters. Every country must incorporate a thorough plan for emergency and disaster preparedness into its developmental framework. The provision of complimentary, high-quality services to society members during emergencies is a governmental responsibility as well as a fundamental tenet of welfare and social security [1].

Natural disasters, such as earthquakes, hurricanes, floods, volcanic eruptions, mudslides, and landslides, are unavoidable phenomena with catastrophic consequences in terms of human injuries and financial damage. Earthquake damage can interrupt transportation systems and critical infrastructure, thereby impeding the operations of rescue vehicles, ambulances, and rescue teams [2].

Road Traffic Injuries (RTIs) are a major public health issue, resulting in a high mortality rate from unintentional injuries and imposing a considerable economic and societal burden [3]. Despite improvements in road injury mortality over recent decades, there is an escalating incidence rate and substantial geographical heterogeneity [4]. Several risk factors for road traffic injuries among different road users have been investigated, including age, sex, types of vehicles involved in collisions, and driver and environmental factors [5]. Road traffic accidents have been identified as a critical public health issue that requires multidisciplinary interventions for effective resolution [6].

Investments to prevent RIs necessitate a precise understanding of the types of injuries involved. This involves distinguishing between the rates and numbers of fatal and non-fatal injuries based on geography and income levels in the country [7].

One of the most critical factors that hinder response operations in disasters is the disruption of road infrastructure. Roads that are obstructed or destroyed make it more difficult to access essential facilities [8].

In the event of a road accident, the responsibility is to provide relief within the city through Emergency Medical Services (EMS) and outside the city through the Iranian Red Crescent Society (IRCS). The distribution of aid, rescue, and road emergency stations in the event of road accidents is a key element of public safety and disaster response. Equity in this distribution entails providing equal access to rescue and emergency services for all individuals involved in road accidents, irrespective of their geographical location or socioeconomic status. This study aimed to investigate the equity in the distribution of rescue stations of the IRCS and EMS across the country, utilizing the Gini coefficient index and the Lorenz curve.

Materials and Methods

Lorenz Curve and Gini Coefficient

The Lorenz curve, developed by American economist Max Lorenz in 1905, serves as a graphical representation of wealth or income distribution inequality within a society. Despite its widespread application in econometrics, its potential use in public health research remains largely unexplored. The Lorenz curve visualizes the dispersion of a probability distribution, enabling the assessment of the concentration of specific measures within a population, such as wealth or disease risk [9, 10].

Indeed, the Lorenz curve is a statistical tool with the potential for broader application in public health research [9]. In this diagram, the 45-degree line represents total income equality. The greater the deviation of the Lorenz curve from this line of equality, the greater the income distribution inequality.

The present study compared the number of Red Crescent rescue and emergency stations using both the Lorenz curve and the Gini coefficient. The following measures were taken:

1. Data Collection: The data, including the number of EMS and RCS stations, was acquired through correspondence with the relevant organizations.
2. Lorenz Curve Analysis: The cumulative percentage of the population was plotted on the Y-axis, and the cumulative number of RCS and EMS stations was plotted on the X-axis.
3. Gini Coefficient Calculation: The Gini coefficient for the distribution of RCS and EMS stations was calculated using the below formula:

Gini Coefficient=A/A+B

The Gini coefficient ranges from 0 (complete equality) to 1 (total inequality).

Prevalence, DALYs, and Death of Road Injuries of Provinces

This study utilized data from the Global Burden of Diseases (GBD) to analyze the prevalence of road injuries, deaths caused by road injuries, and disability resulting from them across 31 provinces across the country. This data was subsequently compared and shown as a map, providing a visual representation of the variations in these factors across different regions of the country. GBD estimates incidence, prevalence, mortality, years of life lost (YLLs), years lived with disability (YLDs), and DALYs for 369 diseases and injuries, for both sexes and across 204 countries and territories. Input data were extracted from censuses, household surveys, civil registration and vital statistics, disease registries, health service use, air pollution monitors, satellite imaging, disease notifications, and other sources. A detailed description of the GBD 2019 methodology was provided in previous publications.

All estimations used in the present study were extracted from the GBD 2019 study, whose data are publicly available at https://vizhub.healthdata.org/gbd-results/.

Definitions Cause of Death Categorization for RIs GBD 2019

Pedestrian RIs are defined as the death or disability caused by a collision with an automobile, motorcycle, pedal cycle, or other vehicles while walking on the road. Cyclist road injuries are defined as the death or disability caused by an unintentional incident as a cyclist or passenger on a pedal cycle. Motorcyclist road injuries are defined as the death or disability that is caused by being a rider or passenger on a motorcycle or motorbike. Motor vehicle road injuries are also known as the death or disability occurring as the result of being a driver or passenger in a motor vehicle. Other road injuries are considered as the death or disability resulting from being a driver or passenger in a vehicle other than an automobile, motorcycle, or bicycle [11].

Results

Lorenz Curve and Gini Coefficient

In terms of population distribution, Tehran (16.73%), Khorasan Razavi (8.12%), Isfahan (6.46%), Fars (6.12%), and Khuzestan (5.94%) were the five most populated provinces, ranking first to fifth, respectively, among the 32 provinces. Conversely, the provinces of Ilam (0.73%), Semnan (0.89%), and Kohgiluyeh and Boyer Ahmad (0.9%) had the lowest population, making them the least populated provinces in the country (Table 1 and Figure 1).

When considering the distribution of RCS stations across each province, the provinces of Isfahan (6.63%), Mazandaran (5.84%), Fars (5.52%), East Azerbaijan (5.05%), and Razavi Khorasan (4.89%) had the highest number of stations. Conversely, the provinces of Kohgiluyeh and Boyer Ahmad (1.1%), Qom (1.42%), Alborz (1.73%), and Zanjan (1.89%) were equipped with the fewest number of stations (Figure 2).

When considering the distribution of EMS stations across each province, the provinces of Isfahan (9.82%), Tehran (9.16%), Bushehr (8.05%), Khuzestan (7.09%), and Ilam (5.29%) were equipped with the highest number of stations. On the other hand, the provinces of Razavi Khorasan (1.22%), Hormozgan (1.31%), Qom (1.43%), and Qazvin (1.49%) had the fewest number of stations (Figure 3).

Table 1. Population, RCS, and emergency station shares (% as Total)

Province Name	Population share (% as Total)	RCS station share (% as Total)	Emergency station share (% as Total)
Alborz	3.42	1.73	2.03
Ardabil	1.60	2.21	1.82
Bushehr	1.47	2.52	8.05
Chaharmahal and Bakhtiari	1.20	3	1.55
East Azerbaijan	4.12	5.05	4.10
Isfahan	6.46	6.63	9.82
Fars	6.12	5.52	2.06
Gilan	3.19	3.63	1.76
Golestan	2.36	2.68	2.00
Hamadan	2.19	3	1.73
Hormozgan	2.24	2.84	1.31
Ilam	0.73	2.52	5.29
Kerman	3.99	4.10	5.08
Kermanshah	2.46	2.68	2.15
Khuzestan	5.94	3.63	7.09
Kohgiluyeh and Boyer-Ahmad	0.90	1.1	5.29
Kurdistan	2.02	2.36	1.67
Lorestan	2.22	3.15	1.64
Markazi	1.80	2.36	3.83
Mazandaran	4.14	5.84	1.94
North Khorasan	1.09	2.36	3.29
Qazvin	1.61	2.68	1.49
Qom	1.63	1.42	1.43
Razavi Khorasan	8.12	4.89	1.22
Semnan	0.89	2.36	1.52
Sistan and Baluchestan	3.50	4.26	4.58
South Khorasan	0.97	3.94	2.33
Tehran	16.73	3.63	9.16
West Azerbaijan	4.12	3.31	2.99
Yazd	1.44	2.05	1.64
Zanjan	1.33	1.89	1.79

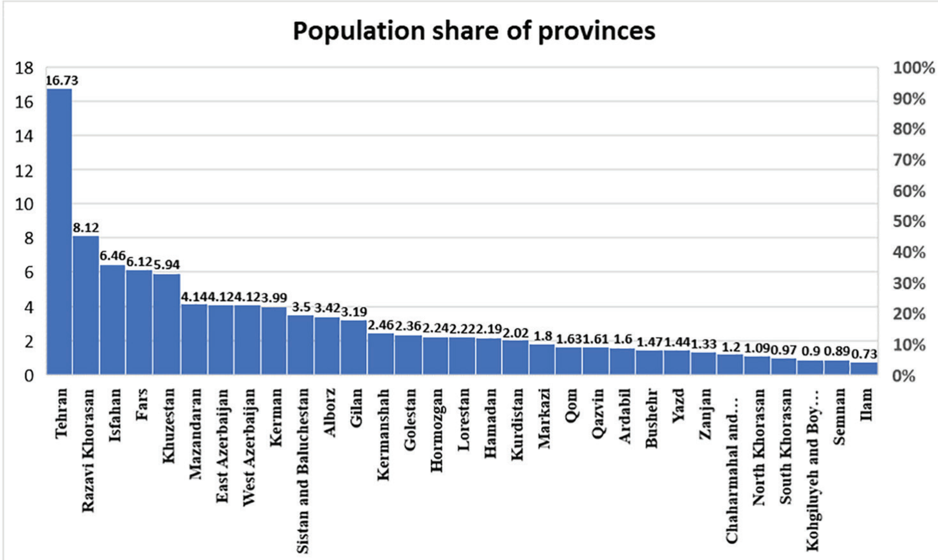

Fig. 1. The share of provinces in the total population of the country

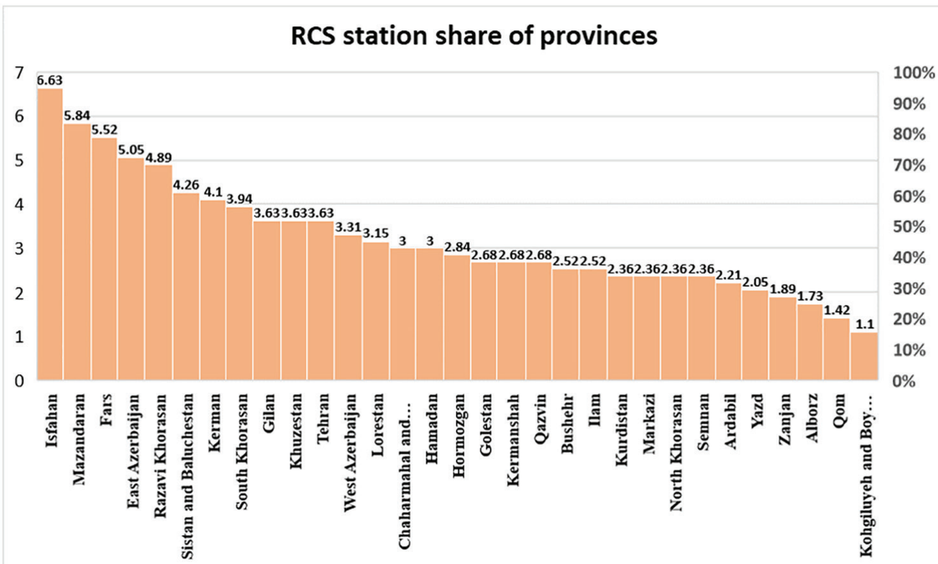

Fig. 2. The share of provinces in the total RCS stations of the country

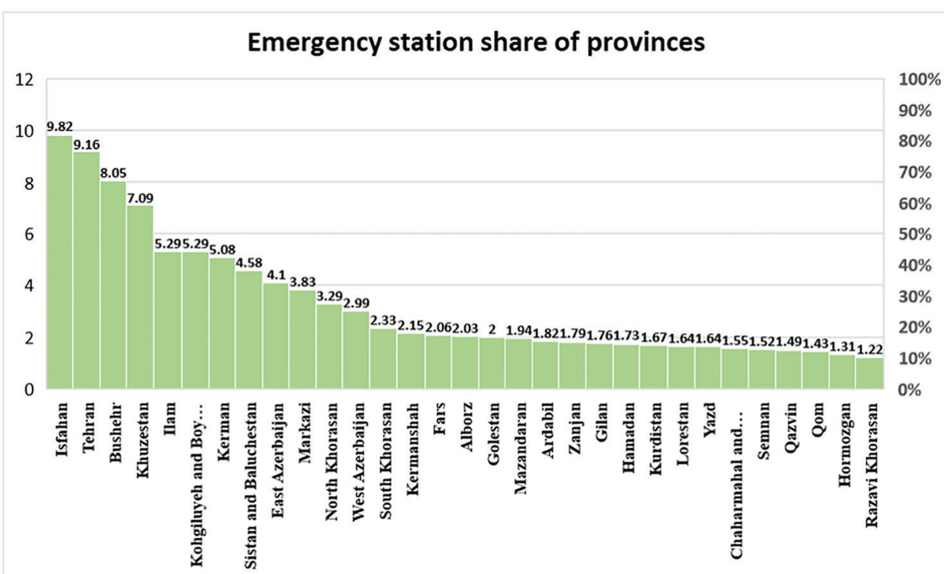

Fig. 3. The share of provinces in the total EMS stations of the country

Utilizing data derived from RCS and EMS stations, the Gini coefficient was computed and the Lorenz curve was subsequently plotted (Figure 4). The Gini coefficient, estimated based on the number of emergency stations across 31 provinces of the country in relation to the population, was determined to be 0.38. Furthermore, the Gini coefficient, computed using the number of RCS stations across 31 provinces, was found to be 0.23. Given that these coefficients were less than 0.5, it could be inferred that the distribution of RCS and EMS stations was equitable. However, the distribution of RCS stations was found to be more equitable than the distribution of EMS stations.

Prevalence, DALYs, and Death of Provinces in Road Injuries

In the context of road injury prevalence, Zanjan, Qazvin, Markazi, Khorasan Razavi, Fars, and Kerman exhibited higher rates in 1990 than in other provinces. By 2019, Kerman, Fars, Sistan and Baluchistan, Mazandaran, and Hormozgan had the highest rates of road injuries (Figure 5).

In 1990, the provinces of North Khorasan, Razavi Khorasan, South Khorasan, Kerman, Kurdistan, and Hamedan reported higher Disability-Adjusted Life Years (DALYs) due to road injuries than other provinces. By 2019, Mazandaran, Kerman, Fars, Kohgiluyeh and Boyer Ahmad, Sistan and Baluchistan, and Hormozgan experienced higher DALYs due to road injuries than other provinces (Figure 6).

In 1990, North Khorasan, Razavi Khorasan, Kerman, Kurdistan, Hamedan, and Markazi reported a higher incidence of fatalities due to road injuries than other provinces of the country. By 2019, the provinces of Golestan, Hamedan, Kerman, Fars, Sistan Baluchistan, and Hormozgan had more traffic injury-related deaths than any other provinces (Figure 7).

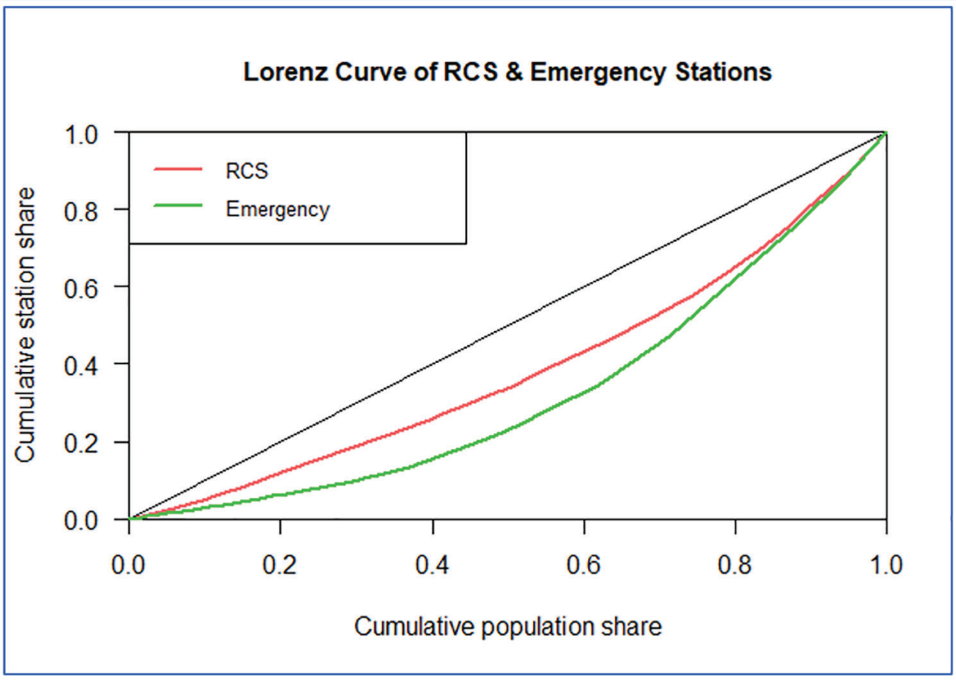

Fig. 4. Lorenz Curve of RCS and EMS Stations

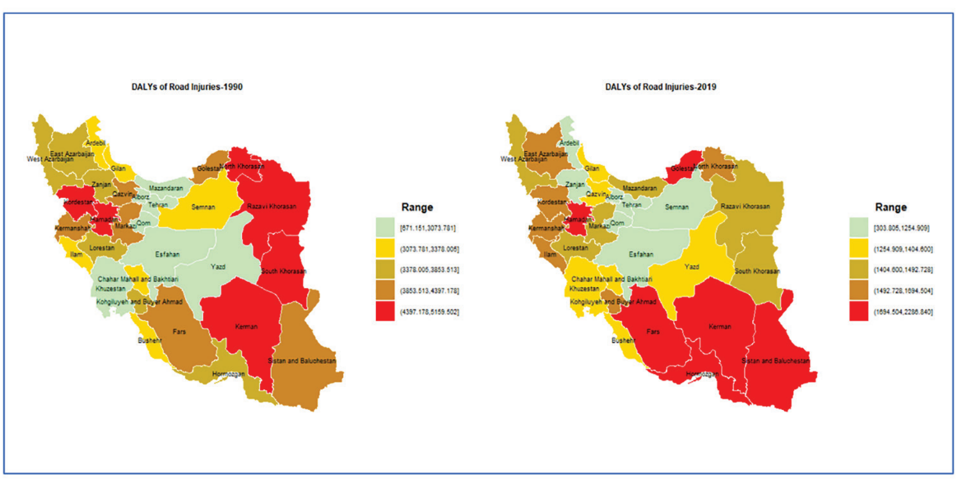

Fig. 5. The prevalence of road injuries in 31 provinces of Iran (1990 & 2019)

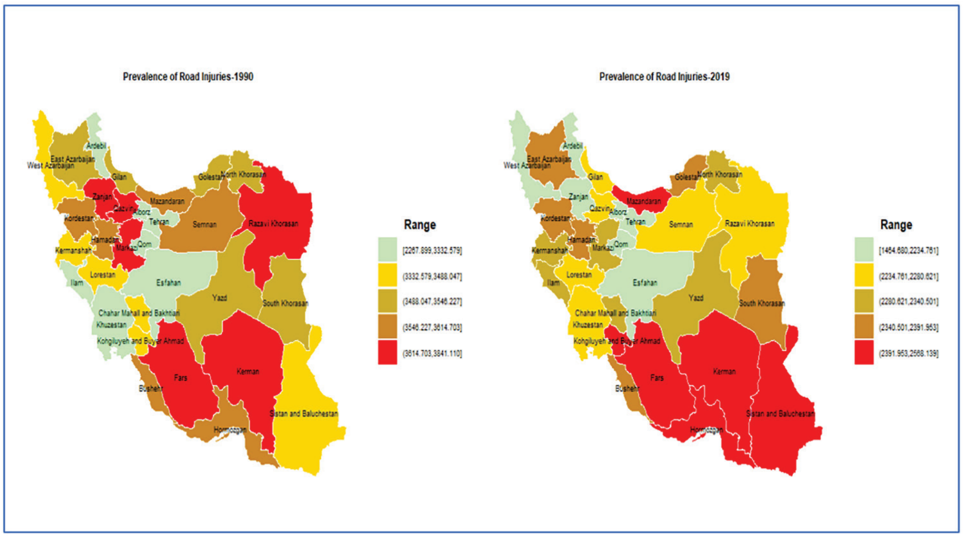

Fig. 6. The DALYs of road injuries in 31 provinces of Iran (1990 & 2019)

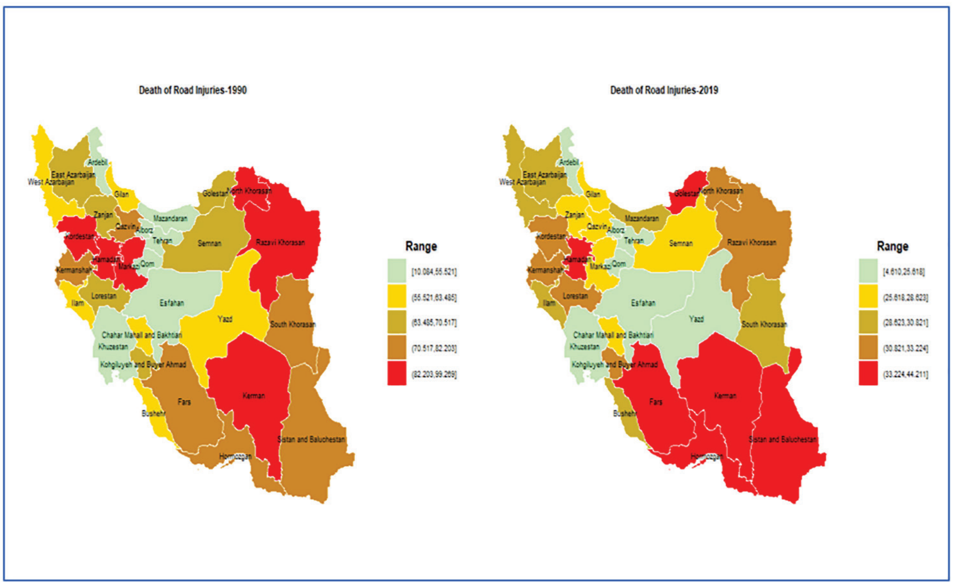

Fig. 7. The Death of road injuries in 31 provinces of Iran (1990 & 2019)

Discussion

Disaster management is generally categorized into four phases: mitigation, preparedness, response, and recovery. The preparedness phase entails ensuring that essential equipment, such as first aid kits, tents, and ambulances, is readily available and appropriately positioned for deployment [12]. The establishment of rescue stations and the planning of rescue paths are two critical tasks in urban emergency response. Emergency rescue program planning primarily involves determining the locations of rescue stations and planning rescue routes, taking into account the locations of evacuees, road network information, and constraints related to rescue vehicles [13].

Iran has one of the world's highest road mortality rates. Road accidents are the third leading cause of death in Iran, following coronary artery disease. Furthermore, the estimated cost of damages caused by accidents in Iran exceeds $600 billion [14]. The relief distribution strategy constitutes a significant component of disaster management operations [15]. The distribution of RCS and emergency stations across the 31 provinces of Iran was investigated using the Lorenz curve and the Gini coefficient. The Lorenz curve of relief and rescue stations was closer to the equality line, with a Gini value of 0.23. The Lorenz curve of the emergency stations was farther from the equality line than the relief and rescue stations, and its Gini coefficient was 0.38. Although the distribution of bases in both categories was considered fair, the distribution of relief and rescue stations was more equitable.

Road traffic injuries and deaths are significant concerns for the Iranian government, and several interventions have been implemented in recent years to prevent accidents and reduce fatalities. Imposing heavy fines on offending drivers and enhancing police control are two of the main activities that have been carried out in recent years [16]. Additionally, the establishment of robust emergency response networks and the swift transfer of injured individuals from accident scenes have proven to be highly effective in reducing fatalities and impairments caused by accidents. In recent decades, numerous studies have been conducted on EMS systems to enhance decision-making strategies, which are of high importance. Balancing efficiency and equity, service quality and cost, and dealing with the intrinsic stochastic nature of the EMS system pose challenges in making optimal decisions [17]. Large quantities of relief supplies, including water, tents, medical supplies, and fuel, are necessary in the aftermath of a major disaster. Meeting the needs of the affected individuals is crucial for the success of disaster relief operations, as a shortage of relief supplies can cause pain and death among the victims [18].

This study had limitations due to the use of the Gini coefficient index, which only measured the distribution of a desired variable based on population and did not consider other factors such as province size, road surface area, number of deaths, and prevalence of road accidents. Therefore, the distribution of data was entirely population-based. To investigate all factors involved in road accidents, future studies should consider multiple causes that affect road accidents, investigate the effect of influencing variables other than population, and explore the data distribution. The study focused on the distribution of rescue and emergency stations based on population. It is recommended that future studies investigate the distribution of data by considering additional factors such as geographical location, socio-economic aspects, and regional infrastructure to embrace a more comprehensive approach to assessing equity. Besides, future research can explore optimizing models and decision support systems to enhance the efficiency and effectiveness of disaster relief operations. The present study provided several policy recommendations. These recommendations included conducting a comprehensive needs assessment to identify underserved areas and allocate new stations, accordingly. It is important to clearly define guidelines and rules for the fair distribution of rescue and emergency stations, considering factors such as population, road network, and historical accident data. A centralized emergency management system should be developed to facilitate real-time information sharing and resource allocation across different agencies and jurisdictions. Additionally, ensuring the availability of rescue and emergency services requires allocating sufficient funds and resources to maintain and upgrade the road infrastructure.

In conclusion, the findings of this study highlighted the importance of sustained endeavors to guarantee the equitable allocation of rescue and emergency services, with a particular emphasis on road accidents and disaster management scenarios. By rectifying the imbalances in station distribution and prioritizing equal access, Governments and relevant organizations could improve the efficacy of emergency responses and play a significant role in mitigating the effects of road injuries and other emergencies on individuals and communities.

Declaration

Ethics approval statement: This study was a part of the research project that was conducted at the Research Center for Emergency and Disaster Resilience. The ethics Number was IR.RCS.REC.1401.025.

Consent for publication: All authors expressed their consent to the publication of this study.

Conflict of Interest: The authors had no conflict of interest.

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Authors' Contribution: PK, PS, SA, and PN designed and coordinated the study. SR and AP performed statistical analyses. SR and FK drafted the manuscript. SA, FK, MR, SJE PS, and BR critically reviewed the manuscript. All authors have read and approved the manuscript.

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Data availability: Available.

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