

Assessment of Road Traffic Noise and Associated Health Complaints-Analysis Through Structural Equation Model

Payal Dubey^{1*}, Kunwar Raghvendra Singh¹, Sudhir Kumar Goyal¹

¹ Department of Civil Engineering

GLA University/ Mathura, Uttar Pradesh 281406, INDIA

*Corresponding Author: payaldubey786@gmail.com

DOI: <https://doi.org/10.30880/ijie.2025.17.05.016>

Article Info

Received: 29 September 2024

Accepted: 7 January 2025

Available online: 30 August 2025

Keywords

Noise pollution, self-assessment, road traffic noise, human health, structural equation model, AMOS software

Abstract

Noise pollution due to the increasing number of vehicles is one of the foremost concerns in the modern era, which hampers the humans physical and mental well-being of people specially residing in developing countries. Various studies have reported associations between noise exposure and heart diseases, insomnia, stress, annoyance, and high blood pressure. These findings motivate us to assess the situation within our area. This paper aims to analyze the effects of traffic noise on dwellers living adjacent to the national highway (NH-44) stretch of 45 kilometers from Chatta to Township in Mathura. The Present study is based on the subjective analysis of the questionnaire on traffic-related noise pollution. The survey was conducted both online and offline mode. The data gathered from 740 respondents were analyzed through structural equation modeling (SEM). Absolute fit, incremental fit, and parsimonious fit indices were used to evaluate the hypothesis and validate the developed model. The study revealed that the factor analysis has given the three components of with overall variance of 49.306. Furthermore, analysis with a fit indices like chi square (100.04), DF (1.640), RMR (0.043), RMSEA (0.029), NFI (0.946), RFI (0.931), IFI (0.978), TLI (0.972), CFI (0.978), PNFI (0.740), and PCFI (0.765), respectively. The established model identified associations among user characteristics, noise effect and diseases. This study aims to provide assistance to policymakers in addressing the aforementioned difficulties. Further research should be conducted to explore potential strategies or interventions for mitigating the impact of traffic noise. The implementation of noise barriers, enforcement of traffic regulations, and provision of informative instructional signage are measures aimed at raising public awareness regarding the effects of traffic noise.

1. Introduction

In developing countries, noise pollution is a major issue, and India is no exception. Noise pollution is on the rise as a result of urbanization and population growth and it is affecting people's health and well-being and lowering their standard of living [1]. Noise pollution has been shown in recent studies to have several harmful consequences on human health [2]–[5]. Generally, the office timing, shop opening timing, school timing, and traffic police duty are between 8:00 am - 8:00 pm so these people are exposed to the high-risk factor of traffic noise pollution which for a minimum of 12 hours a day which is undoubtedly exceeding health and safety. Numerous studies have shown that noise pollution is harmful to one's physical and psychological welfare [6]–[8]. In terms

of ecological contamination, traffic noise is the most noticeable source and its effects are increasing daily [9]. Anxieties, annoyance, sleeping disorder, concentrations, and other mood disorders have been linked to roadside noise pollution [10]–[12]. Prolonged contact with loud noise generated from way traffic has been associated with discomfort, sleep disorders, concentration difficulties, and stress in humans. According to Pathak et al. [6], the most common cause of dizziness, headaches, and exhaustion is exposure to traffic noise. Non-auditory symptoms such as tinnitus and depression have been linked to the detrimental effects of noise on health [13]. Sleep disturbances, attention deficits, and depression are all possible side effects of excessive noise exposure [13]. In a study Ristovska et al. [14], irritation was found to be the primary health effect of stream traffic sources. Patients with the above-mentioned conditions are more likely to suffer from frequent nighttime arousals and exhaustion which brings problems of dizziness. The most vulnerable residents are those who work or live near highways, and they may have both momentary and persistent sound-related health consequences [15]. Students' ability to learn, and write reduces when they are exposed to loud noises, according to a wide variety of studies [16], [17]. The use of structural equation modeling (SEM) is one of the most significant approaches to the investigate of the impacts of noise [18]. Factor analysis (FA) and SEM, two mathematics techniques, have gained attention in early decades due to their frequent application in detecting and evaluating correlations among fictitious prototypes. FA is helpful in research related to direct respondent replies, to put it simply. Finding the connections between acquired variables and those received through survey questions without the use of prior knowledge is helpful. The SEM tactic helps investigate the intricate connections amid the measured variables, which is the second benefit. Additionally, the SEM does a comprehensive calculation of all system-wide needed coefficients [19]–[21].

The primary objective of the analysis is to discover the association between the variables being analyzed. When there was no earlier theory about the pattern of factors or observed variables, it is extremely useful for inferring a set of latent or observable objects from observed variables [22]. FA and SEM can help discover the number of latent factors needed before SEM can be employed in questionnaire-based investigations with a large number of observable variables [23]. It is important to note that the long examination has found that the various well-being problems and mental symptoms were attributed due to prolonged sight to sound, geo-location of humans, and the extent to sound [24]–[28]. While previous studies have established connections between noise pollution and health issues, our research specifically focuses on the subjective experiences of individuals living near NH-44, providing a localized perspective that is often overlooked. Additionally, our use of structural equation modeling (SEM) allows for a nuanced analysis of the relationships among user characteristics, noise effects, and health outcomes, which has not been extensively explored in this context. Hence, it is important to examine several drawbacks of sound pollution [29]. The reason for this examination was to identify the various appearances, including the average life expectancy, geo-location, and sound sense, on the particular well-being grievances and mental signs that were experienced by the target groups that were chosen for the investigation. In addition, with the assistance of the structural equation model, the moderators were located, and path estimates were utilized to evaluate the level of effectiveness possessed by each of these individuals.

2. Methodology

2.1 Study Area

The examination was performed in the areas of Mathura city that are located close to the National Highway-44. The city of Mathura comes under the state of Uttar Pradesh, India, covers a total area of 3,340 square kilometers. According to the preliminary findings of the total population of Mathura is 29.51 Lakh [30]. City serves as a connecting point between the nation's capital New Delhi and the city of Agra, which is home to the world-famous Taj Mahal. It is the one of India's most well-known and revered pilgrimage destination. Consequently, due to its proximity to New Delhi, hundreds of floating vehicles arrive in the city every week. There is a significant influx of traffic due to automobiles that are floating, resulting in noise pollution and adverse effects on human health.

2.2 Questionnaire Survey

A questionnaire survey of the locals ($n = 740$), students, professors, engineers, and other people (shop owners, drivers, traffic cops, security guards, etc.) open to traffic noise was undertaken in the research region. A variety of noise levels questions were asked to the sampling population, which was carefully chosen. People were chosen individuals from various schools, colleges, and universities who attended institutions and daily office going, drivers who follow set routes, shopkeepers were located near NH-44. There are two sections to the questionnaire. The first section included user characteristics such as gender, age, profession, exposure hours, the standard of education, and marital status [31]–[33]. Additionally, individuals who had a history of hearing loss, were taking frequent medications, used ototoxic drugs, or had head injuries were not considered [3]. The respondent's irritation threshold and noise sensitivity were the main topics of the second portion. The respondents were questioned about their general perception of noise, as analyzed by a sole query with 3-point scale devised via [18],

which included the options "Yes, No and Don't Know." The final section deals with the well-being problems and psychological symptoms that the respondents experienced daily.

Based on literature review, noise-related psychological symptoms and health complaints were chosen [13], [34]. The five greatest frequent psychological fitness issues were chosen, including headache, annoyance, stress, concentration issues, and sleeping disorder. The respondents were also separated by age, with the youngest respondents being those who were 0 to 20 years old, and the oldest being those who were >60 years old. The criteria and rationale used for selecting the questions included in the questionnaire is suitable of context, the reliability and validity checked which found significant of the questions which included in study and adopted the scale from [17], [35], [36].

2.3 Statistical Analysis of Data

IBM Statistical package for social science software V20 performed the analysis. SEM is created using the SPSS Amos V23 which helps to understand the association between prolonged sound exposure and fitness worries [34], [37]. Conducted a factor analysis (FA) on the survey questionnaire data to investigate the distribution of the data, the associations between the variables, and most importantly, to uncover the unobserved factors that were driving our results. FA is a data summarizing tool that uses a limited number of units to extract the information needed to characterize the raw data and decipher the complex relationships between its variables [23]. In this way, FA can help identify trends in survey data, rearrange the data if necessary, and clarify the variables assessed in the survey so that the maximum number of extracted factors can be determined. FA was utilized in the current investigation to identify the common factors influencing human health from the variables that were detected in the questionnaire [38]. Using the SPSS software suite, the FA was carried out using the principal component analysis extraction method with 30 convergence iterations set to varimax rotation [39].

SEM is a modeling system that includes different sets of statistical techniques, mathematical models, and algorithms to create a link between the hypothesis and input data and includes a structural model and path model. There are many benefits of using SEM such as it is used to examine complex relationships between variables and takes into account hypothetical or unobserved ones [40]. Also, it generates all system coefficients simultaneously, allowing the investigator to evaluate the consequences of any one link in the background of the complete prototype. Additionally, the generated prototype can be mathematically validated in an immediate study of the whole arrangement of variables to verify the prototype's validity [41]. To understand the immediate and long-term effects of noise, the structural equation model is an excellent technique [42]. A Structural Equation Model (SEM) was employed to analyse the relationships between research variables. This statistical technique involves a two-step approach:

1. **Measurement Model Assessment:** This step evaluates the validity and reliability of the measurement instruments used to assess the constructs of interest.
 - **Reliability:** The consistency of the measurement was assessed using Cronbach's alpha and composite reliability. Both indices should exceed 0.70 to indicate acceptable reliability.
 - **Validity:** The extent to which the measurement instruments accurately measure the intended constructs was evaluated.
 - **Convergent validity:** This assesses whether a construct's indicators are highly correlated with each other. The square root of the average variance extracted (AVE) should be greater than or equal to 0.50.
 - **Discriminant validity:** This ensures that a construct is distinct from other constructs. The correlation between a construct's indicators and those of another construct should be lower than the AVE of either construct.
2. **Structural Model Assessment:** This step tests the hypothesized relationships between the constructs. The structural model specifies the causal pathways and the strength of the relationships between variables.

By conducting both the Measurement Model and Structural Model, SEM provides a comprehensive analysis of the relationships between constructs and the validity and reliability of the measures used to assess them.

Following Steps used to conduct SEM:

1. Development of Theoretical Models: Construct hypotheses regarding the interrelations among variables.
2. Data Acquisition: Gather data on the observable variables.
3. Model Specification: Convert the theoretical model into a series of structural and measurement equations.
4. Model Estimation: Employ statistical software to ascertain the parameters of the model.
5. Model Evaluation: Evaluate the model's compatibility with the data.
6. Analysis Interpretation: Analyse the findings of the examination.

3. Result and Discussion

3.1 Survey Analysis

The total surveyed people were 740 out of which 73 percent were males and 27 percent were females. The results of the questionnaire that 32 percent, 16 percent, and 52 percent of the total surveyed people suffered from high noise levels during the morning, afternoon, and evening respectively. The responses of the respondents highly rely on the location of the individual which causes variance in their responses. When asked about the foremost sources of noise, 83 percent of people said that traffic flow was the biggest reason for noise pollution in the research region, followed by infrastructure projects at 11 percent and commercial operations at 6 percent. Also, 58 percent of the surveyed people complained about traffic noise that affects them on-work, and 42 percent were affected off-work whereas 52 percent of surveyed people suffered from chronic disorders which is a long-term syndrome, and 48 percent suffered from short-term diseases. The result of surveyed people also revealed that 95 percent of the total surveyed people were aware of traffic noise pollution.

3.2 Kaiser-Meyer-Olkin Test and Bartlett Test

The Kaiser-Meyer-Olkin (KMO) test determines if the statistics acquired are evenly distributed among the population under study. For a satisfactory correlation, the KMO coefficient should be over 0.7 [43]. FA is invalid if the identity matrix is a correlation matrix, which can be detected using the Bartlett test. With a KMO of 0.769, the data gathered were found to be suitable for FA, as indicated in Table 1. The tests ensure a good correlation between the initial variables taken into consideration. The significance level was less than the 0.01 which shows that the correlation matrix is not an identity matrix. So, there is no scope for reduction. Thereby proving that FA can be used to extract latent factors from the collective data, by these two tests [38].

Table 1 Kaiser-Meyer-Olkin test and Bartlett test

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.769
Approx. Chi-Square	1835.798
Bartlett's Test of Sphericity df	78
Sig.	.000

3.3 Factor Extraction

Factor loadings show the linking coefficient among a single variable and its common factor. A main component factor analysis extraction approach was used to analyze the data. It integrates variables with strong factor loadings to a specific latent factor together. Table 2 shows the total variance of 49.31 percent for a solution containing a total of three latent components. Latent components with eigenvalues greater than 1 were selected for analysis by FA.

A weak variable is defined with a factor loading of less than 0.45 to better comprehend the extracted factors. It's not even worth looking into [44]. Table 3 is for the original factor loadings of three latent factors. Table 3 displays the three retrieved latent components and their factor loadings. The correlation matrix is rotated when a variable has an association among more than two latent factors to simplify the answer. Table 4 displays the labels and names provided to the various common factors to help decipher their interrelationships and prospective features. Structural equation modeling is used to examine the same extracted common components in greater depth. They are in order in Table 4 because they're sorted by their shared latent components.

Table 2 Explanation of total variance in the FA

Component	Total Variance Explained								
	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Variance of Percentage	Percentage Cumulative	Total	Variance of Percentage	Percentage Cumulative	Total	Variance of Percentage	Percentage Cumulative
1	2.709	20.838	20.838	2.709	20.838	20.838	2.624	20.186	20.186
2	2.397	18.439	39.278	2.397	18.439	39.278	1.901	14.625	34.810
3	1.304	10.028	49.306	1.304	10.028	49.306	1.884	14.495	49.306

Table 1 Rotated component matrix

	Component		
	1	2	3
Qualification	.857		
Age	.854		
Occupation	.789		
Marital status	-.710		
WC		.713	
Personal life		.703	
Routine life		.647	
Sales		.605	
Sd			.689
Cn			.668
St			.665
An			.575

Table 2 Factor load matrix after rotation and the extracted three common factors

Notations	Observed Variable	Loading after rotation	Common factor extracted
A1	Qualification	.857	UC: User Characteristics
A2	Age	.854	
A3	Occupation	.789	
A4	Marital status	-.710	
A5	Working Capability	.713	NE: Noise Effects
A6	Personal life	.703	
A7	Routine life	.647	
A8	Sales	.605	
A9	Sleeping Disorder	.689	D: Diseases
A10	Concentration Difficulty	.668	
A11	Stress	.665	
A12	Annoyance level	.575	

Factor 1 (UC) verifies a total of 20.840 percent of the overall discrepancy visible in Table 4 per four variables, i.e. Qualification (A1), Age (A2), Occupation (A3), and Marital Status (A4). All these variables denote the user characteristics of respondents; hence, the factor was denoted "User characteristics (UC)" as represented in Table 4.

Factor 2 (NE) verifies 18.439 percent of the overall discrepancy visible in Table 4, with four variables, i.e. Working Capability (A5), Personal life (A6), Routine Life (A7), and Sales (A8). This factor was named "Noise Effects (NE)" as represented in Table 4.

Factor 3 (D) verifies 10.028 percent of the overall discrepancy visible in Table 4, with four variables, i.e., sleeping disorder (A9), Concentration Difficulty (A10), Stress (A11), and Annoyance level (A12). All these variables denote the chronicle effect of respondents for long-term syndromes; hence, this factor was named "Diseases (D)" as represented in Table 4.

3.4 Structural Equation Modelling

Relationships among the non-acoustic aspects haven't been examined and explained so far. To comprehend the interconnection between sound and the efficiency to perform the work during business hours can be analyzed by measuring variables. Non-acoustical factors, such as multiple regression analysis or co-relational analysis, are commonly used to examine the impact on job efficiency. The regression analysis has its own set of drawbacks, on the other hand, correlation analysis provides statistics for inter-relationship [45]. However, SEM examines several hypotheses within a model and is a better tool for examining and understanding complex multiple-dependent connections [46]. It examines the most basic theoretical links between latent factors and their observable variables that regression analysis does not provide. A latent factor is a relationship or a construct that cannot be immediately assessed; it is an assumption or an opinion. As a result, it is assumed that these constructs can only be determined using calculated variables as a computable index, such as the questions included in the survey form. SEM can trial a variety of theories about created latent components and their connection which makes it ideal for testing a wide variety of theories [45]. In SEM, the latent factors that are considered can be used both as predictors or inputs and as outcomes or the output that is intended. So far, only a few researchers have employed SEM to examine the complex interactions between non-acoustical factors and traffic noise.

3.5 Model Hypotheses

One of the most important tasks in SEM is the formulation of a model hypothesis [47]. Factor analysis (FA) provides a foundation for developing measurement as well as structural models for SEM. The resulting theories were established to investigate the links among the extracted common factors, as shown in Table 4.

Hypothesis 1- User characteristics Impact Noise Effects.

Hypothesis 2- User characteristics Impact Diseases.

3.6 Structural Model Assessment

The structural model generates the relationship between all latent factors with the help of explained and unexplained variation. The SEM depicts all regression equation models. A benefit of the structural model is its representation as a path model, facilitating the estimation of both indirect and direct effects. Moreover, SEM studies enable researchers to assess the congruence between facts and theory. This is not feasible in conventional multiple regression studies. It is a multivariate statistical analysis technique used to test hypotheses about relationships between measured variables and latent constructs. It combines elements of factor analysis and path analysis to provide a comprehensive framework for understanding complex relationships. Furthermore, the principle of SEM assumes that underlying constructs, or latent variables, exist but cannot be directly measured. These constructs are inferred from observed variables. The relationships between variables SEM specifies relationships between both observed and latent variables which represent hypothesized causal paths or correlations. The measurement model describes how observed variables relate to the latent variables. The structural model specifies relationships between the latent variables themselves. This represents the hypothesized causal pathways or correlations between the underlying constructs. SEM evaluates the fit of the specified model to the data. This involves assessing how well the model explains the observed covariance matrix. Goodness-of-fit indices are used to determine if the model is a good representation of the data. Model Estimation is Maximum Likelihood Estimation (MLE) the most common estimation method, MLE assumes that the data are normally distributed. Other methods include Generalized Least Squares (GLS), Weighted Least Squares (WLS), etc. the model is evaluated by Goodness-of-Fit Indices These indices measure how well the model fits the data. Direct and Indirect Effects in SEM allows for the analysis of both direct and indirect effects between variables. Path Coefficients represent the standardized relationships between variables and R-squared Values indicate the proportion of variance in a dependent variable explained by the independent variables [48].

The SEM was built including a structural model to analyze the relationship among the three latent factors. The four common factors were connected to comprehend the exposure effects of noise, and their effects were studied with the aid of presumptive assumptions and data gathered. The three common factors were connected to comprehend the impact of noise exposure, and their effects were studied with the aid of the hypothesis and data gathered. A multi-dimensional model must be sufficiently legitimate in both combining and separation to provide the best fit, whose path coefficients could produce excellent forecasts [38]. The four common factors were connected to comprehend the exposure effects of noise, and their effects were studied with the aid of presumptive assumptions and data gathered. The three common factors were connected to comprehend the impact of noise exposure, and their effects were studied with the aid of the hypothesis and data gathered. All expected statistical coefficients must be carefully evaluated to verify structural model fitness. Multiple collections of goodness-of-fit indices can be used to accomplish this. The structural equation model can be evaluated using a variety of fit indices, including absolute fit, incremental fit, and parsimonious fit. Table 5 shows the goodness of fit of the structural equation model.

A model developed via AMOS was tested to identify the associations. Additionally, If the value lies between < 0.08 (SRMR) and (RMSEA), it would have been accepted as an adequate model calculated via AMOS. The right values for the model are represented in Table 5 and fell within an acceptable range. The fit indices within recognized boundaries. A good fitting model is accepted if the value of the CMIN/df is < 5 . The chi-square/ degree of freedom ratio test is also within acceptable limits ($\chi^2 / DF = 61$). The model specifies an important association between user characteristics, Noise, and Diseases. The model indicates that the results of the SEM are represented as path models, and it helps to evaluate the fit between theory and the data collected [49]. The model shows that simple structural equation model, describing relationships among some user characteristics, noise effects, and related diseases. The squared multiple correlation was lower for noise and diseases, indicating that user attributes are not influenced by the effects of noise and diseases. Structural equation modelling of cross-sectional data revealed no direct connections between noise impacts and any self-reported health markers. The embedded model indicates that there is notable yet minor correlations between heightened noise annoyance and the variables of sleep disturbances, concentration, and headaches. It indicates significant correlations between noise sensitivity and other subjective health concerns as evidenced by model fit. This aligns with prior study findings indicating that univariate correlations between noise and health dissipate upon the inclusion of additional explanatory variables. In fig 1 The reported route estimate was 0.59, which indicates that personal lives were impacted by transportation noise. Those who said they experienced difficulties in their personal lives due to traffic noise were also significantly to say that noise interfered with their daily routines also standardized path estimate 0.55 [29]. Sleeping disorder path estimates 0.55 as a result of traffic noise which impacts human in multiple ways. The respondents who reported sleeping disorder have also reported being annoyed has a strong relationship with concentration with path estimates of 0.54. However, it possesses a strong bonding with stress with path estimation of 0.51 [35]. If an individual has a higher rate of noise exposure, then it would lead to multiple illnesses and mental issues. Likewise, many well-being fitness issues are also interlinked with high noise band exposure which was analyzed via model [18]. Noise Impact (N) path coefficient of 0.52 was found to have an impact on diseases. "Noise Impact" was a latent variable that consist of Noise related issues like traffic noise affect routine life, personal life and working capabilities etc. Hence, it can be concluded that personal life, routine life and working capabilities of respondents have a noticeable adverse effect on noise pollution and human health like stress, interference in communication, sleeping disorders, concentration, and annoyance due to noise. Therefore, these observed variables are having a predominant impact on the human's personal lives and daily routine life.

Table 3 Goodness of fit of the structural equation model

Type	Index	Cut-Off Values	Obtained Value	Results
Absolute fit	Chi-square	The Lowest Possible	100.04	Fit
	CMIN/DF	2- 5	1.640	Fit
	RMR	< 0.05	0.043	Fit
	RMSEA	< 0.05	0.029	Fit
Incremental fit	NFI	> 0.90	0.946	Fit
	RFI	> 0.90	0.931	Fit
	IFI	> 0.90	0.978	Fit
	TLI	> 0.90	0.972	Fit
	CFI	> 0.90	0.978	Fit
Parsimonious fit	PNFI	> 0.50	0.740	Fit
	PCFI	> 0.50	0.765	Fit

Note: RMR- root mean square residual; RMSEA- root mean square error of approximation; NFI- normed fit index; RFI- relative fit index; IFI- incremental fit index; TLI- Tucker-Lewis's index; CFI- comparative fit index; PNFI- parsimony normed fit-index; PCFI- parsimony comparative fit index.

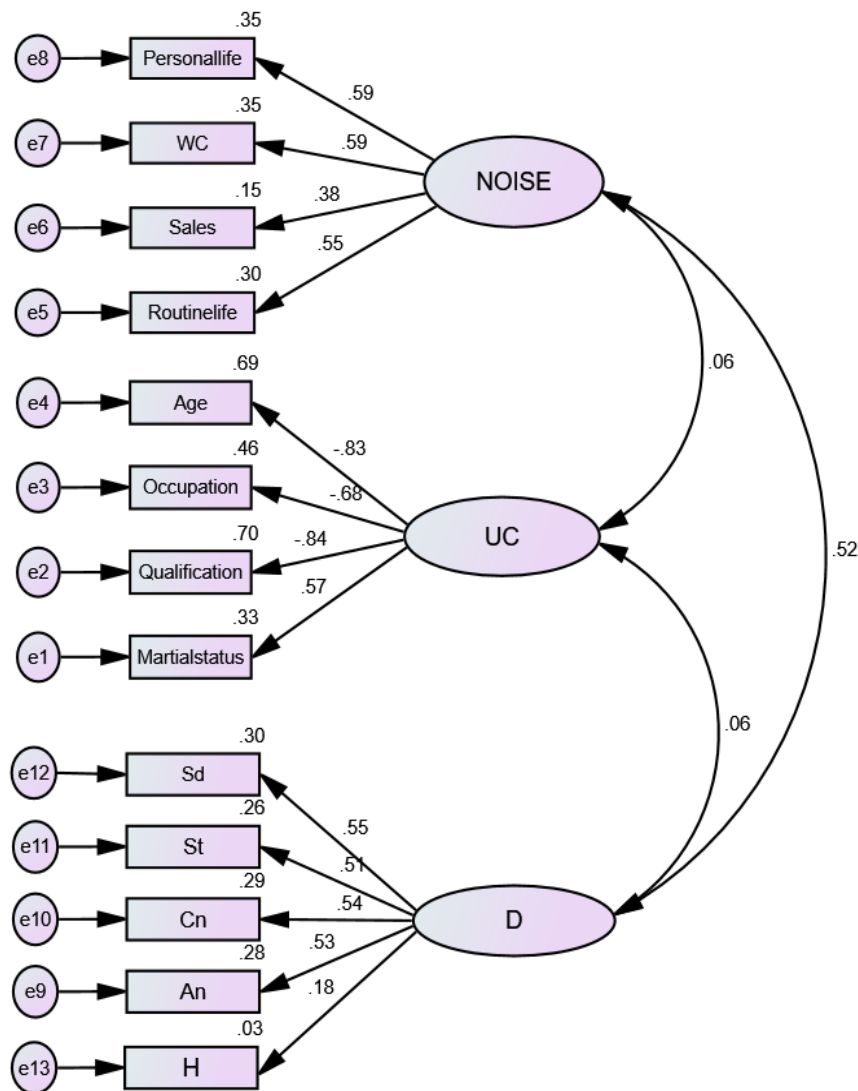


Fig. 1 Measurement model

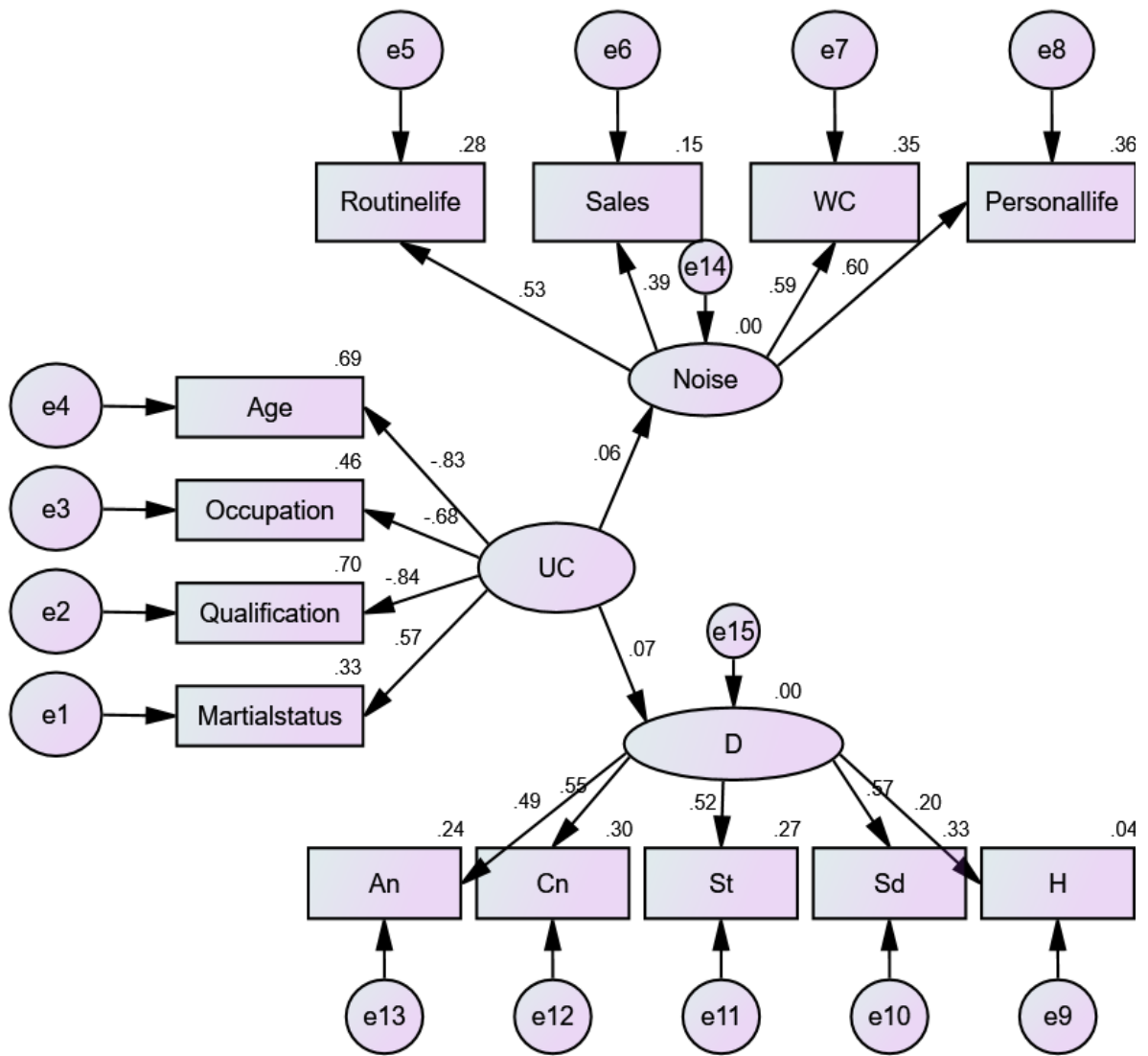


Fig. 2 Structural model relationship among user characteristics, noise effects and related diseases

Table 6 Survey result questionnaire

Serial Number	Questionnaire	Response
Total Respondents		740
1	Gender <ul style="list-style-type: none"> • Male • Female 	541 199
2	Age Groups <ul style="list-style-type: none"> • Group 1 (0-20) • Group 2 (21-40) • Group 3 (41 and above) 	35% 45% 20%
3	Qualification <ul style="list-style-type: none"> • Higher, Senior Secondary and others • Graduation or Post Graduation 	40% 60%
4	Occupation <ul style="list-style-type: none"> • Unemployed • Employed 	65% 35%
5	When traffic noise affects you more <ul style="list-style-type: none"> • On work • Off work • Don't Know 	56% 44% 0
6	Does traffic noise affect your concentration, sales or working efficiency <ul style="list-style-type: none"> • Yes • No • Don't Know 	57% 42% 1%
7	Is traffic noise affecting your basic routine? <ul style="list-style-type: none"> • Yes • No • Don't Know 	55% 40% 5%
8	What type of physical/psychological problems you are facing due to traffic noise? <ul style="list-style-type: none"> • Acute • Chronical • Don't Know 	31% 54% 15%
9	Do you often feel headache, stress, or annoyance because of traffic noise? <ul style="list-style-type: none"> • Yes • No • Don't Know 	59% 31% 10%

4. Conclusion

This study systematically investigated the potential health impacts of noise pollution on individuals. By employing Factor Analysis (FA) and Structural Equation Modeling (SEM), we examined significant user characteristics and the adverse consequences of noise exposure. Our findings revealed that noise pollution, as evidenced by sleep disorders, annoyance, and interference with verbal communication, significantly compromised the health of these individuals. The statistical modeling techniques utilized in this research aimed to identify the key factors influencing human health when exposed to excessive noise levels. The study's results highlight the substantial impact of noise pollution on person exposed to more than 12 hours of noise per day. Given the similarities in traffic, operational, and land-use characteristics, the findings of this analysis are likely applicable to other regions with comparable conditions. To mitigate environmental concerns, this research emphasizes the importance of

implementing various strategies, including afforestation initiatives, forest preservation, and the rehabilitation and improvement of road infrastructure with a focus on incorporating green spaces.

Acknowledgement

I am deeply indebted to my supervisors, Dr. K.R. Singh and Prof. Sudhir Kumar Goyal, for their rigorous intellectual guidance and unwavering support. Their scholarly insights and critical feedback were pivotal to the successful execution and completion of this research.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Payal Dubey, Kunwar Raghvendra Singh; **data collection:** Payal Dubey; **analysis and interpretation of results:** Payal Dubey; **draft manuscript preparation:** Payal Dubey, Kunwar Raghvendra Singh, Sudhir Kumar Goyal. All authors reviewed the results and approved the final version of the manuscript.

References

- [1] Fiedler, P. E. K., Henrique & Zannin, P. H. T. (2013) Evaluation of noise pollution in urban traffic hubs — Noise maps and measurements, *Environmental Impact Assessment Review*, 51, 1–9, <https://doi.org/10.1016/j.eiar.2014.09.014>
- [2] Lee, S.C., Hong, J.Y. and Jeon, J.Y. (2015) Effects of acoustic characteristics of combined construction noise on annoyance, *Build. Environment*, 92, 657–667, <https://doi.org/10.1016/j.buildenv.2015.05.037>
- [3] Ravindra, K., Singh, T., Tripathy, J.P., Mor, S., Munjal, S., Patro, B. and Panda, N. (2016) Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts, *Sci. Total Environ.*, 566, 981–987, <https://doi.org/10.1016/j.scitotenv.2016.05.070>
- [4] Fecht, D., Hansell, A. L., Morley, D., Dajnak, D., Vienneau, D., Beevers, S., Toledano, M.B., Kelly, F.J., Anderson, H.R. and Gulliver, J. (2016) Spatial and temporal associations of road traffic noise and air pollution in London: Implications for epidemiological studies, *Environment International*, 88, 235–242, <https://doi.org/10.1016/j.envint.2015.12.001>
- [5] Swain, B.K. and Goswami, S. (2013) Integration and comparison of assessment and modeling of road traffic noise in Baripada town, India, *International Journal energy Environment*, 4, 303–310.
- [6] V. Pathak, V., Tripathi, B.D. and Mishra, V.K. (2008) Evaluation of traffic noise pollution and attitudes of exposed individuals in working place, *Atmos. Environ.*, 42(16), 3892–3898, <https://doi.org/10.1016/j.atmosenv.2007.12.070>
- [7] Jagniatinskis, A., Fiks, B., Zaporozhets, O and Oosten, N.V. (2016) Annual noise assessment in the vicinity of airports with different flights' intensity, *Applied Acoustic*, 101, 168–178, <https://doi.org/10.1016/j.apacoust.2015.08.017>
- [8] Rahmani, S., Mousavi, S.M., and Kamali, M.J. (2011) Modeling of road-traffic noise with the use of genetic algorithm, *Appl. Soft Comput.*, 11(1), 1008–1013, <https://doi.org/10.1016/j.asoc.2010.01.022>
- [9] Yuan, M., Yin, C., Sun, Y. and Chen, W (2019) Examining the associations between urban built environment and noise pollution in high-density high-rise urban areas : A case study in Wuhan , China, *Sustain. Cities Society*, 50(6), 101678, <https://doi.org/10.1016/j.scs.2019.101678>
- [10] Ongel, A. and Sezgin, F. (2016) Assessing the effects of noise abatement measures on health risks: A case study in Istanbul, *Environ. Impact Assess. Rev.*, 56, 180–187, <https://doi.org/10.1016/j.eiar.2015.10.008>
- [11] Garoum, M., Laaroussi, N. and Ammar, A. (2015, 12-16 July). Road traffic noise analysis and annoyance in Moroccan cities: case of Rabat, [Conference Session] 22nd International Congress on Sound and Vibration, Florence, Italy.
- [12] Goines, L and Hagler, L. (2007) Noise pollution: a modern plague, *South Med J*, 100(3), 287–294, <https://doi.org/10.1097/smj.0b013e3180318be5>
- [13] Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., and Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The lancet*, 383(9925), 1325-1332, [https://doi.org/10.1016/S0140-6736\(13\)61613-X](https://doi.org/10.1016/S0140-6736(13)61613-X)

- [14] Ristovska, G., and Lekaviciute, J. (2013). Environmental noise and sleep disturbance: Research in central, eastern and south-eastern Europe and newly independent states. *Noise and health*, 15(62), 6-11, <https://doi.org/10.4103/1463-1741.107147>
- [15] Gholami, A., Nasiri, P., Monazzam, M., Gharagozlou, A., Monavvari, S. M., and Afrous, A. (2012). Evaluation of traffic noise pollution in a central area of Tehran through noise mapping in GIS, *Advances in Environmental Biology*, 6(8), 2365-2371.
- [16] Vogiatzis, K. (2012). Airport environmental noise mapping and land use management as an environmental protection action policy tool. The case of the Larnaka International Airport (Cyprus), *Science of the Total Environment*, 424, 162-173, <https://doi.org/10.1016/j.scitotenv.2012.02.036>
- [17] Zannin, P. H. T., Engel, M. S., Fiedler, P. E. K., and Bunn, F. (2013). Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil. *Cities*, 31, 317-327, <https://doi.org/10.1016/j.cities.2012.09.008>
- [18] Fyhri, A., and Klæboe, R. (2009) Road traffic noise, sensitivity, annoyance and self-reported health—A structural equation model exercise. *Environment International*, 35(1), 91-97, <https://doi.org/10.1016/j.envint.2008.08.006>
- [19] Shukla, A., and Tandel, B. N. (2024) Association of road traffic noise exposure and school childrens' cognition: A structural equation model approach, *Environmental research*, 240, 117388, <https://doi.org/10.1016/j.envres.2023.117388>
- [20] Vivek, A. K., Gupta, S., Khan, T., and Mohapatra, S. S. (2024). Strategies to mitigate safety and associated problems at gated rail road grade crossing: a structural equation modelling approach, *Transport policy*, 146, 19-30, <https://doi.org/10.1016/j.tranpol.2023.11.002>
- [21] Mepparambath, R. M., Le, D. T. T., Oon, J., Song, J., and Huynh, H. N. (2024) Influence of the built environment on social capital and physical activity in Singapore: A structural equation modelling analysis. *Sustainable Cities and Society*, 103, 105259, <https://doi.org/10.1016/j.scs.2024.105259>
- [22] Finch, J. F., and West, S. G. (1997) The investigation of personality structure: Statistical models. *Journal of Research in Personality*, 31(4), 439-485, <https://doi.org/10.1006/jrpe.1997.2194>
- [23] Richardson, A., Thompson, A., Coghill, E., Chambers, I., and Turnock, C. (2009) Development and implementation of a noise reduction intervention programme: a pre-and postaudit of three hospital wards. *Journal of clinical nursing*, 18(23), 3316-3324, <https://doi.org/10.1111/j.1365-2702.2009.02897.x>
- [24] Guski, R., Schreckenber, D., and Schuemer, R. (2017) WHO environmental noise guidelines for the European region: A systematic review on environmental noise and annoyance, *International journal of environmental research and public health*, 14(12), 1539, <https://doi.org/10.3390/ijerph14121539>
- [25] Miedema, H. M., and Oudshoorn, C. G. (2001) Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental health perspectives*, 109(4), 409-416, <https://doi.org/10.1289/ehp.01109409>
- [26] Muzet, A. (2007). Environmental noise, sleep and health. *Sleep medicine reviews*, 11(2), 135-142, <https://doi.org/10.1016/j.smr.2006.09.001>
- [27] Münzel, T., Gori, T., and Schmidt, F. (2016). CardioPulse. Noise pollution and arterialhypertension. *European heart journal*, 37(12), 933-936, <https://doi.org/10.15420/ehj.2016.37.12.933>
- [28] Evandt, J., Oftedal, B., Hjertager Krog, N., Nafstad, P., Schwarze, P. E., and Marit Aasvang, G. (2017) A population-based study on nighttime road traffic noise and insomnia. *Sleep*, 40(2), zsw055, <https://doi.org/10.1093/sleep/zsw055>
- [29] Yadav, M. M., and Tandel, B. (2021) Structural equation model-based selection and strength Co-relation of variables for work performance efficiency under traffic noise exposure, *Archives of Acoustics*, 46(1), 155-166, <http://dx.doi.org/10.24425/aoa.2021.136569>
- [30] India Census.net. (2024, Oct 19). Mathura population census by the India census.net Retrieved Oct 19, 2024, from <https://www.indiacensus.net/district/mathura>
- [31] Paiva, K. M., Cardoso, M. R. A., and Zannin, P. H. T. (2019) Exposure to road traffic noise: Annoyance, perception and associated factors among Brazil's adult population, *Science of the Total Environment*, 650, 978-986, <https://doi.org/10.1016/j.scitotenv.2018.09.041>
- [32] Fields, J. M., de Jong, R. G., Gjestland, T., Flindell, I. H., Job, R. S., Kurra, S., and Schumer, R. (2001) Standardized general-purpose noise reaction questions for community noise surveys: Research and recommendation. *Journal of sound and vibration*, 242(4), 641-679, <https://doi.org/10.1006/jsvi.2000.3384>

- [33] Hong, J., Lee, S., Lim, C., Kim, J., Kim, K., and Kim, G. (2018) Community annoyance toward transportation noise: Review of a 4-year comprehensive survey in Korea, *Applied Acoustics*, 139, 229-234, <https://doi.org/10.1016/j.apacoust.2018.04.037>
- [34] Okokon, E. O., Yli-Tuomi, T., Turunen, A. W., Tiittanen, P., Juutilainen, J., and Lanki, T. (2018) Traffic noise, noise annoyance and psychotropic medication use, *Environment international*, 119, 287-294, <https://doi.org/10.1016/j.envint.2018.06.034>
- [35] Nazneen, S., Raza, A., and Khan, S. (2020) Assessment of noise pollution and associated subjective health complaints and psychological symptoms: analysis through structure equation model, *Environmental Science and Pollution Research*, 27, 21570-21580, <https://doi.org/10.1007/s11356-020-08655-x>
- [36] Farooqi, Z. U. R., Sabir, M., Latif, J., Aslam, Z., Ahmad, H. R., Ahmad, I., and Ilić, P. (2020) Assessment of noise pollution and its effects on human health in industrial hub of Pakistan, *Environmental Science and Pollution Research*, 27, 2819-2828, <https://doi.org/10.1007/s11356-019-07105-7>
- [37] Wothge, J., Belke, C., Möhler, U., Guski, R., and Schreckenber, D. (2017) The combined effects of aircraft and road traffic noise and aircraft and railway noise on noise annoyance, *International Journal Environment Research Public Health*, 14(8), 871, <https://doi.org/10.3390/ijerph14080871>
- [38] Liu, W., Zhao, T., Zhou, W., and Tang, J. (2018) Safety risk factors of metro tunnel construction in China: An integrated study with EFA and SEM. *Safety Science*, 105, 98-113, <https://doi.org/10.1016/j.ssci.2018.01.009>
- [39] Costello, A. B., and Osborne, J. (2019) Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis, *Practical assessment, research, and evaluation*, 10(1), 7, <https://doi.org/10.7275/yj1-4868>
- [40] Bag, S. (2015). A short review on structural equation modeling: applications and future research directions, *Journal of Supply Chain Management Systems*, 4(3), 64-69, <http://dx.doi.org/10.21863/jscms/2015.4.3.014>
- [41] Mallick, Z., Badruddin, I. A., Hussain, M. K., Ahmed, N. S., and Kanesan, J. (2009) Noise characteristics of grass-trimming machine engines and their effect on operators, *Noise and Health*, 11(43), 98-102, <https://doi.org/10.4103/1463-1741.50694>
- [42] Dion, P. A. (2008). Interpreting structural equation modeling results: A reply to Martin and Cullen, *Journal of business ethics*, 83, 365-368, <https://doi.org/10.1007/s10551-007-9634-7>
- [43] Patel, D. A., and Jha, K. N. (2016). Structural equation modeling for relationship-based determinants of safety performance in construction projects. *Journal of management in engineering*, 32(6), 05016017, [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000457](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000457)
- [44] Bowden, E. E., and Wang, L. M. (2006) Appropriate characterization of background noise levels in the workplace. In *Building Integration Solutions* 1-9, [https://doi.org/10.1061/40798\(190\)20](https://doi.org/10.1061/40798(190)20)
- [45] Pennig, S., and Schady, A. (2014). Railway noise annoyance: Exposure-response relationships and testing a theoretical model by structural equation analysis. *Noise and Health*, 16(73), 388-399, <https://doi.org/10.4103/1463-1741.144417>
- [46] Ryu, H., Park, I. K., Chun, B. S., and Chang, S. I. (2017) Spatial statistical analysis of the effects of urban form indicators on road-traffic noise exposure of a city in South Korea, *Applied acoustics*, 115, 93-100, <https://doi.org/10.1016/j.apacoust.2016.08.025>
- [47] Xia, B., Xiong, B., Skitmore, M., Wu, P., and Hu, F. (2016) Investigating the impact of project definition clarity on project performance: Structural equation modeling study, *Journal of Management in Engineering*, 32(1), 04015022, [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000386](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000386)
- [48] Kline, R. B. (2023) *Principles and practice of structural equation modeling*. Guilford publications.
- [49] Steiger, J. H. (1990) Structural model evaluation and modification: An interval estimation approach, *Multivariate behavioral research*, 25(2), 173-180, <https://doi.org/10.1207/s15327906mbr25024>