Research Paper

Developing a Questionnaire to Investigate Monthly Human Errors Among Railway Traffic Control Room Employees

Soleiman Ramezanifar[1], Ali Askari[2], Mohsen Poursadeghiyan[3], Mahshid Namdari[4], Ali Salehi Sahlabadi[5*]

1. Department of Occupational Health and Safety at Work, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2. Department of Occupational Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran.
3. Social Determinants of Health Research Center, Ardabil University of Medical Sciences, Ardabil, Iran.
4. Department of Community Oral Health, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
5. Department of Occupational Health and Safety at Work, Safety Promotion and Injury Prevention Research Center, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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ABSTRACT

Objectives: The working situation of railway traffic control rooms (RTCR) employees makes them susceptible to human error. On the other hand, the occurrence of human error by these staff can lead to catastrophic events. Due to the lack of a standard questionnaire in estimating the probability of monthly human errors in employees of the RTCR, this study designs and validates such a tool.

Methods: In this mixed-method research, an initial questionnaire of 67 questions was designed, using the literature review and experts' experiences. To standardize and validate this questionnaire, the opinions of 15 experts, including university professors and experienced people working in control rooms were used. To determine the validity of the questionnaire, two indexes content validity index and content validity ratio were used. Meanwhile, to check the reliability, the weighted kappa coefficient was used.

Results: All the initial questions were accepted and a final questionnaire with 67 questions was compiled in two sections for employees of the central control room and employees working in other RTCR. The content validity index values of the questionnaire were 0.9, 0.9 and 0.92 in terms of simplicity, relevancy and clarity, respectively. The content validity ratio value was 0.87. The reliability of this questionnaire was also confirmed by obtaining 73.71%, 87.14% and 80.31% for the minimum, maximum and average percentage of agreement between the questions, respectively.

Discussion: The designed questionnaire can estimate the probability of monthly human errors among RTCR employees and can be used in future studies.

*** Corresponding Author:**
Ali Salehi Sahlabadi, PhD.
Address: *Department of Occupational Health and Safety at Work, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 22432040-41*
E-mail: *asalehi529@sbmu.ac.ir*

Highlights

- The present questionnaire has good validity and reliability.

- The questionnaire can be used to measure the probability of monthly human error among employees of railway traffic control rooms (RTCR). By using this tool, in addition to examining the human errors of the employees themselves, it is possible to examine the impact of other factors, such as multiple tasks or doing some tasks on the human errors of these employees, thereby reducing the probability of human error.

- Other researchers are advised to design tools and software in addition to using this tool to reduce the probability of human errors in susceptible and risky jobs such as control rooms.

Plain Language Summary

RTCR employees are susceptible to human error, and human errors can lead to catastrophic events. To estimate the probability of monthly human errors in RTCR employees, a questionnaire was designed and validated by experts. The questionnaire was designed after reviewing the literature and experts' experiences and based on the results the questionnaire has an acceptable reliability and validity. This questionnaire can be used to estimate the probability of monthly human errors among RTCR employees in future studies.

Introduction

Traffic accidents in Iran have a high prevalence and severity [1]. Traffic accidents due to deviating from the road due to human error due to sleepiness, resulting in high mortality [2]. Railway transport accidents can have serious consequences, including injuries and fatalities. According to the US Department of Transportation, human error is a significant factor in many train accidents [3]. In the US, railway fatalities totaled 893 in 2021, 20% higher than the revised total of 744 in 2020 and the highest since 2007. Nonfatal injuries totaled 5781, showing an increase of 4%. Of the 617 trespass-related fatalities, 94% were attributed to persons other than railroad employees. Meanwhile, 11 employees were killed while on duty, matching the 2020 count. There were 6 train passenger fatalities, up from two in 2020 [4]. Train accidents can be caused by a variety of factors, including equipment failure, mechanical failure and human error. Although railway transport is increasing around the world, despite the adoption of various safety measures, railroad accidents, and fatalities have been rising in many countries. Railway disasters have increased in developing countries, while the opposite is true in Europe. According to statistics, 74% of global railway disasters have occurred in Africa, Asia and South/Central America combined [5]. The information obtained from industrial accidents indicates the high contribution of human errors (70%-90%) in many catastrophic accidents, such as the Amtrak train accident (2017 and 2018, USA) [6-8]. The leading causes of such errors can also be seen as the application of incorrect mental processes, such as neglect, inattention, forgetfulness, and carelessness by people [9-11].

With the existence of increasing technological advancements, manpower is still considered the most critical element in working systems. [9] Therefore, human errors are possible in many occupations, including control room operators [12, 13]. These operators monitor and control various processes using advanced and modern hardware, such as closed-circuit televisions or visual displays [14, 15]. They must evaluate large amounts of data while monitoring and controlling such complex and dangerous processes to make effective and critical decisions to achieve system goals [16].

In the railway industry, the work processes of traffic control room operators are such that they exchange extensive information during their work shifts and have a high workload [13, 17]. Furthermore, the occurrence of catastrophic events like the London train collision (England, 1999) and the Neyshabour train accident (Iran, 2004) [18] and the investigations carried out in the field of rail accidents in different countries, including India and England, at different periods indicate the high role of human error in the occurrence of many of these accidents [17-20].

Accordingly, many researchers have investigated the probability of human errors among employees working in the railway industry by using various human error techniques [21-24]. Having a lot of flexibility and applicability, learning and using quickly and easily, as well as having a comprehensive and structured approach are among the advantages of some of these techniques. However, these techniques mainly focus on job tasks rather than individual people's errors [25].

Therefore, due to the lack of a specific tool to estimate the probability of human errors of individuals in railway traffic control rooms (RTCRs) and also the necessity of having a tool in this field according to those mentioned above, the present study prepares a standard, valid, and reliable tool to measure the probability of monthly human errors among the RTCR employees to take a step toward preventing human error and, subsequently, the occurrence of accidents.

Materials and Methods

In this mixed-method research, in the first step after forming an experts panel, an initial questionnaire containing 67 questions in two parts (the first part for the employees of the central control room and the second part for the employees of the RTCR in different regions of the country) using some data collection methods and experts' opinions were designed. To check and determine the face and content validity of this questionnaire, the members of the expert panel, and in line with its reliability estimation, 35 employers working in the RTCR participated. The participation of panel members in this study took place in three rounds between November 2021 and February 2022. After the investigations, the final questionnaire was designed with 67 questions without removing any of the questions. The implementation process of this research is presented in Figure 1.

Forming an expert panel

To ensure the validity and reliability of the questionnaire, the questionnaire should be tested by several experts. The members of the panel of experts should also be selected from among the experts who are active in the field of the questionnaire content so that correct and accurate judgments can be made possible [26]. Based on this, 15 experts were selected according to the predetermined objectives of the study and asked to comment on each of the questions. These people have been selected considering their experience, expertise, and knowledge in this field. The Mean±SD age and work experience of these experts were 39.00±4.175 and 10.53±2.800, respectively (Table 1).

Collecting information

The questions of this questionnaire were designed using methods and some data collection tools, such as literature reviews and existing data, observing the work duties of the employees, as well as interviewing each of the employees and consulting with experts and the primary researchers of this research during several sessions. Also, in this regard, this study used all the opinions of the members of the expert panel and available scientific resources.

Instruments validity

Determining face validity

In the present study, the face validity of the questionnaire questions was measured in qualitative and quantitative ways.

Qualitative face validity

To perform qualitative face validity, the initially designed questionnaire was given to seven expert panel members consisting of three university assistant professors in the field of occupational health and safety from Shahid Beheshti University Medical of Sciences, two experienced employees working in the central control room, and two employees from the RTCR of the Tehran District (Iran) with more than 15 years of experience. Then, they were asked to comment on the questionnaire questions and their appearance. After receiving the opinions of each of these people, the necessary changes were made to the questions, and their qualitative face validity was done.

Quantitative face validity

In this step, the quantitative method of impact score was used to reduce and eliminate inappropriate terms and determine the importance of each of these terms. In this method, to determine the quantitative face validity of the questionnaire, the questions were provided to the members of the expert panel and they were asked to evaluate the appearance of each of the questionnaire questions in terms of simplicity, relevancy, and clarity, and comment on each of them according to the purpose of the research [27]. For this purpose, the questions presented in the first, second, and both parts of the questionnaire were respectively provided to the experienced employees of the central control room (n=5), the experienced employees of the Tehran District the RTCR (n=5), and university assistant professors (n=5) to comment on the features of the questions.

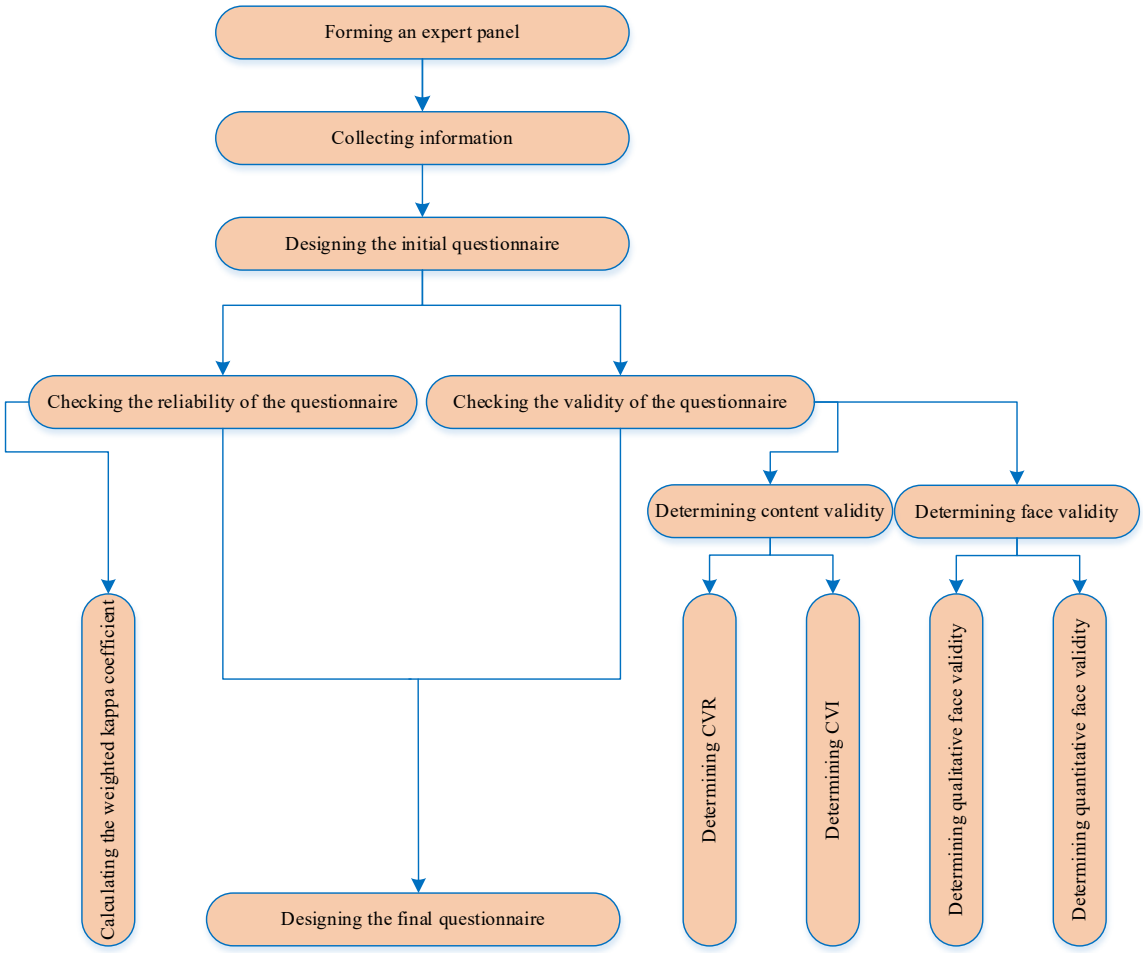

Figure 1. Conceptual questionnaire design process flow diagram

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Determining content validity

To check the content validity, two indexes of content validity ratio (CVR) and content validity index (CVI) were used according to the following steps (with the participation of the same participating expert panel members in determining face validity).

Step 1: Determining the CVR index

Ten experts (five university faculty members and five employees of the central control room) were asked about the first part of the questionnaire, and ten other experts (five university faculty members and five employees of the control room of the Tehran District, Iran) were asked about the second part of the questionnaire to comment on the importance and necessity of all the questions in each part. Three ranges, namely necessary, useful but unnecessary, and unnecessary were used to measure experts' opinions. After collecting comments, CVR values for each question were calculated according to Equation 1 and compared with Lawshe's table [28]. Since the opinions of ten experts were used in each section of the questionnaire, the questions with numbers >0.62 were accepted. In Equation 1, "ne" is equal to the number of experts who chose the "necessary" option, and "N" is equal to the total number of experts.

$$1.\ CVR=\frac{ne-N/_2}{N/_2}$$

Step 2: Determining the content validity index

The CVI value of the questions was determined using the method of Waltz and Basel (1981) and according to Equation 2 [29]. In this regard, the questionnaire was sent to each member of the panel of experts, and they were asked to comment on each of the three criteria of simplicity, relevancy and clarity based on a 4-point Likert scale (1=unrelated, 2=somewhat related, 3=related, and 4=completely related). If the CVI score of the ques-

Table 1. Demographic characteristics of the participants of this study

Characteristic		No. (%)	
		Panel of Experts (n=15)	Employers (n=35)
Gender	Male	15(100)	35(100)
Age (y)	<30	0	17(48.6)
	30-40	9(60)	15(42.9)
	>40	6(40)	3(8.6)
Work experience (y)	<5	0	4(11.4)
	5-10	7(46.6)	23(65.7)
	>10	8(53.3)	8(22.9)
Marital status	Married	15(100)	28(80)
	Single	0	7(20)
Level of education	Diploma degree	0	2(5.7)
	Associate degree	0	11(31.4)
	Bachelor's degree or higher	15(100)	22(62.9)
Service location	Central control room	5(33.3)	20(57)
	Tehran District control room	5(33.3)	15(43)
	Shahid Beheshti University of Medical Sciences	5(33.3)	0

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tions is >0.79, the content validity of the questions will be accepted [26]. In Equation 2, "n" is equal to the total number of experts who selected the options "completely relevant" and "relevant," and "N" is equal to the total number of experts.

2. $CVI=n/_{N}$

Instrument reliability

Determining the reliability of the questionnaire

To measure the reliability of the questionnaire, this tool was distributed in two stages with a time interval of 12 days in February 2022 among 35 employees of the central control room and Tehran District (Iran) control room. The selection was made considering the level of experience and expertise of these individuals. The Mean±SD age and work experience of these employees were 31.03±4.462 and 8.86±2.522, respectively (Table 1). Subsequently, using the weighted kappa coefficient calculated in the Stata software, version 13, the reliability of this questionnaire was calculated.

Results

In this research, after face validity, none of the questions were removed, and only five questions were edited. In addition, considering that all questions had CVR >0.62 and CVI >0.79, the content validity of the questions was also confirmed. The CVI values of the questionnaire were 0.9, 0.9 and 0.92 in terms of simplicity, relevancy, and clarity, respectively. Also, its CVR value was 0.87 (Table 2).

The reliability of the questionnaire was also proved by obtaining the values of 73.71%, 87.14% and 80.31% for the minimum, maximum and average percentages of agreement between 67 questions (Table 2).

Ultimately, a final questionnaire consisting of two parts was designed (Appendix 1), in which in the first part, 43 questions specific to 12 job positions working in the

Table 2. Values of weighted kappa coefficient, degree of agreement, content validity index, and content validity ratio of the questions

Part	Question No.	Weighted Kappa Coefficient	Degree of Agreement (%)	CVI			CVR	Question No.	Weighted Kappa Coefficient	Degree of Agreement (%)	CVI			CVR
				Simplicity	Relevancy	Clarity					Simplicity	Relevancy	Clarity	
1: Questions specific to the central RTCR	1	0.4481	86.86	0.9	0.9	1	0.8	23	0.4317	79.14	0.9	1	0.9	1
	2	0.1869	74.29	0.8	0.9	0.9	1	24	0.4156	82.00	0.8	0.9	0.8	1
	3	0.3897	82.86	0.9	1	0.9	0.8	25	0.3482	85.71	1	1	0.9	1
	4	0.1963	74.57	0.9	0.9	0.9	1	26	0.3711	81.14	0.9	0.8	1	0.8
	5	0.4932	86.86	0.8	1	0.9	0.8	27	0.2407	79.14	0.8	0.9	0.9	0.8
	6	0.2610	74.57	0.8	1	0.9	1	28	0.4147	82.57	0.8	1	0.9	1
	7	0.4895	87.14	1	1	0.9	1	29	0.1955	76.86	1	1	0.9	1
	8	0.2736	82.57	0.9	0.8	1	0.8	30	0.3221	80.00	0.8	0.8	1	0.8
	9	0.2450	79.14	1	0.9	0.9	0.8	31	0.4053	82.29	1	0.8	0.8	1
	10	0.2114	78.29	1	0.8	0.9	1	32	0.5195	87.14	1	0.9	1	0.8
	11	0.1830	82.00	0.9	0.9	0.9	1	33	0.2039	74.57	0.9	1	0.8	0.8
	12	0.2618	81.43	0.9	1	1	0.8	34	0.2153	74.86	1	0.8	0.8	0.8
	13	0.0870	79.43	0.9	0.9	0.8	0.8	35	0.1531	73.71	1	0.9	1	0.8
	14	0.2939	83.43	1	0.8	0.9	0.8	36	0.2273	76.86	0.8	0.8	1	0.8
	15	0.0558	74.57	0.9	1	1	0.8	37	0.1829	79.43	0.8	1	1	1
	16	0.4160	82.57	1	0.9	1	1	38	0.1243	73.71	1	0.8	0.9	0.8
	17	0.4878	85.14	0.9	0.9	0.9	1	39	0.2142	82.00	0.9	0.9	1	1
	18	0.1720	78/86	1	1	0.9	0.8	40	0.1766	79.14	0.9	0.8	0.9	0.8
	19	0.4347	86.00	0.9	0.9	1	0.8	41	0.1419	80.00	1	1	0.9	0.8
	20	0.3449	82.57	0.9	0.8	0.9	0.8	42	0.3228	84.57	0.8	0.9	1	0.8
	21	0.4019	84.00	0.8	1	0.9	1	43	0.3178	84.00	0.8	0.8	0.8	1
	22	0.3038	79.14	1	0.8	1	1							
2: Questions specific to other control rooms	1	0.2159	83.43	0.9	0.9	1	0.8	13	0.0708	76.86	1	0.9	0.8	0.8
	2	0.2960	79.71	0.9	0.8	0.9	0.8	14	0.1967	74.86	0.9	1	1	0.8
	3	0.3062	79.43	0.9	0.9	0.9	0.8	15	0.3441	82.57	0.9	0.8	0.9	1
	4	0.3098	79.14	1	1	0.9	0.8	16	0.2616	77.14	0.9	1	0.9	0.8
	5	0.1907	81.43	0.9	0.8	1	0.8	17	0.3216	82.57	0.9	1	1	0.8
	6	0.2339	79.14	1	1	0.9	0.8	18	0.1723	77.14	0.8	0.9	1	0.8
	7	0.1275	74.86	0.9	0.9	1	1	19	0.1690	80.29	1	1	0.9	0.8
	8	0.0458	76.00	0.9	1	0.9	1	20	0.1687	75.14	0.9	0.8	1	0.8
	9	0.1946	76.29	0.9	0.9	1	0.8	21	0.2318	76.57	1	0.9	0.9	1
	10	0.2400	84.29	0.8	0.9	0.8	0.8	22	0.4109	84.00	1	1	1	0.8
	11	0.1998	78.00	0.9	0.8	1	1	23	0.3783	86.57	0.8	0.9	0.9	0.8
	12	0.2470	85.71	0.8	1	0.8	0.8	24	0.2811	78.00	0.8	0.9	0.8	0.8

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Abbreviations: CVR: Content validity ratio; CVI: Content validity index; RTCR: Railway traffic control rooms.

Table 3. Characteristics of questions related to job positions

	Job Position	No.	ORS	Coefficient	Job Position	No.	ORS	Coefficient	Job Position	No.	ORS	Coefficient
Railway traffic central control room	Boss	12	0-60	1.66	Line expert	11	0-55	1.82	Passenger expert	12	0-60	1.66
	Supervisor	11	0-55	1.82	Traffic expert	13	0-65	1.54	Traction expert	12	0-60	1.66
	Communication expert	12	0-60	1.66	Signal expert	11	0-55	1.82	Deputy manager	12	0-60	1.66
	ATC expert	15	0-75	1.33	Suburban train expert	11	0-55	1.82	Wagon expert	10	0-50	2
Other control rooms in different districts	RCRF	3	0-15	6.66	RFSC	4	0-20	5	RFCFW	3	0-15	6.66
	Dispatcher	5	0-25	4	Traffic Controller	3	0-15	6.66	Supervisor	6	0-30	3.33

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Abbreviations: N: Number of questions; ORS: Overall range of scores; ATC: Automatic train control; RCRF: Responsible for controlling the railway fleet; RFSC: Rail fleet steering controller; RFCFW: Rail fleet controller in the field of wagons.

central RTCRs and in the second part, 24 questions specific to six job positions working in other RTCRs were presented (Table 3). Among the questions distributed in the first part, nine are public and completed by all central RTCR employees.

Discussion

Considering that railway lines carry out a large volume of public transportation [30], the occurrence of human error by the RTCR operators can lead to substantial financial and life losses [13]. On the other hand, considering various factors, such as the absence of systems to avoid human errors [31], the ineffectiveness of the laws and regulations [32] and the payment of irreparable financial and life losses following the incidence of human errors [13], it is obligatory to design and apply different techniques to increase safety level at workplaces [33]. Therefore, according to the mentioned points, in this study, a reliable tool was presented to measure the probability of monthly human errors among the RTCR employees. This questionnaire is designed in two parts. The first (with 43 questions) and second (with 24 questions) parts of this questionnaire can measure, the probability of human error among employees in the railway traffic central control rooms. In this study, CVI and CVR as the most reliable measurement methods [26] were used to check the validity of the questionnaire. The CVI values of this questionnaire in terms of simplicity, relevance, and clarity were equal to 0.9, 0.9 and 0.92, respectively, and its CVR value was estimated to be equal to 0.87. The reliability of this tool was also investigated with the participation of 35 employees working in the central control rooms and railway traffic in the Tehran District. They answered the questions in two stages, with a time interval of fewer than two weeks. According to the results obtained from this answering and applying and calculating the weighted kappa coefficient, the minimum, maximum, and average percentage of agreement between the questions were 73.71%, 80.31% and 87.14%, respectively; reliability. The study by Mahdinia et al. investigated the effects of work pressure, mental workload, human-system interaction, and environmental distraction on three types of human errors (slip, mistake, and error) in steel industry workers. In this study, a questionnaire was used as a valid and reliable tool to measure the human errors of the participants. Notably, the internal consistency coefficients (Cronbach α) of the three parts of the human error questionnaire used in this study were 0.78, 0.88 and 0.84, respectively and the answers to the questions were measured based on a 0-5 Likert scale [34]. The answers to the designed questionnaire, by Lee et al., are measured in a range of 0-5. In another study, the relationship between sleep, sleep environments at work, and the human errors of train drivers, the human errors of these drivers were measured based on their judgment and by mentioning several questions and the relationship with other desired components (sleep and sleeping places at work) [35]. In another research conducted by Rowland et al., the questionnaire tool was used to investigate emergency care workers' views about the types of human errors and the factors influencing human errors that affect the safety of patients in the pre-hospital emergency care environment [36]. The present study tried designing an approved and appropriate questionnaire by forming an expert panel consisting of university faculty

members and experts in RTCRs as well as collecting the available information. According to the stated content, along with the use of standard methods of identifying and evaluating human errors, the use of other measurement tools, such as questionnaires or software can help to reduce or prevent the occurrence of human errors in many work environments, especially places with high job importance such as control rooms.

Conclusion

According to the results of this research, the present questionnaire has good validity and reliability. It can be used to measure the probability of monthly human error among employees of RTCSs. By using this tool, in addition to examining the human errors of the employees themselves, it is possible to examine the impact of other factors on the human errors of these employees, thereby reducing the probability of human error. Therefore, other researchers are advised to design tools and software in addition to using this tool to reduce the probability of human errors in susceptible and risky jobs such as control rooms.

Study limitations

Although the validity and reliability of the results are statistically acceptable, if it were possible to increase the number of participants in the study, it is predicted that the results would be obtained more accurately.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (Code: IR.SBMU.PHNS.REC. 1400.039). Each participant entered the study after completing the written consent form to conduct this research. An informed consent form was obtained from all participants. All participants signed the informed consent form and were explained the procedure of research before the study onset.

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Authors' contributions

All authors contributed equally to preparing this article.

Conflict of interest

All authors declared no conflict of interest.

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Appendix 1.

Part 1: Monthly probability of human error questionnaire for RTCR employees

Please select the answer that best describes the calculated amount of human error among RTCR employees for the previous month. Please select the most appropriate answer (questions 9-1 and other questions related to your job position). If you are uncertain about the answer, please select the closest one. Your answers will remain confidential and do not affect your activities or process.

Job position: Education level: Job experience: Marital status: Age:

Questions 1-9: General

Questions 10-12: Head of department

Questions 13-14: Shift supervisor

Questions 15-17: Communication expert

Questions 18-23: Automatic train control expert

Questions 24-25: Line expert

Questions 26-29: Track and movement expert

Questions 30-31: Sign expert

Questions 32-33: Local branch expert

Questions 34-36: Passenger expert

Questions 37-39: Traction force expert

Question 40: Cargo expert

Questions 41-43: Deputy department

Question 44: Other

Appendix Table 1. Features of questions related to job positions

Row	How likely have you been to commit errors while performing any of the following activities in the past month?	Never	Very Little	Little	Moderate	Much	Very Much
	When you are busy following up and informing of phonograms.						
	When you are looking to follow the causes of accidents.						
	When you have to review the unfinished business that was transferred to you from the previous colleague.						
	When you are busy investigating and following up on the reasons that led to train stoppages, breakdowns, and train problems.						
	When you are busy monitoring and checking the progress of trains.						
	When you view and review the drawing graphs.						
	When you prepare and set up tables, statistics, and daily reports.						

Row	How likely have you been to commit errors while performing any of the following activities in the past month?	Never	Very Little	Little	Moderate	Much	Very Much
	When you are looking to do business correspondence.						
	When you are talking and exchanging information with colleagues and relevant people.						
	When you are busy checking the daily unloading and loading of trains in the regions.						
	When you are planning to assign locomotives to regions.						
	When you are managing the affairs related to the course and movement of trains.						
	When you are planning the distribution of fleets.						
	When you make the necessary coordination between the central control support units.						
	When you check the condition of communication lines, data lines, and radio wireless.						
	When you investigate the causes of telephone failures.						
	When you track the status of wireless diesel and cameras.						
	When you check for network-level automatic train control failures.						
	When you follow the reasons for running without automatic train control diesels with automatic train control.						
	When you track the status of parts shortages in depots.						
	When looking for automatic train control troubleshooting at the nearest depot.						
	When you are communicating between automatic train control depots in different areas.						
	When looking to change automatic train control error codes.						
	When you follow and check the status of licensed and non-licensed blockings.						
	When you prepare and adjust weekly reports to produce the perfect graph.						
	When you are busy dividing diesels.						
	When looking to establish shipping priorities.						
	When you make the necessary plans for the movement of trains.						
	When you create the necessary coordination between the control rooms of the areas.						
	When you are monitoring symptomatic stops.						
	When you are engaged in monitoring reporting activity (playback).						
	When you check the status of suburban trains.						
	When you add and remove suburban trains.						
	When you are busy exchanging information with travel groups in different areas.						
	When you are busy exchanging information with the heads of the trains.						
	When you are busy checking the statistics of daily passenger trains.						
	When you are, busy investigating and following up on the causes of diesel failures.						

Row	How likely have you been to commit errors while performing any of the following activities in the past month?	Never	Very Little	Little	Moderate	Much	Very Much
	When you are busy handing over recalled diesels.						
	When you provide the necessary information to the general manager of the traction force when an accident occurs.						
	When you are busy, investigating activities related to office automation.						
	When you distribute the diesel in the network.						
	When you distribute freight wagons.						
	When you are looking for necessary arrangements and follow-ups to fix train breakdowns.						

Part 2. Human error probability questionnaire for RTCR employees

The following questions concern the probability of human error among control center staff during the past month. Please indicate the correct answer that best indicates the estimated probability of human error determined by you. If you are not sure about the answer, please select the closest one. Your responses will remain confidential and will not affect your processes or activities. Try to answer all questions related to your job position.

Job position: Education level: Job experience: Marital status: Age:

Questions 1-3: Director of rolling stock control

Questions 4-9: Assistant chief for control centre

Questions 10-12: Director of control for movement and operation

Questions 13-15: Rail stock control in the wagon domain

Questions 16-19: Control on the railway way

Questions 20-24: Director of the dispatcher

Appendix Table 2.

Row	How Likely Have You Been to Commit Errors While Performing any of the Following Activities in the Past Month?	Never	Very Little	Little	Moderate	Much	Very Much
	When you check the movement of locomotives and wagons.						
	When you track and predict the status of agents.						
	When you are busy checking the statistics of dispatch trains.						
	When you perform activities related to planning and forecasting the formation of trains.						
	When you perform activities related to planning and forecasting the allocation of diesel.						
	When you are busy checking the course and movement of trains.						
	When you are looking to track and inform about the status of trains.						
	When you are looking to track and inform about the status of train breakdowns.						
	When you have to make an instant decision about train breakdowns.						
	When you are looking to plan how to transport freight trains.						

Row	How Likely Have You Been to Commit Errors While Performing any of the Following Activities in the Past Month?	Never	Very Little	Little	Moderate	Much	Very Much
	When you are busy allocating cargo, monitoring and coordinating the loading of freight wagons.						
	When you are busy monitoring and checking the drawing graphs.						
	When you check the causes of the breakdown of wagons.						
	When you are busy planning the course and movement of wagons.						
	When you check the correctness of the placement of wagons on the trains.						
	When you are planning the locomotives entering and leaving the stations.						
	When you are looking for the causes of locomotive breakdowns.						
	When looking to dispatch relief locomotives.						
	When you are busy changing agents and locomotives.						
	When you establish a wireless telephone connection between agents.						
	When you are busy testing the status of the dispatcher device in the regions of Iran.						
	When you are checking the health of the locomotive trunk.						
	When you are busy following up and reporting signal and communication breakdowns.						
	When you are busy planning the course and movement of wagons.						

Scoring and interpretation of the human error probability questionnaire: After the completion of the questionnaire by staff, we assign respective scores as follows to each of the answers: Never=0; very little=1; little=2; moderate=3; much=4; very much=5. The sum of the scores of the responses obtained for each individual is multiplied by the corresponding factor for each job position (Appendix Table 3) and finally, the probability of human error is classified into the following four categories: Low: 0-25; medium: 26-50; high: 51-75; very high: 76-100.

Appendix Table 3. Features of questions related to job positions

Railway Traffic Central Control Room			
Job Position	**Total Number of Questions**	**Range of Overall Scores**	**Weighting Factor**
Chief of department	12	0-60	1.66
Chief of the Shift	11	0-50	18.82
Communication expert	12	0-60	1.66
Automatic train control expert	15	0-75	1.33
Railway line expert	11	0-55	1.82
Movement and operation expert	13	0-65	1.54
Sign expert	11	0-55	1.82
Suburban railway line expert	11	0-55	1.82
Passenger expert	12	0-60	1.66

Railway Traffic Central Control Room				
	Job Position	Total Number of Questions	Range of Overall Scores	Weighting Factor
	Locomotive power expert	12	0-60	1.66
	Wagon expert	10	0-50	2
	Deputy of department	12	0-60	1.66
RTCR	Director of rolling stock control	3	0-15	6.66
RTCR	Assistant chief for control centre	6	0-30	3.33
RTCR	Director of control for movement and operation	3	0-15	6.66
RTCR	Rail stock control in the wagon domain	3	0-15	6.66
RTCR	Control of the railway way	4	0-20	5
RTCR	Director of the dis-patcher	5	0-25	4

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