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Modeling the Association between Noise Exposure, Noise Annoyance, Aggression, and Cognitive Failures using the Bayesian Network Method

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Abstract

Background: Noise pollution from various internal and external sources affects people's behaviors and job performance. The current study investigated the effects of noise pollution on annoyance, aggression, and cognitive failures.

Materials and Methods: This descriptive study was conducted in 2020-2021 recruiting 400 employees of Tejarat Bank in Tehran. First, questionnaires of cognitive failures, noise annoyance, sensitivity, aggression, and demographic information were completed by the study staff. Next, association between the variables were determined. Finally, using Bayesian models, the association between variables were modeled and important factors were identified using sensitivity analysis.

Results: Based on the results, the mean scores of noise exposure, annoyance, sensitivity, aggression and cognitive failures were 62.86 ± 6.66, 57.74 ± 23.47, 68.26 ± 17.94, 71.19 ±12.68, and 46.83 ± 12.00, respectively. Of all the variables, only annoyance and noise sensitivity had significant effect on aggression. The factors of accuracy, precision, and recall of the Bayesian model were 0.8, 0.89, and 0.96, respectively, which indicates the appropriate diagnostic performance of the model.

Conclusion: Based on our findings, it can be concluded that noise annoyance increases the likelihood of cognitive failures, so that the highest probability of cognitive failures occurs when people are annoyed. In addition, because people with higher noise exposure and higher education experience more annoyance, it can be concluded that the variables of education and noise exposure cause cognitive failures through annoyance.

Keywords: Noise, Annoyance, Aggression, Cognitive, Bayesian Method

Introduction

Open plan offices, which are increasingly common today, are similar offices or work environments designed for more than one person, in which people interact and communicate with each other [1]. These work environments provide various benefits for employers. For example, for any given number of workstations, an open plan office requires less space than individual offices, and the equipment costs less. In addition, open plan offices seem to facilitate communication between colleagues [2]. The use of these offices is common all over the world; almost 60% of French companies use them [3]. According to statistical data reported by the Statistics Center of Iran in 2015 and 2016, many active human forces are working in banks and open plan offices [4].

The duties of bank employees include working with video display terminals and interacting with clients, which requires constant focus, attention to data processing, and the use of diagnostic, memory, programming, and decision-making skills [5]. In fact, bank employees have many administrative, financial, and accounting tasks that create a heavy mental workload and require a lot of concentration to be performed properly [4]. Tasks that require a lot of concentration make employees more vulnerable to noise than everyday tasks [6]. When employees face environmental factors that reduce their ability to perform tasks, they may change not only their task-performing strategy, but also their behavior [7].

In an open plan office, there are various audio sources among which are traffic noise, ventilation systems, telephones, and printers and have harmful effects on people's performance and jobs. Above all, the main source of noise production is the activity of people and their interpersonal conversations, which are low frequency sources [8]. Noise from unwanted conversations affects cognitive tasks such as short-term memory usage, mental arithmetic, comprehension, correction, and written performance [6].

Aggression is a major factor in occupational health that negatively impacts people's lives in work and social environments. Violence and aggression are closely related to the health of individuals and to adverse behaviors, as the World Health Organization (WHO) has ranked anger and aggression among the top 20 causes of years lost due to disability (YLD) [9]. In examining the relationship between aggression and the rate of failures, it can be stated that a history of aggression increases the potential for failure in employees [10]. People perceive noise differently, which may affect the level of impact noise has on a person’s mental health [11].

Noise sensitivity as an individual internal characteristic is another important factors in determining the degree of annoyance when facing noise [12]. It can be defined as an internal state that enhances stimulation by noise [13]. As research often shows lower job satisfaction and productivity as well as poorer health in employees working in open plan offices, further study of these work environments seems necessary [2, 14]. Studies on the psychological effects of noise (mainly the effect of noise on cognitive functions) have also been conducted in open plan offices [14]. Nevertheless, because of insufficient and sometimes contradictory results regarding the effect of noise on aggression, failure rates, annoyance, and noise sensitivity in bank employees, additional studies must be conducted. Furthermore, because noise in open plan offices is a major annoying factor [15] despite its relatively low level (less than 65 dB (A)), and because tasks related to professions making use of open plan offices often require high concentration and minimal failures, it is necessary to study the influential factors in this regard using statistical analysis.

A Bayesian network model is an approach to increase the accuracy of estimating parameters, even with a low sample size, by using the results of previous studies and meta-analyses. Bayesian networks are belief-based graphical models used to make decisions in situations with high uncertainty. The graphic model means that the construction of the network is based on the rules of graphs, and the meaning of being based on belief is that this network reflects the belief and knowledge of the individual in a particular field. Bayesian networks are based on cause-and-effect relationships between several variables. The purpose of designing and analyzing them is to make decisions under conditions with high uncertainty [16]. The current study purposed to investigate the effect of noise on aggression, cognitive failures, and annoyance in Tejarat Bank employees in Tehran and also to present a model with the Bayesian network model approach.

Materials and Methods

This descriptive study was conducted in 2020-2021 recruiting the employees of Tejarat Bank branches in Tehran under ethics approval no. IR.MODARES.REC.1400.092.

Criteria for inclusion in this study comprised having at least one year of work experience, being in charge of the counters that interact with clients, and voluntary participation in completing the questionnaires. Accordingly, employees who are not behind the counters as well as service employees were not studied as a sample, because they lacked frequent and direct interaction with clients and differ from other employees under study. Individuals with a history of hearing disorders and related diseases determined through the review of their periodic medical examination files and individual self-declaration were excluded.

This study was conducted in several sections, the steps of which are shown in Fig.1:

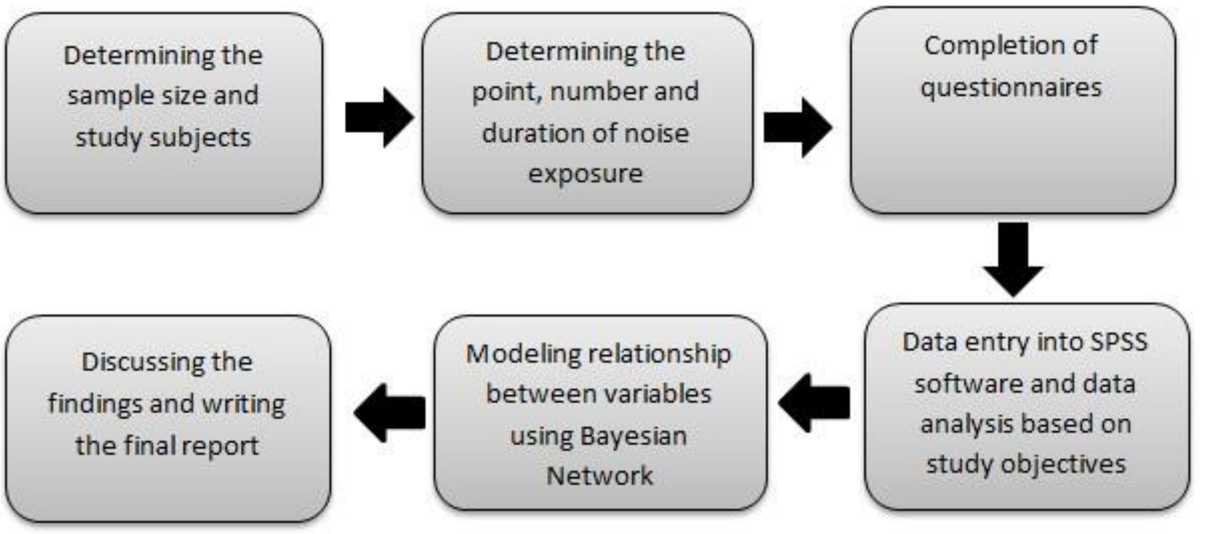

Fig. 1. Schematic view of research implementation steps

Because the total number of people working in branches of Tejarat Bank in Tehran was known, the Cochran formula was used. The main formula for calculating the Cochran sample size in a limited community is as follows:

Formula 1.

$$n = \frac{\frac{Z^2 p \times q}{d^2}}{1 + \frac{1}{N}\left(\frac{Z^2 p \times q}{d^2} - 1\right)}$$

Where n is the size of the statistical sample, N is the volume of the statistical population, d is the allowable failures (usually considered to be 0.05), and Z is the value of a normal variable with a confidence level of 1-α. In the binary test, the Z value for the 95% confidence level is 1.96, and p is the ratio of having the desired attribute. $p = 1 - q$ is also the ratio of not having the desired attribute. In this method, p and q are usually considered 0.5.

According to the obtained statistics, approximately 4000 people are working in the branches of Tejarat Bank of Tehran. By placing this number in Formula 1, the minimum number of samples required for the study was calculated to be 350 people. Taking into account a withdrawal rate of 15%, the number of samples required for this study was set at 400 people.

A random sampling method was used to select the studied samples from the mentioned sections considering the geographical distribution of banks in Tehran. First, one bank from each of several geographical districts of the city (districts 2, 3, 4, 6, 7, 8, 9, 11, 13, and 14) was selected as representative of the banks in that district. As data obtained from the survey and the results of questionnaires in banks in different districts of the city were not significantly different, the geographical distribution of banks was not considered. Thus, regardless of geographical area, Tejarat Bank branches were randomly selected, and qualified employees were invited to voluntarily participate in the study.

Bank employees who interact with clients are exposed to different types of in-bank sounds, including device sounds, clients' voices, and conversations between colleagues. To determine the amount of noise exposure of individuals, the requirements of the ISO 9612 standard were observed [17]. Job-based measurement strategies were used to measure the noise exposure of individuals according to the type and nature of their work [18].

A researcher-made questionnaire was used to collect background and demographic data. To determine the rate of cognitive failures, noise annoyance, noise sensitivity, and aggression, subjects were asked to complete the Broadbent Cognitive Failures Questionnaire, the Annoyance Scale, and the Buss Perry Aggression Questionnaire at the end of the work shift. Additional information about the questionnaires is provided below.

Cognitive failures can be defined as mind-related failures in things that people can do flawlessly and thoroughly and include problems with memory, attention, and function [19]. The Broadbent Cognitive Failures Questionnaire (CFQ) was used to assess cognitive failures. It included 25 questions in the field of cognitive failures and measures the 4 dimensions of memory, nominal memory, concentration, and motor actions. The validity, internal consistency, and reproducibility of this questionnaire have been studied by Hassanzadeh et al. According to their results, the

Cronbach's alpha coefficient of this tool is 0.96, which indicates its high reliability [20].

To assess noise annoyance, participants were asked to rate the degree of annoyance related to workplace noise on a 100-point graphical ranking scale with two verbal poles: "zero annoyance" and "very annoying 100". This scale has been used in many other studies [21, 22]. The validity and reliability of the Persian translation of this questionnaire has been examined by AliMohammadi and is available in ISO / TS15666: 2003 [23].

Noise sensitivity indicates a person's inner state and degree of responsiveness to noise [24]. The Weinstein Noise Sensitivity Scale consists of 21 Likert-scale questions scored from zero to five. The final score of this questionnaire is between zero and 105, and the higher it is, the more sensitive the person is to noise. The validity of the Persian version of this questionnaire has been evaluated and confirmed by AliMohammadi et al. (Cronbach's alpha coefficient of this questionnaire was 0.78) [25].

The Buss and Perry Questionnaire was used to assess aggression [26]. This questionnaire is a 29-item questionnaire with items scored on a five-point Likert scale. The questions are designed in four areas: physical aggression, verbal aggression, anger, and hostility. Questions 1 to 9 concern physical aggression, 10 to 14 verbal aggression, 15 to 21 show anger, and 22 to 29 hostility [27]. In 2008, Samani evaluated the reliability and validity of this questionnaire. Based on the results, the Buss and Perry questionnaire has appropriate validity and reliability for use by researchers and experts. Cronbach's alpha method was used to determine the reliability of the questionnaires. Cronbach's alpha values obtained from 30 questionnaires for noise sensitivity, cognitive failures, and aggression were 0.84, 0.89, and 0.86, respectively, which indicates the appropriate reliability of the questionnaires.

After collecting questionnaire data and noise measurement, the data were entered in SPSS software version 22. First, descriptive data was analyzed using descriptive statistics methods. To examine the mean differences of quantitative variables (age, work experience, noise exposure, noise annoyance, cognitive failures, memory, nominal memory, distraction, motor actions, aggression, physical aggression, verbal aggression, anger, and hostility) between the two-state variables, the independent t-test was used assuming equality of variances. To evaluate the difference between the means of quantitative variables, among the three-state variables, one-way analysis of variance more was used. The Pearson correlation test investigated the relationship of noise exposure, noise annoyance, noise sensitivity, age, and work experience with the studied variables such as cognitive failure and its dimensions and aggression and its dimensions. A multiple linear regression test was used to evaluate the effects of noise exposure, sensitivity, age, and work experience on noise annoyance. In the next step, the multiple linear regression test was used to evaluate the effects of age, work experience, noise exposure, and sensitivity and noise annoyance on cognitive failures. Finally, the multiple linear regression test evaluated the effects of age, work experience, noise exposure, sensitivity, and noise annoyance on aggression and its dimensions.

The Bayesian network is a probabilistic graphical model that shows a set of variables and probabilities associated with each other. In other words, it is a straight graph and a cycle in which nodes are the variables of the problem. The structure of a Bayesian network is a graphical representation of the interactions of the variables to be modeled.

Each Bayesian network consists of three main components, including a set of nodes, a set of clauses, and a set of probabilities. Bayesian networks allow analysts to perform forward and reverse calculations. In fact, by collecting the status of the cause parameters, the cause status can be obtained. Moreover, with this method, when the status of the cause or the same parameter predicted by a reversal process is available, it will be possible to calculate the status of effective parameters. In other words, how much each parameter will affect the final output can be determined [28].

Results

From among those invited to participate in the current study, 34 people (8.5%) had a history of mental health problems such as depression and other mental illnesses; 366 people (91.5%) had no history of any mental illness or disorder. Furthermore, 43 people (10.8%) had an associate’s degree, 313 (78.2%) had a bachelor's degree, and 44 (11%) people had a master's degree.

To examine the correlation of age, work experience, noise exposure, noise annoyance and noise sensitivity with aggression and its dimensions, the Pearson correlation test was used, the results of which are presented in Table 1.

Table 1. Correlation of age, work experience, noise exposure, noise annoyance, and noise sensitivity with aggression and its dimensions

	Age	Work experience	Noise exposure	Annoyance	Noise sensitivity	Aggression	Physical aggression	Verbal aggression	Anger	Hostility
Age	1									
Work Experience	0.856*	1								
Noise exposure	-.053	-0.078	1							
Annoyance	-0.083	-0.115**	0.748**	1						
Noise sensitivity	-0.079	-0.120	0.791**	0.895**	1					
aggression	-0.110*	-0.143**	0.403**	0.487**	0.493**	1				
Physical aggression	-0.009	-0.044	0.023	-0.004	0.045	0.657**	1			
Verbal aggression	-0.067	-0.094	0.763**	0.956**	0.868**	0.512**	0.022	1		
Anger	-0.071	-0.067	0.071	0.098*	0.105*	0.497**	0.024	0.077	1	
Hostility	-0.128*	-0.133**	0.084	0.099*	0.133**	0.494**	0.112*	0.099*	0.070	1

** Significance at the failures level of 0.01
* Significance at the failures level of 0.05

The correlation of age, work experience, noise exposure, noise annoyance and noise sensitivity with cognitive failures and its dimensions was investigated using the Pearson correlation test, the results of which are presented in Table 2.

Table 2. Correlation of age, work experience, noise exposure, annoyance, and sensitivity with cognitive failures and its dimensions

	Age	Work experience	Noise exposure	Annoyance	Noise sensitivity	Cognitive failures	Memory	Nominal memory	Distractions	Motor actions
Age	1									
Work experience	0.856**	1								
Noise exposure	-0.053*	-0.078	1							
Annoyance	-0.083	-0.115*	0.748**	1						
Noise sensitivity	-0.079	-0.120*	0.791**	0.895**	1					
Cognitive failures	-0.017	-0.016	0.677**	0.746**	0.677**	1				
Memory	-0.033	0.028	0.193**	0.327**	0.235**	0.612**	1			
Nominal memory	0.036	0.015	0.404**	0.430**	0.340**	0.558**	0.226**	1		
Distractions	-0.027	-0.046	0.625**	0.594**	0.573**	0.644**	0.161**	0.742**	1	
Motor actions	0.024	0.020	0.001	0.108*	0.038	0.155**	0.167**	0.181**	0.128*	1

** Significance at the failures level of 0.01
* Significance at the failures level of 0.05

According to the results of the Pearson test, age was not related to the studied variables, but work experience had a significant inverse correlation with annoyance (-0.115) and noise sensitivity (-0.120), such that increasing work experience reduced annoyance and sensitivity. The results of this test showed that exposure to noise was significantly and positively associated with the variables of annoyance, sensitivity, cognitive failures, memory, nominal memory, and distraction. Increasing exposure to noise led to an increase in all the mentioned variables. Additionally, noise annoyance had a significant relationship with sensitivity, cognitive failures, memory, nominal memory, distraction, and motor actions and had correlations of 0.895,** 0.746,** 0.327,** 0.430, 0.594,** and 0.108,* respectively, with these variables. Noise sensitivity, like noise annoyance, was positively and significantly associated with cognitive, memory, nominal memory, and distraction. The correlation of noise sensitivity with these variables was 0.677, 0.235, 0.340, and 0.573, respectively.

The correlation of aggression and its dimensions with cognitive failures and its dimensions was investigated using the Pearson correlation test, the results of which are presented in Table 3.

Table 3. Correlation of aggression and its dimensions with cognitive failures and its dimensions

	Aggression	Physical aggression	Verbal aggression	Anger	Hostility	Cognitive failures	Memory	Nominal memory	Distractions	Motor actions
Aggression	1									
Physical aggression	0.657**	1								
Verbal aggression	0.512**	0.022	1							
Anger	0.497**	0.024	0.077	1						
Hostility	0.494**	0.112*	0.099*	0.070	1					
Cognitive failures	0.347**	-0.003	0.743*	0.053	0.016	1				
Memory	0.027	-0.072	0.278**	-0.054	-0.075	0.612**	1			
Nominal memory	0.236**	0.027	0.469**	0.009	0.038	0.558**	0.226**	1		
Distractions	0.355**	0.080	0.647**	0.011	0.065	0.644**	0.161**	0.742**	1	
Motor actions	-0.042	-0.074	0.086	0.010	-0.108*	0.155*	0.167**	0.181**	0.128*	1

** Significance at the failures level of 0.01
* Significance at the failures level of 0.05

At this stage, the first task is to determine the structure of an initial model and the study nodes, i.e., the base or primary nodes, the middle nodes, and the target node. Noise annoyance and aggression were selected as the middle node based on the made prototype. Then, based on the results of the questionnaire, variables that had a significant relationship with the middle node were selected as the primary node, and finally, the cognitive failures variable was selected as the target node. Fig.1 shows the made prototype.

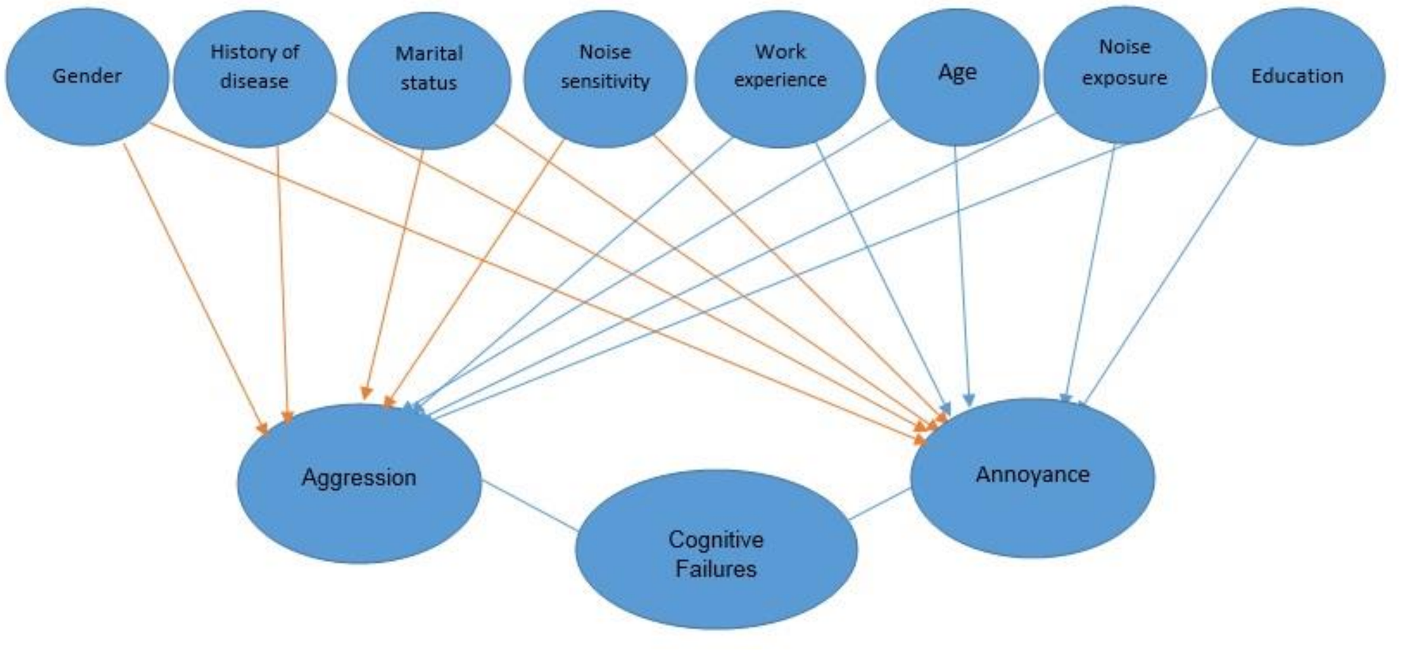

Fig. 1. The made prototype model

Because considering all the above factors in the construction of a Bayesian network was very complicated, by considering the more statistically effective factors, four influential variables were selected from the eight existing ones and entered into the Bayesian network. Moreover, as the use of two-state variables makes it easier to do so, so quantitative and continuous variables, and three-state and more variables became binary variables. For example, in the case of noise annoyance, people who had an annoyance of more than 50 were classified in the "annoyed" group, and people who had an annoyance of lower than 50 were classified in the "no annoyance" group. In the next step, the probability distributions of the initial nodes and conditional probability tables were calculated. The conditional probability table of the final cognitive failures variable is shown in Table 4.

Table 4. Cognitive failures probability distribution

Noise annoyance	Yes		No	
Aggression	Yes	No	Yes	No
Yes	0.57	0.39	0	0.02
No	0.43	0.61	1	0.98

The conditional probability table of a variable includes the conditional probability of that variable in relation to the parent node. After all the probabilities have been calculated, by entering one or more inputs, this model can be used to calculate the values of the output variables. Figure 2 shows the final model made.

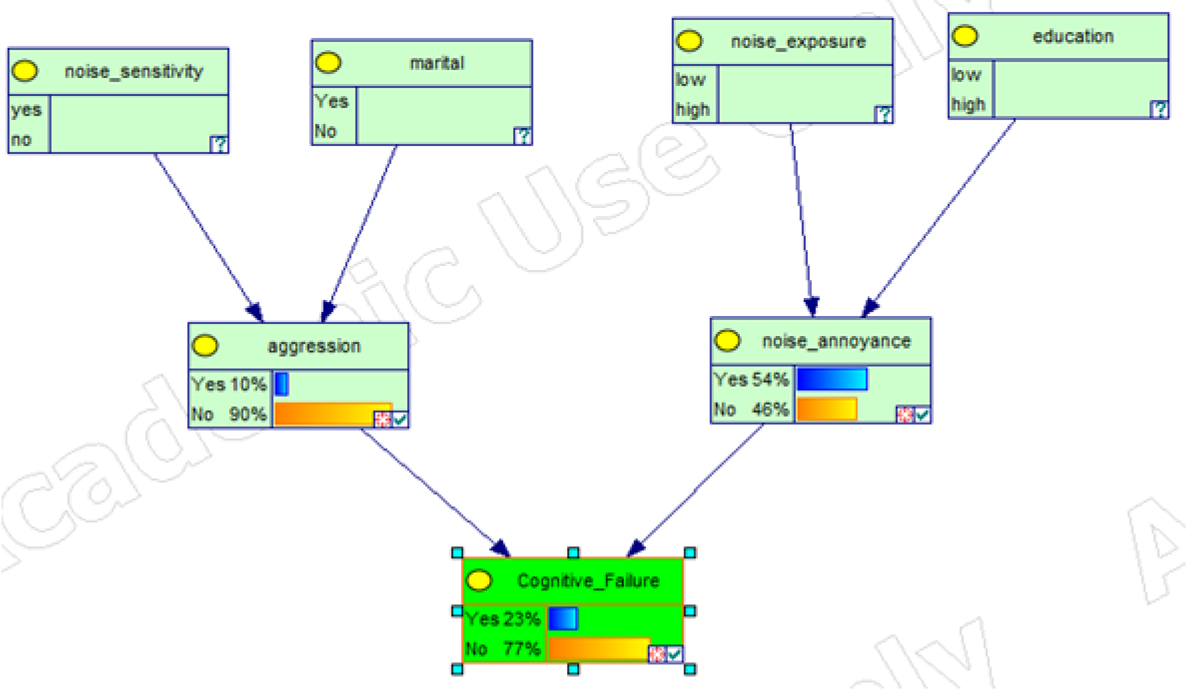

Fig. 2. Final made model

To evaluate the constructed model, two factors of robustness and diagnostic performance were monitored. To evaluate the model robustness, the five-fold cross-validation method was used, in which All data were randomly divided into five smaller categories (subgroups 1 to 5), with each category containing 20% of the total data. Then the probability of the final variable was calculated in subgroups 1 to 5. Thus, new submodels were created using new data categories. It should be noted that to increase the accuracy of the work, this process was repeated 5 times so that all data were included in the validation data group once, and then the calculated probability difference with the remaining 80% of the data was obtained. For example, in sub-model 1, the data from groups 2 to 5 were used as available data, and data from group 1 were used to validate the model. Then, Formula 2 was used to calculate the root mean square failures.

Formula 2.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (P_i - O_i)^2}{n}}$$

where RMSE is the root mean square failures, Pi is the probability of final variable using available data (80% of total data), Oi is the probability of final variable using validation data (20% of total data), and n is the total number of data.
The results of the RMSE calculation are shown in Table 5.

Table 5. Results of model robustness evaluation: Calculation of root-mean-square errors

Submodels made with 80% of the total data	Probability of the final variable in the submodels made with 80% of the total data		Submodels made with 20% of the total data	Probability of the final variable in the submodels made with 20% of the total data		Probability difference	.Root mean square errors (rmse)
Submodel 1	Yes	24%	Submodel 6	Yes	21%	0.03	0.0015
	No	76%		No	795		
Submodel 2	Yes	24%	Submodel 7	Yes	23%	0.01	0.0005
	No	76%		No	77%		
Submodel 3	Yes	23%	Submodel 8	Yes	25%	0.02	0.001
	No	77%		No	75%		
Submodel 4	Yes	25%	Submodel 9	Yes	19%	0.06	0.003
	No	75%		No	81%		
Submodel 5	Yes	22%	Submodel 10	Yes	48%	0.026	0.013
	No	78%		No	52%		

As shown in Table (3.6), the RMSE for submodels 1 to 5 is less than 0.01. Moreover, this number was calculated to be 0.013 for submodel 6, which means that the difference of the probability of training and validation data is less than 0.01 on average (less than 0.013 in submodel 6), indicating the appropriate reliability of the constructed model (Mean total failures: 0.0038).

Evaluation of diagnostic performance: For this purpose, the three factors of accuracy, precision, and recall were examined. The accuracy of the model indicates the number of samples that are correctly classified among the total samples and the accuracy of the number of samples that are correctly classified among the actual positive samples (resulting from the questionnaire). Finally, data recall is the number of samples that are correctly identified among the positive samples (obtained from the model) (32). Based on this, the factor of accuracy, precision, and recall were 0.8, 0.89, and 0.96, respectively, which indicates the appropriate diagnostic performance of the model. Table 6 shows the results of checking the factor of accuracy.

Table 6. Results of the accuracy of the made model

Sample	Education	Noise exposure	Marital status	Noise sensitivity	Cognitive failures from the questionnaire	Cognitive failures from the model
1	Low	Low	No	No	No	No
2	Low	High	No	Yes	Yes	No
3	Low	Low	No	No	No	No
4	Low	High	No	Yes	No	Yes
5	Low	High	No	Yes	Yes	Yes
6	Low	Low	No	No	No	No
7	Low	High	No	Yes	Yes	Yes
8	Low	High	No	Yes	No	Yes
9	Low	Low	No	Low	No	No
10	Low	High	No	Yes	No	Yes
11	Low	Low	No	No	No	No
12	High	High	No	Yes	Yes	Yes
13	Low	High	No	Yes	Yes	Yes
14	Low	Low	No	Low	No	No
15	Low	High	No	Yes	Yes	Yes
16	Low	Low	No	No	No	No
17	Low	High	No	Yes	Yes	Yes
18	Low	High	Yes	High	Yes	Yes
19	Low	High	No	Yes	Yes	Yes
20	Low	High	Yes	High	Yes	Yes
21	Low	High	Yes	High	Yes	Yes
22	Low	Low	No	No	No	No
23	Low	High	No	High	Yes	Yes
24	Low	High	Yes	Yes	No	Yes
25	Low	High	No	Yes	Yes	Yes
26	Low	High	No	High	No	Yes
27	Low	Low	No	No	No	No
28	Low	High	No	High	Yes	Yes
29	Low	High	No	High	Yes	Yes
30	Low	High	No	Yes	Yes	Yes

Discussion

In this study, the means of noise exposure and noise annoyance were 62.86 and 57.74 dB, respectively. The level of noise exposure is above the allowable level of exposure recommended by the National Institute of Occupational Safety and Health for administrative work which requires mental performance. Furthermore, the requirements of the Environmental Protection Agency in residential-commercial environments is lower than 55 dB [30]. The main sources of noise in the studied banks are the activities of employees (e.g., working with computer keyboards, telephone conversations, talking to customers, talking to other colleagues, money counting machines, queue management system, alerts and phone rings in banks), customer behaviors in waiting stations, air conditioners, and outdoor noise sources (such as car traffic) [31].

The occurrence of noise annoyance depends on two key factors, namely noise exposure and individual characteristics such as noise sensitivity. Based on the current results, noise sensitivity had a significant increasing effect on noise annoyance. Numerous studies have been conducted on the relationship between sensitivity and noise annoyance, the results of which show that noise sensitivity acts as a mediating variable for the occurrence of noise annoyance [32, 33]. Based on the available findings, noise sensitivity acts as an independent predictor; in other words, people with high noise sensitivity experience higher noise annoyance.

Based on the results, noise exposure caused cognitive failures directly and by creating secondary effects such as noise annoyance. These results are consistent with the results of previous studies [15, 34, 35]. Noise annoyance may have a synergistic effect which increases agitation and distraction and decreases mental function [36]. Numerous studies have shown that chronic exposure to intermediate and higher levels of noise will lead to decreased attention and memory and increased stress [37-39]. Several pathways have been suggested for the effect of chronic noise exposure on performance, including impaired attention, increased stimulation, improper filtering of sound during cognitive activities, and consequently, the loss of focused attention and noise annoyance [40-43].

The purpose of this study was to investigate the effect of noise and other contextual and demographic variables on aggression and its dimensions. According to the results, noise exposure, noise annoyance and noise sensitivity were positively and significantly associated with aggression. The results of the multiple linear regression test, however, showed that noise annoyance and noise sensitivity were the only variables affecting aggression. According to the standard beta coefficient, it can be seen that noise annoyance had a lower effect (0.224) than noise sensitivity (0.271). Some experimental studies have shown that aggression is significantly associated with noise and annoyance [44]. Other researchers believe that exposure to noise alone cannot cause aggressive behavior, but in combination with previous provocation, anger or hostility, it can cause aggressive behavior [45, 46]. The results of this study also showed that although exposure to noise has a significant relationship with aggression, based on regression results, it can be acknowledged that exposure to noise does not directly affect aggression, however, it may cause aggressive behaviors in office workers by causing noise annoyance.

Limited studies have been performed on the effect of noise exposure on aggression, so the relationship between the two cannot be precisely explained. One study showed that people exposed to noise exhibit aggressive behaviors if they lack the ability to control the noise [47]. The results of several studies have shown that neurotic and introverted people are highly sensitive to noise waves, and therefore, their behavior is more affected when they are exposed to noise [48]. In this regard, the results of the present study showed that people with high noise sensitivity exhibit more aggressive behaviors. In addition to annoyance and noise sensitivity, other variables such as workload, aggressive behavior of the client, job security, etc. can be valid reasons for the aggression of bank employees [49] who are outside the scope of the present study. Identifying and managing the causes of violence by bank employees is an important issue that has been considered by researchers, because this factor can impose a heavy economic burden on banks and other financial services providers.

Based on the results of the Bayesian model, the variable of education level as the main demographic variable, with a probability of 88.75 for people with associate's degree and bachelor's degree and a probability of 11.25 for master's degree holders, along with the variable of noise exposure, with a probability of 13.25 for exposure of lower than 55 dB and a probability of 86.75 for exposure higher than 55 dB, had a direct effect on noise annoyance. It should be noted that people exposed to noise lower than 55 decibels, regardless of their level of education, do not suffer from noise annoyance with a probability of 1; people exposed to noise higher than 55 decibels, however, suffer from noise annoyance with a probability of 0.61 for people with an associate degree and a probability of 0.7 for undergraduate and graduate degree holders. Previous studies have well studied the effects of noise and its features on annoyance, but findings regarding the relationship between education level and annoyance level are not sufficient. Given that people with a higher level of education experience more annoyance, it can be said that people with a higher level of education are more vulnerable to the effects of noise. This may be because more educated people have higher expectations of workplace health conditions and become more annoyed by the noise of the workplace when reality is not consistent with their expectations. More educated people may also be more aware of the effects of noise. Increasing awareness of the effects of noise increases noise sensitivity and, consequently, noise annoyance. Noise annoyance, in turn, increases the likelihood of cognitive failures. In fact, the highest probability of occurring cognitive failures is when people get annoyed (with a probability of 0.57 for aggressive people and a probability of 0.39 for non-aggressive people). In addition, because people with higher noise exposure and a higher education experience more annoyance, it can be concluded that the variables of education and noise exposure causes cognitive failures through annoyance.

Among demographic variables, marital status had the most significant relationship with aggression with a probability of 62.5 for married people and 37.5 for single people with noise sensitivity with a probability of 85.75 for people sensitive to noise and 14.25 for people who are not sensitive to noise; as input variables to the aggression node, they had a direct effect on aggression. For example, the probability of being aggressive was 0.17 for single and sensitive individuals, which was the highest probability. Furthermore, the lowest level of aggression with zero probability was related to people who were not sensitive to noise, and marital status was not effective in this regard. In previous studies, the effect of noise sensitivity on the occurrence of aggression has been well studied, but the findings on the relationship of different marital statuses are insufficient. Given that single and sensitive people are more aggressive, it can be said that these people are more vulnerable to the effects of noise. This may be because married people probably have more stable emotions and personalities, because their sexual and emotional needs are satisfied. Additionally, these people are probably more patient and experienced in dealing with problems and stressors such as noise, so they are less prone to stress and aggression than single people [50]. Noise annoyance and aggression, in turn, had a direct effect on the cognitive failures variable. For example, aggressive people who suffered from noise annoyance had cognitive failures with a probability of 0.57.

Therefore, it can be stated that noise sensitivity and marital status indirectly affect cognitive failures. Noise exposure and education also affect cognitive failures indirectly. It should be noted that the highest probability of cognitive failures occurs in aggressive people who have also suffered from noise annoyance (with a probability of 0.57).

As it was not possible to take into account all the factors affecting the intermediate variables and make the model complex, it is recommended that in order to achieve more accurate results, similar studies be performed in different populations and working conditions without the limitations mentioned in this study.

There were some limitations in this study, the expression of which is important to preserve the originality of the research and facilitate future studies. The first was the use of subjective methods to collect employee data. Although the subjective method is the best way for individuals to express subjective changes, the use of objective methods such as counting failures as well as more consistent monitoring of employees' aggressive and hostile behaviors can enhance the strength of future studies. Considering that in this study, the data required by researchers were self-reported, it can be stated that the findings are accompanied by bias. To overcome this limitation, future research is suggested to use different evaluation methods such as self-evaluation, evaluation by colleagues and officials, and third party evaluation to collect data. Another limitation of this study, which leads to the non-generalizability of its results to all administrative employees, is that the working conditions and duties of bank employees are different from those of other administrative employees. Ignoring the effect of personality type, environmental parameters such as ventilation, brightness, and air temperature can be another limitation of the present study.

Conclusion

Based on the findings of the current study, it can be stated that people with higher levels of education are more vulnerable to the effects of noise, and noise annoyance, in turn, increases the likelihood of cognitive failures, such that the highest probability of cognitive failures occurs when people are annoyed. In addition, because people with higher noise exposure and higher education experience more annoyance, it can be concluded that the variables of education and noise exposure cause cognitive failures through annoyance. Regarding the aggression variable, considering that single people and those who are sensitive to noise became more aggressive, it can be said that these people are more vulnerable to the effects of noise.

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