Epidemiology and Health System Journal
doi:10.34172/ehsj.26267 2024 Autumn;11(4):198-203 http://ehsj.skums.ac.ir

Original Article

Relationship Between Noise Characteristics (Frequency Cut-off Point) and Communication Skills and Cognitive Triad in Industrial Workers

Vahideh Abolhasannejad[1], Fereydoon Laal[1*], Homeyra Mohammadi Darmiyan[1], Hamid Salehiniya[2]

[1]Department of Occupational Health and Safety Engineering, School of Health, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran
[2]Department of Epidemiology and Biostatistics, School of Health, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran

***Corresponding Author:**
Fereydoon Laal,
Email: fereydoonlaal@gmail.com

Received: September 9, 2024
Revised: December 16, 2024
Accepted: December 25, 2024
ePublished: December 31, 2024

Abstract

Background and aims: Sound is one of the most significant factors influencing communication and cognitive processes in industrial environments. Therefore, the objective of this study was to investigate the complex relationship between noise characteristics, specifically the frequency cut-off point, and proficiency in communication and cognitive abilities.

Methods: This descriptive-analytical study was conducted with a sample of 263 workers in the tile industry. The sound equivalent level (Leq) and dosimetry were calculated using the standard methods established by the American Conference of Governmental and Industrial Hygienists and ISO 9612. Sound pressure levels were recorded in octave band center frequencies using a calibrated sound analyzer (CEL-450 model). Additionally, the Cognitive Triad Inventory (CTI) and the Queendom Communication Skills Test-Revised (QCSTR) were employed to assess communication and cognitive skills, respectively. The data were analyzed using independent samples t-tests, Pearson's correlation coefficient, and one-way analysis of variance.

Results: The subjects were exposed to a Leq with a dose of 13.54 ± 86.76 and 4246.34 ± 1784.20, respectively. The scores for the CTI and the QCSTR were 11.35 ± 111.90 and 20.92 ± 153.05, respectively. The results indicated a significant difference in CTI scores based on gender ($P < 0.001$). Additionally, an inverse and significant relationship was observed between exposure dose and CTI scores ($P = 0.004$). Furthermore, no significant differences were found in CTI and QCSTR scores between the two groups exposed to low ($f \leq 250$ Hz) and high ($f > 250$ Hz) dominant frequency sounds.

Conclusion: An increase in exposure dose was associated with a decrease in CTI scores. Contrarily, no significant correlation was observed between CTI and QCSTR scores in the two groups exposed to low and high dominant frequency sounds. This finding supports the notion that depression is more prevalent in men.

Keywords: Communication skill, Cognitive triad, Sound dose, Sound equivalent level

Introduction

Noise pollution is one of the most significant physical hazards in occupational settings. It can adversely affect employees' quality of working life by inducing psychological effects that often manifest gradually.[1] The World Health Organization concluded as early as 1971 that noise poses a significant threat to human well-being, resulting in a variety of negative effects.[2] Exposure to noise has now been linked to a range of health issues that extend beyond auditory concerns.[3] According to reviews, approximately 2 million workers in Iran are exposed to excessive noise levels.[4] According to Masoudzadeh et al, the mental health status of individuals in low-noise areas is better than that of those in high-noise areas.[5] Based on the findings of Abbasi et al, noise acts as a stressor in the workplace and can account for variations in work-related stress levels.[6] Stress is a complex interplay of emotional and physical reactions to challenging situations, functioning as both a motivator and a hindrance in navigating one's environment. However, repeated exposure to stressful conditions can negatively impact both physical and mental health. Chronic stress, in particular, has been linked to the development of depression.[7] Several studies have indicated that noise exposure is associated with depressive symptoms.[8-10]

In accordance with Beck's cognitive theory, the development of depressive symptoms is thought to be facilitated by what he describes as the cognitive triad, which includes negative perceptions of oneself, the world, and the future.[11] Research conducted by Marchetti et al suggests that this cognitive triad acts as a significant vulnerability factor for individuals experiencing symptoms

of depression.[12,13] Furthermore, Braet's study revealed that negative views held toward oneself and one's future were particularly strongly associated with depressive symptoms and mental health disorders.[14] Noise pollution is a significant health concern across various fields, as it can impair hearing and speech, induce fatigue and stress, and hinder attention and effective communication.[15] Communication is the human activity that binds people together and fosters relationships.[16] Employees exchange ideas and information through workplace communication, and effective communication is essential for completing any task.[17] This concept of personal interaction refers to the exchange of verbal and non-verbal communication between two or more individuals.[18] Furthermore, a lack of transparency in instructions and ambiguous messaging that some workers do not fully comprehend can lead to miscommunications regarding expectations, resulting in errors and inefficiencies. According to the study by Wilson et al, poor communication can heighten misunderstandings, misinterpretations, and errors in tasks or projects within the work environment.[19,20] Communication skills encompass the behaviors that enable individuals to effectively and efficiently share their thoughts and feelings, facilitating the achievement of interpersonal goals in interactions and relationship processes.[17] Research has revealed an intriguing correlation between noise exposure in work environments and the deterioration of communication skills. Excessive exposure to disruptive noises acts as a stressor, impairing our ability to communicate effectively, thereby highlighting how our immediate surroundings can significantly influence cognitive functions that are essential for successful interactions.[21,22]

Assessing the negative health impacts of noise exposure based solely on noise intensity is insufficient; a comprehensive evaluation should include frequency spectrum analysis. Furthermore, previous studies have not addressed the impact of noise frequencies on the cognitive triad and communication skills in industrial environments. Therefore, the present study aims to fill these gaps in the existing literature by providing a holistic view of the effects of noise, specifically examining the relationships associated with dominant noise frequency cut-off points. The analysis of sound frequency cut-off points and the related encounters in the investigated relationships is a distinguishing feature of this study. Additionally, this research is conducted with a larger sample size, which is in line with recommendations from prior studies. It is important to note that variations in industry type and work processes have resulted in differences in sound characteristics, suggesting that this issue warrants further investigation.

Materials and Methods

Subjects and Survey

An insightful descriptive-analytical study was conducted within the tile and ceramics industries in 2023. A cohort of 300 individuals was meticulously selected through simple random sampling techniques to participate in this groundbreaking exploration. Based on a minimum correlation between variables of 0.19,[22] a sample size of 287 participants was determined, achieving a confidence level of 95% and a test power of 90%. To account for incomplete cases, the final sample size was adjusted to 300 individuals. The details of the sample size calculation are provided as follows:

Exact-Correlation: Bivariate normal model
Options: Exact distribution
Analysis: A priori: Computation of the required sample size
Input: Tail(s) = Two
Correlation ρ H1 = 0.19
α err prob = 0.05
Power (1-β err prob) = 0.9
Correlation ρ H0 = 0
Output: Lower critical r = -0.1158089
Upper critical r = 0.1158089
Total sample size = 287
Actual power = 0.9009624

After excluding incomplete samples, the study was conducted with 263 participants. The inclusion criteria for the study required participants to have a minimum of six months of work experience and to be free from cardiovascular diseases, diabetes, and congenital hearing impairments. On the other hand, workers who were treated with psychoactive drugs were excluded from the study. This information was gathered through participant interviews and self-reports. It is important to note that all participants retained the right to withdraw from the study at any stage.

The following questionnaires were used in the first phase of the study:

- Demographic Information: A checklist prepared by the researchers
- Cognitive Triad Inventory (CTI): A tool designed to assess cognitive patterns
- Queendom Communication Skill Test–Revised (QCSTR): A standardized test to evaluate communication skills.

Data on noise exposure were collected in the second phase.

Questionnaire

The CTI is a self-assessment questionnaire designed to evaluate individuals' thoughts about themselves, their world, and their future. The inventory consists of 36 items rated on a Likert-type scale that ranges from "strongly agree" to "strongly disagree." It features three distinct subscales that focus on participants' perspectives regarding themselves (how individuals perceive their own identity and worth), their surroundings (how they view their environment and the people within it), and their outlook for the future (their expectations and hopes regarding future events and circumstances).

Higher scores on the CTI indicate a more positive

outlook, while lower scores reflect a more negative perspective. Although the CTI is theoretically divided into these three subscales, research has demonstrated that it possesses a single-factor structure, which is often labelled as "inherent negativity".[23] The CTI is believed to assess three key dimensions of self-perception, including the view of the self as a whole, the view of the self in the world, and the view of the self in the future.[24] In the study conducted by Farhadi Cheshmeh Morvari et al, the validity and reliability of Beck's CTI were confirmed, demonstrating a high level of internal consistency with a Cronbach's alpha coefficient of 0.93.[25]

The refined QCSTR was meticulously developed by Queendom in 2004 to assess adult communication abilities. This comprehensive assessment consists of 34 thoughtfully designed items that evaluate various aspects of communication proficiency, including the interpretation of verbal and nonverbal cues (9 items), emotional regulation (9 items), listening skills (6 items), insight into communication (5 items), and assertiveness (5 items).

Participants respond to the items using a five-point Likert-type scale, indicating the frequency of their behaviors from "never" to "always." The overall score on the QCSTR can range from 34 to 170. Based on their scores and in terms of levels of communication, participants are categorized into low (scores between 34 and 68), medium (scores between 68 and 102), and high (scores exceeding 102) competence groups.

This scoring framework allows for a nuanced understanding of an individual's communication skills, where higher scores reflect greater effectiveness in conveying messages.

Furthermore, within the framework established by Zarei et al, the QCSTR was found to possess considerable reliability, achieving a commendable Cronbach's alpha coefficient of 0.88.[26]

Noise Exposure Measurement and Frequency Spectrum Analysis

In this study, noise exposure was measured using the ISO 9612 standard method.[27] Equivalent noise level [LAeq (dBA), defined as the A-weighted Leq sound level] was determined using a TES 1355 model calibrated noise dosimeter closer to the identified worker's hearing position in various sections. In the study, the duration of noise measurement was calculated based on variations in noise levels, ensuring that the assessment captured the full range of acoustic conditions present in the environment. The sound pressure levels were recorded using a calibrated sound analyzer (CEL-450 model), which allowed for precise measurement across different frequency bands. Thus, noise exposure characteristics depend on specified dominant noise frequency cut-off points (dominant frequency of 250 Hz and lower and more than 250 Hz).[28]

Statistical Analysis

Descriptive statistics, such as frequencies, percentages, means, and standard deviations, were used to describe the collected data. According to the normality of the data distribution, statistical analyses were conducted using an independent sample t-test, Pearson's correlation coefficient analysis, and one-way analysis of variance. The data were analyzed using SPSS (version 26), and the significance level was set at 0.05.

Results

The age and work experience of participants were 33.49 and 9.54 years, respectively. Most workers in different parts of tile factories had a diploma or education. About 236 (89.7%) people were men. Detailed information is presented in Table 1.

Participants were exposed to a noise level of 86.76 ± 13.54 dB(A), which exceeded the allowable limit. The means of the CTI and communication skills (QCSTR) subscales and overall scores of the subjects were reported in this study. The total scores of CTI and QCSTR were 111.90 ± 11.34 and 153.05 ± 20.92, respectively. Overall, 78.3% of workers displayed good communication skills, and the remaining 21.7% demonstrated moderate communication skills. The three CTI scales and the five dimensions of communication skills scores are listed in Table 2. Based on the findings, the mean scores of CTI and QCSTR were 167.48 ± 14.30 and 111.07 ± 8.94 in women and 151.40 ± 20.94 and 112.00 ± 11.65 in men, respectively.

Based on the independent t-test, no significant difference was observed between QCSTR and gender ($P = 0.92$). However, the mean scores of QCSTR in the men were somewhat higher. The results showed a significant difference between CTI and gender ($P < 0.001$). It should be mentioned that CTI and QCSTR had no significant relationship with age ($P = 0.4$, $P = -0.08$), work experience ($P = 0.78$, $P = -0.06$), and education level ($P > 0.05$). Similarly, there was no significant correlation between noise exposure and communication skills ($P = 0.09$, $r = -0.10$). However, a significant relationship was found between noise exposure and cognitive triad ($P = 0.004$, $r = -0.178$); thus, participants with higher noise exposure experienced a more negative outlook. According to the results, there was no significant association between CTI and QCSTR ($P = 0.07$). The risk analysis was performed based on questionnaire variables. The results revealed that the risk of exposure at the obtained levels was ruled out

Table 1. Demographic Data of All Participants (N = 263)

Variable		Mean ± SD, N (%)	Range
Age (y)		33.49 ± 6.49	19-59
Work experience (y)		9.54 ± 5.11	1-24
Gender	Male	236 (89.7)	
	Female	27 (10.3)	
Education level	≤ Diploma	190 (72.2)	
	Associate degree and BSc	66 (25.1)	
	≥ MSc	7 (2.7)	

Note. SD: Standard deviation.

Table 2. Mean and Standard Deviation of CTI and QCSTR Subscale Scores Among Participants

Subscale	Variable	Mean ± SD	Range
CTI	View to the self	55.47 ± 8.95	22-70
	View to the world	42.96 ± 6.30	22-62
	View to the future	54.61 ± 10.86	15-70
	Total (cognitive triad)	111.90 ± 11.35	82-168
QCSTR	Understanding verbal and nonverbal messages	33.15 ± 4.16	19-45
	Emotional regulation	27.59 ± 5.45	16-79
	Listening skill	20.98 ± 3.49	10-30
	Insight into the communication	17.05 ± 2.56	5-23
	Assertiveness	14.42 ± 3.31	7-23
	Total (communication skills)	153.05 ± 20.92	96-189

Note. SD: Standard deviation; CTI: Cognitive Triad Inventory; QCSTR: Queendom Communication Skills Test-Revised.

due to the lack of a relationship between the level of noise exposure and communication skills.

In this study of individual exposures, the time-weighted average based on the type of exposure and its duration was measured in people. Moreover, a frequency analysis was conducted at people's workstations and within the hearing range to determine the frequency characteristics of encountered sounds. Based on the noise frequency cut-off point (dominant noise frequency of less than or equal to 250 Hz and more than it), the mean of the CTI and QCSTR were not significantly different. The distribution of noise frequency is illustrated in Figure 1.

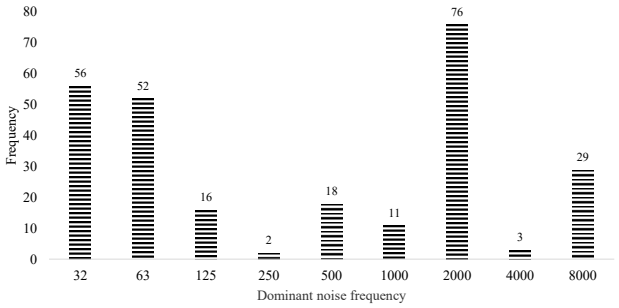

Figure 1. Distribution of Noise Frequencies Among the Participants

Discussion

The essence of this study was unravelling the potential correlation between the cognitive triad and communication skills in relation to noise exposure parameters among workers. Most participants displayed commendable levels of communication proficiency. Effective communication is essential for human performance and forms the basis of interpersonal relations.[29] Recently, there has been a growing focus on the importance of communication skills and interpersonal interactions in every individual's life.[30] Effective communication is now widely recognized as crucial for advancement and achievement in individual and societal contexts.[31] In this study, no notable connection was found between communication skills and gender. The results of our research are in line with the findings of Khatib Zanjani and Moharreri,[31] Gheirati et al,[32] Zarei et al,[26] and Fallah Madvari et al[22] but contradict those of Zhou et al.[33] It could be due to a difference in cultural status, assessment tools, sample size, and participants. Meanwhile, Sasaki et al found that training interventions can change attitudes and improve relationships.[34,35] In the current study, participants' worst and best cognitive views were of the world and the self, respectively. Some studies showed that the opposing views of the self and the future were the components most strongly correlated with depressive symptoms.[14] According to the findings, a significant difference was observed between CTI and gender, so women's mean CTI scores were higher than men's. In other words, women had a more positive view than men. This finding supports the notion that depression is more likely in men. At the same time, the depression prevalence rate in women was 2–3 times higher than that in men.[36] In the present research, CTI and QCSTR did not vary in terms of age, work experience, and education level.

Regarding age, the results of this study conform to the findings of Fallah Madvari et al,[22] but the results of the study by Yusefi et al[37] are not consistent with those of the current study. Furthermore, the findings of Norouzinia et al revealed no statistically significant relationship between academic members' communication skills and work experience,[38] which matches the results of the current study. The present research showed that the noise exposure exceeded the permissible limit.

In the study by Mostaghaci et al, workers were exposed to noise levels above 85 dB, which demonstrated a high incidence of noise-induced hearing loss among tile and ceramic workers.[39] Noise is an unpleasant sound that can cause undesirable physiological and neuropsychological effects and change human health.[40] The non-auditory effects of noise are a significant health and safety concern. Noise annoyance is one of the most significant adverse effects of noise exposure. Numerous research findings confirmed a strong correlation between noise exposure and annoyance. Studies have shown that depression as a mental health component might be impacted by noise annoyance.[41] Drawing upon the research of Beutel et al, a clear link emerged between noise annoyance and both anxiety and depression within the general population.[10] The present investigation delved into how noise exposure impacted the cognitive triad among workers, revealing an intriguing inverse correlation between these variables. This implies that increasing the noise level has led to strengthening individuals' negative views (viz., view of the self, view of the world, and view of the future), which contradicts the results of the study performed by Madvari et al.[42] Further, the findings of Pittard et al indicated positive cognitions within the cognitive triad shield against depressive symptoms, emphasizing the importance of self-affirming thoughts.[43] Despite this insight, our study failed to unveil any significant association between noise exposure levels and communication prowess among workers, mirroring past research that yielded contradictory

outcomes regarding noise's impact on communication skills.[22] Moreover, our findings revealed no statistically significant correlation between the cognitive triad and communication skills. In a study by Madvari et al, there was no significant relationship between communication skills and the cognitive triad,[42] which is consistent with the current research findings. Most studies on the adverse health effects of noise have focused on the noise intensity rather than its frequency spectrum. The findings of this study showed that communication skills and the cognitive triad of participants had no significant difference based on the noise frequency cut-off point (dominant frequency of 250 Hz and lower and more than 250 Hz). According to Abbasi et al, the effects of noise exposure were significantly correlated with the frequency of the noise.[44] The frequency spectrum is a critical characteristic of noise. However, there is a lack of research examining the impact of various noise frequency spectra on communication skills and the cognitive triad in humans. Given the influence of noise characteristics, along with other personal and environmental factors, on the outcomes and auditory and non-auditory effects of workplace exposure, it is recommended that future studies explore the role of these diverse factors. Additionally, conducting analyses of noise exposure risk assessment is suggested for future research endeavors.

Limitations of the Study

The present study, while yielding valuable findings, is not without limitations that may serve as a catalyst for further research endeavors. A comparative approach is warranted to explore the nuances across various occupations, populations, and socioeconomic conditions.

Conclusion

In the present study, a significant association was identified between exposure to noise and the cognitive triad of participants. The findings support the notion that depression is more prevalent among men. Conversely, there were no associations between demographic variables and communication skills or the cognitive triad. Given that the level of exposure exceeded standard thresholds, it is imperative to implement both technical and managerial interventions.

Acknowledgments

The researchers express their sincere gratitude to the individuals who participated in this study.

Authors' Contributions

Conceptualization: Fereydoon Laal.
Data curation: Vahideh Abolhasannejad, Fereydoon Laal, Homeyra Mohammadi Darmiyan.
Formal analysis: Hamid Salehiniya, Fereydoon Laal.
Investigation: Vahideh Abolhasannejad, Fereydoon Laal.
Methodology: Vahideh Abolhasannejad, Fereydoon Laal.
Project administration: Fereydoon Laal.
Resources: Vahideh Abolhasannejad, Fereydoon Laal, Hamid Salehiniya.
Supervision: Fereydoon Laal.
Writing–original draft: Vahideh Abolhasannejad, Fereydoon Laal, Homeyra Mohammadi Darmiyan, Hamid Salehiniya.
Writing–review & editing: Fereydoon Laal, Vahideh Abolhasannejad.

Competing Interests

It is essential to note that the authors of this inquiry have affirmed their commitment to integrity by declaring no conflict of interests relevant to this investigation. This ethical gesture ensures transparency and enhances trustworthiness within scholarly pursuits.

Ethical Approval

This study underwent rigorous review by the esteemed Ethics Committee at Birjand University of Medical Sciences, receiving approval under the ethical code IR.BUMS.REC.1402.038.

Funding

None.

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