Evaluating and Prioritizing Factors Affecting Road Traffic Accident Relief in Iran

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Abstract

BACKGROUND: Timely delivery of emergency care and reducing the transmission time of injured people to health centers is very effective in reducing the number of deaths and injuries in accidents. The purpose of this study was to evaluate the factors affecting road traffic accident relief in Iran with an emphasis on air transport.

METHODS: The present study was performed through resorting to Multiple Attribute Decision Making (MADM) statistical techniques and operation research like analytic hierarchy process (AHP) by means of establishing hierarchy process, pairwise comparisons, combining weights, analyzing sensitivity, and ranking method, which were compatible with the research methods and type of variables. The study population consisted of 3759 managers, faculty members, experts in the field of rescue, and relief, and traffic users. 349 participants were selected using Cochran sampling method. They answered a researcher-made questionnaire about the factors affecting road traffic accident relief in Iran, which validity and reliability were approved. The collected data and research hypotheses were considered through statistical test. Expert Choice software was used to facilitate the process of research.

RESULTS: Human factors, equipment factors, managerial factors, and environmental conditions criteria with relative weights of 0.3810, 0.3738, 0.2149, and 0.0303, respectively, had the highest effect on human casualties in rescue operations. Assessment of sub-criteria showed that the lack of a functional structure and appropriate organization to lead rescue operations, emergency and hospital personnel with lack of enough expertise and skill, and delays in rescue and increase in the time of rescue had the first places of importance, respectively. Finally, prioritizing rescue operations based on the type of transportation indicated that air emergency, ground emergency, and Red Crescent rescue and relief, had respectively the first, second, and third places in affecting the decrease in human casualties.

CONCLUSION: Lack of expertise and skills of staff, equipment failure, and lack of systematic structure in relief systems have increased damage to the injured, and by creating substructure, air rescue is a priority in reducing human casualties compared to land relief.

Keywords: Analytic Hierarchy Process (AHP); Road Traffic Accident; Rescue; Air Transport

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Introduction

A quick look at the high rate of traffic accidents in the country can reveal the importance of the road accident relief. The Red Crescent and the Emergency are among the leading health and safety officials in this field, committed to providing high quality services in this regard.

In addition, factors including the uncertain nature of the incidents, deficiencies in timely

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Factors Affecting Road Traffic Accident Relief

preparation, scene commanding and management, inadequate expertise and experience in transferring the injured, improper provision of advanced life support (ALS) and basic life support (BLS), lack of appropriate equipment, adverse environmental conditions, and several other factors provide the ground for disruption and risk as well as the diminished quality of road rescue operations. Therefore, the increased risk causes increased injuries and deaths, and ultimately high costs to the relief system and the injured in this field. One of the key elements of safety management systems is hazard identification, risk assessment, and their control, helping the experts to make reasonable decisions to diminish the probability of accidents and the severity of their consequences performing necessary investigations (1).

As a medical relief system, air rescue has certain advantages such as reduced travel time and the ability to provide relief in urban and rural areas and even the seas, although these facilities are closely related to the geographical location of the region and the capability of the system. In many provinces, rescue helicopters play the role of accident support, the most important task of which being transporting patients to the nearest hospital center. The unique facilities of helicopters to deliver fast, stable, and effective service are in contrast with the planning problems and high cost of this system, which has reduced its acceptability in the third world countries (2).

The injured people relieved by the air rescue system will benefit from its three main features compared to the road rescue system during the early moments of the relief operation. Important benefits of this system include access to impassable areas, reduction in time of the early rescue, and faster transfer of the injured to medical centers. So, from a functional viewpoint, comparing the two abovementioned relief systems given the large number of people rescued from inevitable death by air ambulances will yield a definite result (3).

In Iran, due to functional problems such as the lack of facilities for helicopters to be deployed in all hospitals, their use to transfer patients from one medical center to another has been paid less attention. As, one of the most important issues in providing timely services to the individuals in need of rescue is the optimal location of deployment of the helicopters (4).

Establishing a base in any urban area by study can provide the fastest service to patients, however given the limitations in urban spaces and lack of access to sufficient helicopters and trained personnel, advanced studies to determine optimal locations for rescue centers, especially in residential areas is of paramount importance (5).

In a study on patients transported by rescue helicopters to Imam Khomeini Hospital in Tehran, Iran, Alamdari et al. found that out of 158 patients studied, 92% were injured by an accident and the average time between patient arrival to the emergency room and the first physician visit was 23 minutes. They concluded that the use of an appropriate criterion for screening of air rescue patients was necessary (6).

Farahani Deljoo et al. employed the Healthcare Failure Mode and Effect Analysis (HFMEA) model to identify and analyze potential errors in road rescue operations and divided the road rescue operations into 2 processes, 12 sub-processes, and 3 activities. They identified potential analysis and errors for each activity; in total, of the errors identified, 48%, 24%, and 11% was associated with manpower, equipment failure, method and process, respectively, with rest related to the system, environment, and so on (7).

Shiri et al. indicated that there was a positive relationship between different geographical, human, socio-educational, and logistic (support) factors of road rescue posts and decrease in the number of casualties leading to death in roads of Ilam, Iran. Additionally, equipping and upgrading the fleet of road rescue posts from different dimensions can have a positive impact on reducing road accidents in Ilam from the perspective of drivers of different types of vehicles (8). Other studies have reported similar results (9).

An investigation by Ra Saraei Pour et al. showed that the suitability and timeliness are among the most important goals to show the quality of services (10). In addition, Ghezavati and Soltanzadeh found that the effective location of the relief equipment prior to a crisis is one of the most important strategies to improve performance and decrease delay in relief (11).

The present study was accomplished aiming to evaluate and prioritize the factors effective in road traffic accident relief in Iran using the analytic hierarchy process (AHP) method and to examine the facilities and limitations of the air relief taking into account its costs and cost-benefit analyses in the application of this system.
Materials and Methods

This study is of the library type in terms of data collection, applied in terms of purpose and nature of the subject studied, descriptive in terms of the research method and area of social investigations, descriptive-analytical in terms of approach and problem-solving manner, and survey in terms of use of the questionnaire technique to collect information. The statistical population of the study included managers, professors, rescue and traffic specialists, and traffic users. The total statistical population was 3759, 349 of whom were selected based on Cochran sampling formula.

Then, using a researcher-made questionnaire, the validity and reliability of which were examined, factors affecting traffic accident relief were identified. Then, using statistical techniques and Multiple Attribute Decision Making (MADM) operational research, including AHP, the factors affecting traffic accident relief were ranked. Moreover, the Expert Choice software was utilized for quickly conducting of this study.

Results

In this study, four main criteria were specified in order to prioritize the factors contributing to the increase in traffic accident casualties in rescue, including human factor, equipment factor, management and procedures factor, performance, and environmental circumstances. Then, the pairwise comparisons matrix of decision-making was obtained after constructing the model in the Expert Choice software and entry of the pairwise comparisons of indices and weight of the criteria and sub-criteria. The AHP analysis revealed that the human, equipment, management, and environmental condition criteria with relative weights of 0.3810, 0.3738, 0.2149, and 0.0303 had the highest effect in increasing the relief for the traffic accidents, respectively. The inconsistency rate of the pair-wise comparisons was found to be 0.02 and, since it was less than 0.1, these comparisons were acceptable.

In the prioritization of relief based on the type of vehicle, the air relief, ground emergency, Red Crescent relief, rail relief, and marine relief with a relative weight of 0.3150, 0.3130, 0.2900, 0.0470, and 0.0350 respectively ranked first to fifth in terms of effect on reducing the human casualties.

Table 1 demonstrates the ranking of the sub-scales and prioritization of the sub-criteria of the factors affecting the traffic accident relief. It is observed that the lack of a common structure of the case with a relative weight of 0.2380 with the first priority had the greatest role in providing relief for the traffic accidents. Furthermore, the lack of expertise and sufficient skills of the relief and hospital staff, delay in relief and increase of relief time, lack of air emergency facilities, lack of ground emergency equipment (motorbike and automotive), deficiency in relief and hospital equipment, inappropriate climatic conditions, and lack of comprehensive information management system with a relative weight of 0.0900, 0.0735, 0.0690, 0.0600, 0.0549, 0.0021, and 0.0012 ranked first to seventh, respectively.

Discussion

In this study, four main criteria with 22 sub-criteria, were identified as effective factors in increasing human casualties in road traffic accident rescue and relief. In order of impact, these criteria were human, equipment, management and procedures, performance, and environmental conditions, respectively. In addition, various potential causes of errors that could interrupt or disrupt the process were identified. After analyzing the system errors, corrective actions in the system can contribute to improving the desired process and enhancing the safety of activities.

In the ranking of the sub-scales, the lack of a common structure and proper organization to conduct the rescue operations, the lack of expertise and sufficient skills of the relief and hospital staff, delay in relief and increase of relief time, lack of air emergency facilities, and lack of ground emergency equipment (motorbike and automotive) ranked first to fifth, respectively.

In relief prioritization by vehicle type in the order of rescue, emergency, Red Crescent relief, rail relief, and marine rescue had the greatest effect on reducing human casualties.

The results of the present study are consistent with those of the studies by Haghani and Oh (12), Ozdamar et al. (13), Campbell et al. (14), Chahar Soghi Amin et al., Rasouli et al. (9), Ghezavati and Soltanzadeh (11), and Farahani Deljoo et al. (7) Therefore, it is recommended that improving measures be provided for each of the criteria and sub-criteria and their reasons in terms of educational, equipment, process, technological, and other measures.
Table 1. Criteria and sub-criteria of factors affecting road traffic accident relief using the Expert Choice software

<table>
<thead>
<tr>
<th>Rank in total</th>
<th>Relative weight</th>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Rank in the sub-criterion</th>
<th>Relative weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>0.3810</td>
<td>Human factor</td>
<td>Personnel depression</td>
<td>9</td>
<td>0.0543</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insufficient expertise and skills of relief and hospital staff</td>
<td>2</td>
<td>0.0900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insufficient training (knowledge of personnel and people)</td>
<td>10</td>
<td>0.0450</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human resources shortage</td>
<td>7</td>
<td>0.0547</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rescue team mistaken routing</td>
<td>19</td>
<td>0.0090</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Delay in relief and increase in relief time</td>
<td>3</td>
<td>0.0735</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fatigue and motivelessness of staff</td>
<td>8</td>
<td>0.0545</td>
</tr>
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<td></td>
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<td></td>
<td>Fatigue and motivelessness of staff</td>
<td>8</td>
<td>0.0545</td>
</tr>
<tr>
<td>Second</td>
<td>0.3738</td>
<td>Equipment</td>
<td>Deficiency in air emergency facilities</td>
<td>4</td>
<td>0.0669</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lack of ground emergency facilities (motorbike and automotive)</td>
<td>5</td>
<td>0.0600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Failure of hospital and rescue equipment (procedure intervention equipment, endotracheal tube, venipuncture, serum therapy, and neck collar fixation)</td>
<td>6</td>
<td>0.0549</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lack of common electronic system</td>
<td>11</td>
<td>0.0500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improper location and deployment of facilities, bases, and teams</td>
<td>12</td>
<td>0.0490</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Failure to set up and launch new rescue bases</td>
<td>14</td>
<td>0.0460</td>
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<td></td>
<td></td>
<td></td>
<td>Lack of a comprehensive information management system using information networks</td>
<td>22</td>
<td>0.0012</td>
</tr>
<tr>
<td>Third</td>
<td>0.0303</td>
<td>Procedures, functions, and environmental conditions</td>
<td>Defective rules and regulations</td>
<td>20</td>
<td>0.0038</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inappropriate road conditions</td>
<td>18</td>
<td>0.0100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inappropriate climatic conditions</td>
<td>21</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mental issues governing the scene</td>
<td>17</td>
<td>0.0144</td>
</tr>
<tr>
<td>Fourth</td>
<td>0.2149</td>
<td>Management factors</td>
<td>Lack of a common structure and proper organization to conduct rescue operations</td>
<td>1</td>
<td>0.1600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Parallel operation of the beneficiary organization in rescue</td>
<td>15</td>
<td>0.0300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lack of a unit management and lack of inter-organizational coordination</td>
<td>16</td>
<td>0.0237</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lack of a comprehensive information management system using information networks</td>
<td>22</td>
<td>0.0012</td>
</tr>
</tbody>
</table>
Given the high percentage of human errors and equipment shortcomings, most of the measures must be around these two criteria, and given the nature of these operations, which is a human-centered process, requires the serious attention of the organization to specialized training of personnel involved in the relief process. In addition, in most cases, due to the inadequacy of the charts of the rescue teams, the relief teams encounter difficulties delivering services, and cases such as venipuncture, emergency treatment, etc. are not performed due to a lack of technicians, and in several cases, the lives of the injured individuals are endangered. In some cases, the type and causes of errors are such that it involves all or part of the responsible organs in the rescue process. In such cases, only providing the solution and problem-solving provided by the Red Crescent and the emergency are not effective, rather it is necessary to design some kind of interactive decision-making between the partner organizations and specify the way in which each of them operates, in addition to the re-examination of their relationship.

Management criteria (lack of proper organization structure for directing rescue operations, parallel operation of the organization in the rescue provision, lack of a unified management and lack of inter-organizational coordination, lack of comprehensive information management system using information networks) are also effective in increasing the relief human casualties. Additionally, although the existing approvals have separately described the tasks of each organ in traffic accidents, the lack of coordination has sometimes led to irreparable consequences; in this case, the formation of these organs in the form of a unified organization can be a helping offer.

It can be claimed that implementing a scientific system to document potential defects and errors (human, process, equipment, management, etc.) in the implementation of road rescue processes provides the primary information required to assess the safety and health of the rescue operations in a desirable way. It is worth noting that careful improvement and controlling of these activities can minimize the possibility of errors and their consequences in a preventive manner, provide the ground to improve the quality of service and diminish the risk of rescue operations, and reduce mental and physical injuries and casualties for the injured and rescue personnel, in addition to improving resource management in relief organizations. Haghani and Oh performed a case study of relief in crisis despite the diversity of goods and networks, and assuming that the goods move from one node to the next, they allocated the shortest time to the most important goods and defined the capacity of the good transmission system as a function of time. Their objective was to minimize travel costs; to do this, they employed a heuristic approach assuming three transport models, three origins, and two destinations (12).

Furthermore, Ozdamar et al. addressed the logical coordination of relief operations, focusing on the transfer of the injured to relief centers. An important part of their model was related to the allocation of medical teams to rescue centers, however they ignored the subjects of location of the clinics (13). Sheu modeled a logical network consisting of relief centers, commodity distribution centers, and relief demanding points and proposed that this model be considered in the phases of predicting relief time changes, categorizing the affected areas, determining distribution priorities, and performing relief operations (15).

Tzeng et al. addressed a multipurpose relief distribution model to minimize travel costs and time and maximize system satisfaction. Their network consisted of five warehouse points, eight rescue demanding points, and four good transfer stations (4). Moreover, Chern et al. studied a similar network with four warehouses, four distribution stations, and eight demand points, in addition to refueling stations. They conducted their studies on the basis of two categories of demand: one as the input requests such as food, water, and medical relief, and the other as the output requests such as the dead, the injured, and the like (16).

In the study by Campbell et al., the average patient transfer time was 23.5 minutes, and despite using a helicopter as a fast but costly device, the fastest patient visit made by the physician at the moment of arrival was 210 minutes later (14). A study carried out by Matsumoto et al. on using the air rescue system in Japan, it was found that the death rate was reduced by 30% and the number of people who fully recovered after using this system increased by about 150% (17).
the results of the presented study revealed that air relief ranks first in providing relief, and issues such as service in times of lack of access to cars in some areas, road closures and inaccessible areas, helicopter capability in sea relief, and the like are among the strengths of this system. Meanwhile, the high cost of upgrading the air fleet, deploying the system comprehensively, and maintaining it are among the most important issues that have made difficulties for the planners and decision makers to use this system widely. Given the models presented, relief should be provided in such a way that the shortest distance traveled is achieved with the most productivity in the time consumed. However, due to the shortage of rescue air bases and the long distances of these bases, as well as the lack of the rescue helicopter in the Iranian Red Crescent Rescue Organization, the wide and economical use of this system in the country is not feasible. In order to increase the efficiency of air relief systems, providing a suitable model for deploying helicopters at the appropriate distances and providing services at the shortest time with the maximum speed and the shortest distance traveled can be helpful.

Conclusion
In this study, the factors affecting traffic accident relief was investigated with an emphasis on air rescue and the benefits, impacts, and limitations of using the air relief systems. Based on the findings and the issues discussed in this study, the following proposals are made to modify these processes:

1. Establishing common structures and unified management in rescue and preventing the parallelism of the relevant organizations
2. Launching a common electronic system and intelligent transportation systems for relief and rescue routing and proper deployment of facilities, bases, and teams, preventing delays in relief, and increasing rescue and location time.

Creating infrastructure and enhancing air emergency and ground emergency (motorbikes and automotive) facilities and eliminating emergency equipment defects.

Conflict of Interests
Authors have no conflict of interests.

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