Investigating the Factors Affecting the Collision of Two Passenger Trains: A Case Study

Adel Eftekhari[1], Samaneh Mirzaei[1], Roohangiz Norouzinia[2,3], Golrokh Atighechian[3] iD

[1] Department of Health in Emergency and Disaster, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[2] School of Paramedical Sciences, ALborz University of Medical Sciences, Karaj, Iran
[3] Department of Health in Emergencies and Disaster, School of Management and Medical Information Sciences, Management and Health Economic Research Center, Isfahan university of Medical Sciences, Isfahan, Iran

ARTICLE INFO	ABSTRACT
ORIGINAL ARTICLE **Article history:** Received: 23 Des 2017 Revised: 7 Jan 2018 Accepted: 10 Feb 2018 ***Corresponding author:** Golrokh Atighechian **Address:** Health in Emergencies and Disaster, School of Management and Medical Information Sciences, Isfahan university of Medical Sciences **Email:** atighechian_golrokh@yahoo.com **Tel:** 09131292858	**Introduction:** Recognizing the factors affecting rail accidents plays a very important role in preventing its recurrence in the future. This study aimed to investigate the factors affecting the collision of two passenger trains near the "Haft Khan Station" between Semnan-Damghan in 2016. **Method**s: This case study was conducted to collect data from documentation and reports available at news websites and scientific associations, incident reports, and on scene observations of the staff. **Results**: After describing the accident and exploring the obvious causes of its occurrence, the underlying factors in the accident were identified in three groups: management, individual and environmental conditions. **Conclusion**: The results of the study showed that there are many factors involved in accidents and controlling the effective factors can prevent the occurrence of these events. **Keyword:** Analysis, Incidence, Transportation

Introduction

Rail transport has been occurred for over 150 years in the world. Developing a variety of transportation methods has caused widespread accidents (1). Rail crashes have been underestimated due to the high rates of road and air crashes, while the figures show that the rate of rail crashes in Iran is much higher than the average global rate due to the density of railways. However, the density of Iranian railways is very low, as the 12 provincial capitals are still outside this network and the share of rail passenger transportation is 8% and load share 12% of the total freight transport in the country (2).

Although rail transport safety has improved in the United States during the last 2.5 decades, train accidents have increased in the rail transport industry (3). A significant number of these major rail accidents are due to a hierarchy of systematic

failure to comply with principles and guidelines (4).

Due to the importance of safety in rail transport, recognizing the factors affecting the occurrence of rail accidents is one of the important goals of the railway industry.

Many accidents occur due to multiple complex factors that defeat or neutralize the security shields and the protective layers of the system (5, 6). The statistics show that more than half of the accidents in Iran railways are related to human factors, as it is shown that 59 and 62 percent of railway accidents were related to human factors in the years 91 and 92 respectively (7).

Attributing accidents merely to human errors might not be logical. Therefore, the errors and consequences of the accidents are, in general, the effect of several factors, such as poor design of the workstation, unbalanced work environment, complex operation process, insecure working conditions, inadequate and faulty maintenance, overemphasis on production or product, inefficient training, non-responsive or passive management system, poor planning and, ultimately, poverty or poor awareness of safety in the organization (5). Certainly, the occurrence of errors and mistakes governed by the interference and influence of human beings is unavoidable. In an important complex such as railroad, in the important section such as the way and movement this error sometimes appeared in the form of accidents, and consequently irreparable financial and bodily injury (8, 9).

The catastrophic collision of two trains at Haft khan station in Semnan province in 2016, which killed 47 passengers and wounded 103 people, must strictly be investigated. The collision of two trains in Semnan was not the first rail accident in the country. Earlier on November 29, 2003, a cargo train in Neyshabur was blown up due to technical problems at the station. The explosion strength based on a professional analysis was equivalent to the destruction power of 180 tons of TNT. It was so severe that led to the destruction of several surrounding villages and the sound of the explosion reached Mashhad city, too. The

catastrophic collision of the two trains at Haft Khan Station in Semnan province was similar to the one took place on June 2014, followed by two trains running along Tehran-Mashhad at Amuran-Damghan Station. In the accident of 2014, passing of red light at the entrance to the station beyond speed limits and redirection and the incorrect announcement of the station control operator were announced as the main causes of the tragedy of the Tehran-Mashhad train. In the reports of train accidents, poor safety awareness, inadequate training, lack of additional defense systems, failure to fully implement safety systems, failure to track down deficiencies are among the other causes of these incidents (4). Considering the progress of rail transport in Iran as well as the widespread social and economic consequences of accidents in this section, the investigation of rail accidents is of particular importance because the investigation and analysis of these accidents is the first step in reducing accidents and improving the safety. The specific situation of Iran in the region and the proper transit and geographical conditions of the country and the need for the development of the transport sector show the importance of investigation of rail accidents, since the investigation of these accidents will be the first step in reducing disasters and improving safety (10). The purpose of this study was to investigate the causes of the accident, taking into account the precautionary measures and the occurrence of the accident. For this purpose, first there was a description of the accident in order to clearly identify the dimensions of the incident, and then carefully examine the factors behind it.

Description of the incident

The collision of the train in Semnan-Damghan area points to the accident of two passenger trains near the "Haft Khan" station in Semnan-Damghan area. In this accident, which occurred at 7:22 am on Friday December 5, 2016, Semnan to Mashhad train collided with Tabriz to Mashhad train from behind, which was stopped on the same rails. Following the collision of two trains, four wagons were derailed and five wagons were burned. In this incident, 47

people were killed and 103 were injured. In the wake of the accident, 12 ambulances, 2 bus ambulances and 1 helicopter were sent to the accident site and the injured were transferred to Damghan Hospital. The bodies were completely burnt and their identification was very difficult.

At the railroad accident on Friday at Haft Khan Station, the only way to access the accident scene road was through the railway dusty bypass, which led to the accident scene from Amouran station. This road was inappropriate and difficult to cross over; in addition, in some places it was mountainous and snowy. The Amuran station is more than 45 km far from the accident site, which, according to the type and condition of the road, passing through it with an ambulance Benz Sprinter takes about 50 minutes in the best weather conditions. The station connects to the main road of Damghan, Semnan, with a narrow and two-way road, 10 km long. On Friday, passing through the road was more difficult and less rapid due to the high traffic of paramedic's vehicles and trucks. Moving behind the trucks with airborne dirt and slowing down or stopping ambulances when passing through the cars, made it slower to arrive at the scene than usual days.

The temperature in the vicinity of the accident was 10 to 14 degrees below zero. Nevertheless, by 11:40 all injured were transferred to the Kosar Velayat hospitals settled in Semnan and Damghan proviences, respectively. Furthermore, Abkhoran bypass was blocked by snow and ice and access to the area was not possible. The relief status of the incident was much better than the incident in the past two years. Of course, this does not mean that the management was better in the current incident. However, the sky being light and the possibility of using the helicopter made the service provision better. The incident is one of the deadliest rail events in Iran after the Neyshabur train accident (11).

Sequence of incident events

According to the operator's announcement by the Islamic Republic Railways Company, the sequence of the events up to the incident has been as follows:

• At 6:14 am on Friday, December 5, 1395, the 4802 Tabriz-Mashhad train, consisting of locomotives number 1622 and 13 passenger caravans, with 432 passengers traveled from the "Vorogh station" to the "Seven-hangar" station.

• At 6:32 pm, the Tabriz-Mashhad train stopped due to the cold and freezing of the brake system at km 291, informing the control center.

• At 7:00 PM, the Centralized Traffic Control operators shift (CTC) would be finished and new ones would be replaced.

• At 7:08 pm, the locomotive driver of the Tabriz-Mashhad train through telephongram No.1 from haft khan station informs the traffic control that: "Due to the freezing of the train brake, we stop at km 291, which then start moving after the defect is resolved."

• At 7:08, passenger train 3242 Semnan-Mashhad, consisting of locomotive number 1557 and 5 wagons, with 110 passengers enter Gerdab station.

• At 7:09 pm, the Semnan-Mashhad train passes the haft khan station.

• At 7:14 pm, due to the red light of the middle block, Semnan-Mashhad train stopped behind the light, and locomotive driver announces the stopping and red light, and asked for instructions from the centralised traffic control expert. The CTC expert in Shahroud verbally through radiotelephone gives permission to Semnan-Mashhad locomotive driver for the shutdown of the automatic train control system (ATC) and continuing to the haft Khan Station.

• From 7:18 pm, Semnan-Mashhad train moves from its position. The CTC expert while talking with the area control reports the mid-block light failure.

• At 7:22, Shahrood traffic control controller informs the signs operator of the breakdown.

• At 7:22, the semnan-mashhad passenger train 3242 runs at a speed of 132 km/h (speed limit was 140 km/h) collides with 4802 Tabriz-Mashhad train (stopped train).

After the collision, the 1557 Semnan-Mashhad train is derailed, overturned and catches fire, and the last three wagons of the Tabriz-Mashhad train and the 5 wagons of Semnan-Mashhad catch fire and both odd and even blocks were blocked (12).

Materials and Methods

This case study that was conducted in 2016. In order to collect data, existing documentation and direct observations were used. Hence, all the documentation and reports available at news websites and scientific associations, as well as the incident report, were analyzed.

Results

Findings from various studies indicate that the risk of accident and derailing in rail transport is a major concern for the rail industry, the government and the people. Different approaches to analysis, management and risk reduction have been considered or enacted (13). Investigating the causes of accidents is an important qualitative approach to understanding and managing transport safety (3). Train collision and derailment are often the result of sequences of complicated causes and there may be several ways to prevent these causes (14). Although risk management is focused on hazard identification and risk control, the lessons learned from accidents are still one of the key measures in preventing accidents. Learning from accidents helps to improve safety and prevent unwanted accidents. How much we can learn from the events of the past depends on the exact analysis of the incident (15).

Causes of Incident

The findings of this study showed that individual, managerial and environmental factors were factors affecting the accident of Semnan-Mashhad. Each of these causes in this incident can be summarized as follows.

Management factors

The organization decisions and safety management policies that could have contributed to the incident would likely include the absence of an integrated automated control system completely and the lack of a mechanism to identify the skills weakness of the employees in travel sector.

Individual factors

The wrong issuance of orders for departure by the Traffic Control Center operators and the deactivation of the ATC system by the Traffic Control Center operators, the second train driver's inquiry from the local control expert on the emergency braking system of the ATC system, the inquiry from the radiotelephone's expert system instead of the inquiry from the failure announcement system in the area control center, and the lack of attention to the red light and the order to exit the ATC system and the continuation of non-automated travel by the driver and the absence of an inquiry from the area control center of the individual factors of the incident.

Environmental factors

The environmental factors in the occurrence of this incident are defects in the ATC system, the unrealistic nature of most ATC warnings, failure to fully implement the ATC system, and the absence of the installation of the Balise system, the curvature of the train course and stop of the front train at the back of the hill and the lack of visibility of the back trains and the difficulty to pass in the area and the absence of the ground aid.

In general, railway events can be partly related to the mismatch between human and machine, or human and work (tasks), which include design errors or system performance errors, which consist factors such as inappropriate work space and defects in the design of locomotive driver's work stations or line traffic control operator, inadequate or confusing warning signals, lack of number or degree of warning lights, lack of warning systems or their unreliability due to sequential false alarms. Warning systems with poor design cause wrong decision on the part of locomotive driver and to line traffic control operator, especially when factors such as lack of attention, tiredness (especially fatigue), distraction, and drug use add to the problem. While the equipment and hardware used by them had a lot of shortcomings, operating standards are unfortunately not up to date and work

and emergency instructions are inefficient. Sometimes, constant neglect of the system defects is one of the causes of the accident. However, in many cases, operators ignore or abandon the standard of work to be able to do their job. Because these procedures are not up to date, they are not compatible with working conditions, require software and hardware adjustment, or, in simpler terms, they are too complicated and restrictive. Turning off the automatic control systems or their intelligent defense shields, ignoring warning signals due to previous false warnings, not paying attention to abnormal data due to chronic unexpected performance, trusting personal inferences and beliefs rather than objective data due to lack of trust in the integrity of accurate measuring machines are all because of the operator's mistrust of the control mechanisms of the system, which brings about the dangerous process of "normalizing deviations" (or the naturalization and neglecting of deviations).This organizational phenomenon leads to disturbance in the system and ultimately to a major disaster (8).

Discussion

In analyzing accidents, attention to the various causes of an accident is very important and merely considering the closest cause, without considering other causes and not trying to eliminate them, can lead to repetition of such accidents in the future.

In the analysis of the accident under study, it was discovered that although the main cause of the accident was human error, various causes and factors other than individual factors such as environmental factors and decisions and policies to manage the organization are also the basis for the occurrence of such events.

Individual factors influencing this accident include the issuance of the wrong departure order by the traffic control center operators, the deactivation of the ATC system by the traffic control center operators and the non-decreasing speed of Mashhad to Tabriz train. Error is part of being human, and this sentence is still defined as part of the human being's existential character.

While organizations attempt to reach zero-level error, this goal is not an ideal goal and is not achievable in all respects. As long as humans function in a complex environment, error will occur and this will increase in stress situation, overwork and fatigue. Organizations need to efficiently manage errors, thereby reducing the likelihood of errors and the resulting effects.

Several studies have shown that human factors affecting railway accidents are physical and physiological factors of employees, their psychological and behavioral factors, non-compliance with general rules of travel, weakness of safety management, physical factors of the work environment, lack of education and sufficient and effective experience of employees. Among these factors, psychological and behavioral factors of employees in railway accidents have been regarded as the most important (16).

In addition to the human error, incorrect operation of the ATC system and the unrealistic warnings of the system in the past was one of the factors that caused the operators of the control unit to distrust the warnings issued by the system. The train control system was launched in March of 2014 with a cost of 37 million euros to improve safety and reduce human error; however, the system had reported an error for 2000 times from April 2014 until the accident.

Since most of the warnings announced by the system were unrealistic, the Traffic Control Center operators had been ignorant of ATC successive errors and assumed that on the day of the accident, as in the past, there was a system failure and an unrealistic warning has been announced. Some Experts also note that the incomplete installation of the TCT system and the lack of installation of the Balise system and axial count in middle blocks are among the other factors, as the Balise system was not installed in the middle blocks between the two stations, only in the first and the last blocks. According to the experts, if they had used axial count as part of the Balise system-and had calculated the number of wagons passing through block, this accident would not have occurred, because in this case,

the block in which the train was stopped was shown as "Occupied". Meanwhile, in countries where this system is fully implemented, the human error rate has reached zero. Other environmental factors in the occurrence of this incident include train path curvature and the stopping of the front train behind the hill and the lack of visibility for rear train, and the inability to pass in the area and the lack of presence on the accident scene via ground, also made relief emergency difficult (17).

Based on the analysis of accidents on the railway, it can be said that the elimination of all the risks and risks of accidents is not possible; however, by accurately identifying all factors affecting the occurrence of rail accidents and actions such as the use of advanced technology, the improvement of work processes and effective management of human resources are an effective step in reducing the risk of accidents. Measures include regular safety training, accelerating the establishment of a safety record system for identifying those susceptible to the incident, more monitoring of the head of passenger trains and performing their technical duties in accordance with the general rules of movement, the proper monitoring of travel head department on the correct and regular implementation of the passenger trains' travel program and making the necessary adjustments in future plans, accurate control of the speed of trains in the daily commissions graphs of the head departments of the regions and the sensitivity of the district authorities to this issue, the exact examination of the speed of trains arriving to the destination before the expected time and taking the necessary action to prevent any disorder in planning the passenger trains travel, special attention to motivating factors for employees, providing safety rules, regulations and instructions on the optimal use of the system, inspection, monitoring and control over the implementation of safety regulations in the use of the system, meeting safety equipment and facilities, accelerating the elimination of unsafe faults of the system, the prediction of incidents and carrying out defensive

maneuvers to handle it, raising awareness of safety, paying serious attention to recruiting on the basis of meritocracy, reducing working hours, especially in night shifts, using young workforce instead of retired staff, implementation and promotion of educational programs depending on the organization status, the launch of rail relief and rescue program and training \a specialized team, the establishment of rail emergency and firefighting, carrying out joint maneuvers with railway system, access to rail ways road maps by the Accident Management Center of each city (in Neyshabur accident, the presence on the scene was delayed due to lack of familiarity with the road) could reduce the risk of accidents in the future.

Conclusion

In analysis of this accident, it was determined that the individual, environmental factors and organizational management decisions and policies, are also the basis for the occurrence of such accidents. In the above accident, an incomplete installation of the ATC is an error and can be the main cause of the accident. Moreover, ignoring frequent warnings by experts about the ATC system can be a factor in the above-mentioned accident. Not paying attention to errors can increase the errors of intelligent systems, so that existing and viewing warnings of intelligent systems becomes a routine (error normalization and error repetition itself is a very big error and, like poison and cancer, for intelligent systems). On one hand, there is a major problem in the system of companies dealing with signs and safety, such as problem with the structure of the company or the companies supporting the signs and safety, the failure to fully comply with the safety and security standards of signs and safety systems by Iranian manufacturers, and consequently, the weakness in the design and construction of the ATC, all of which can be the possible causes of the above disaster.

Suggestions

Based on the analysis of accidents on the railway, it can be said that the elimination of all the

risks of the accidents is not possible; however, by accurately identifying all the factors affecting the occurrence of rail accidents and actions such as the use of advanced technology, the improvement of work processes and effective management of human resources are effective steps in reducing the risk of accidents.

As experience has shown, most rail accidents in Iran (those who have casualties) are outside the city and it is difficult to reach the accident site. Therefore, it is proposed to provide opportunities and facilities for using rail ambulance, conducting joint maneuvers with the railway, providing a map of routes to access the railway centers for the accident management center of each city. On the other hand, in order to prevent similar accidents, it is recommended to prevent the occurrence of accidents in the future by using advanced train control equipment and procedures and establishing a system of accountability at all

levels and emphasizing on the safety control system of the railway to prevent from the accidents in future.

Conflict of interest

The authors declared no competing interests.

Authors' contribution

SM and GA contributed to the concept, design, data analysis, and manuscript preparation. AE and RN edited and reviewed the manuscript. All authors approved the final draft of the manuscript.

Reference

1. Khairnar KF, Ingle S, Wagh ND, et al. Monitoring of railway traffic pollution and health effects on exposed population. Nature, Environment and Pollution Technology. 2011; 10(3): 377-84.

2. Salamatnews. Rail crash rates in Iran are 18 times the world average. 2016. Available from: http://www.salamatnews.com/news/199195/. [persian]

3. Reinach S, Viale A. Application of a human error framework to conduct train accident/ incident investigations. Accident Analysis & Prevention. 2006;38(2):396-406.

4. Asgari.A. The train of crisis 2016. Available from: http:// disasterman. blogfa. com/ ?p=4. [persian]

5. Paknejad N. Investigation of rail accidents with the role of human factor in railway accidents in Zagros area. Railway Training and Research Center. 2015:277. Available from: http://www.rai.ir/dorsapax/ userfiles/file/RTC/m277.pdf [persian]

6. Underwood P, Waterson P .Systems thinking, the Swiss Cheese Model and accident analysis: a comparative systemic analysis of the Grayrigg train derailment using the ATSB, AcciMap and STAMP models. Accident Analysis & Prevention. 2014; 68:75-94.

7. Rahimi H. Analysis of the incident exiting the passenger train line 20 of Mashhad, Tehran, at the Bekran station. 16th International Rail Transport Conference, Iranian Rail Transport Engineering Association; 2014 October 19-20; Tehran, Iran Rail Transport Engineering Association. 2014; RTC16_022. [persian]

8. Mashkoti N, Khashe Y. Learn about railway crashes and suggestions for Iran University of Southern California: Salamatnews; 2016 . Available from:http://www.salamatnews. com/ news/ 201268./ [persian]

9. Schafer D, Barkan C. Relationship between train length and accident causes and rates. Transportation Research Record: Journal of the Transportation Research Board. 2008; (2043): 73-82.

10. Rezvani baboli MA, Akbari M. Investigating the status of rail accidents with the approach of comparing safety indicators in the railways of Iran, USA and Canada. Second National Conference on Road Accidents, Railways and Air incident; 2011 November 10; Zanjan, Azad University of Zanjan. 2011;NCRRAF02_019. [persian]

11. Farsnews agency. Details of the collision of passenger trains at the seventh channel/ 2 major errors

due to the incident 2016. Available from: http://www.farsnews.com/newstext.php?nn=1395090 6001729. [persian]

12. Iranian Students News Agency From the railroad, a preliminary report of the incident involving passenger trains was published 2016 [Available from: http://www. isna.ir/news/95090704432. [persian]

13. Liu X, Barkan C, Saat M. Analysis of derailments by accident cause: evaluating railroad track upgrades to reduce transportation risk. Transportation Research Record: Journal of the Transportation Research Board. 2011;(2261): 178-85.

14. Evans AW. Fatal train accidents on Europe's railways: 1980–2009. Accident Analysis & Prevention. 2011;43(1):391-40.

15. Fan Y, Li Z, Pei J, et al. Applying systems thinking approach to accident analysis in China: Case study of "7.23" Yong-Tai-Wen High-Speed train accident. Safety science. 2015; 76:190-201.

16. Mortazavi SB, Mahdavi S, Asilian H, et al. Identification and assessment of human errors in srp unit of control room of tehran oil refinery using heist technique, 2007. Journal of Kermanshah University of Medical Sciences. 2008;12(3):308-22. [persian]

17. Mehrnews Agency. The ATC system was incomplete and error-prone / human error was due to the cause 2016. Available from: http:// www. mehrnews. com/news/3835474. [persian]