A

Dissertation report

on

"EFFECTS OF NOISE ON JAIPUR LOW FLOOR BUS DRIVER'S PERFORMANCE"

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY
IN
INDUSTRIAL ENGINEERING

Submitted by

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JAIPUR – 302017 (RAJASTHAN), INDIA

CERTIFICATE

This is to certify that the dissertation entitled **"Effects of Noise on Jaipur Low Floor Bus Driver's Performance"** being submitted by **Manoj Kumar Jagrawal (2014PIE5007)** is a bonafide work carried out by him under my supervision and guidance, and hence approved for submission to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.) in Industrial Engineering**. The matter embodied in this dissertation report has not been submitted anywhere else for the award of any other degree or diploma.

Place: Jaipur
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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **"Effects of Noise on Jaipur Low Floor Bus Driver's Performance"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.)** in **Industrial Engineering**, and submitted to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** is an authentic record of my own work carried out by me during a period of one year from July 2015 to June 2016 under the guidance and supervision of **Prof. Awadhesh Bhardwaj** of the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for the award of any other degree or diploma.

Manoj Kumar Jagrawal
(2014PIE5007)

Place: Jaipur
Dated: June 2016

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- Manoj Kumar Jagrawal

ABSTRACT

A noise level above the permissible limit is quite likely to cause ill effects on driver's health. However, some individuals are more sensitive even to the maximum permissible noise levels because of individual variations in sensitivity. There is also a problem of reduction of driver's efficiency because of road traffic noise and their own vehicle noise. This research is focused on finding out the effects of noise level inside the vehicle cabin on Low Floor drivers in Jaipur. Therefore, health and performance related are collected from the literature. The health of a bus driver can be measured by their fatigue. Six factors can be classified (noise level, duration of noise exposure, the age of the driver, the age of the vehicle, BMI of the driver and driving experience). Dependencies of fatigue with above factors are calculated by Multiple Regression Analysis. The main conclusions are, (1) Noise is the most important factor which increases the fatigue of driver with the beta value of 0.603 followed by duration of noise exposure, the age of driver and age of vehicle with the beta values of 0.259, 0.176 and 0.128 respectively. (2) BMI of driver and driving experience are insignificant as compared to above 4 factors. (3) 4 models have been identified, and 4^{th} model is the best among all because it has the highest R-square value of 0.920 which implies that the model four fits better to the data than the other models, and it explains 92% of the variability of the response data around its mean.

Keywords: noise level, low floor bus, fatigue, duration of noise exposure, BMI of driver and driver's efficiency.

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CHAPTER 1: INTRODUCTION

Noise pollution is defined as any type of very loud or annoying noise that affects people's life. The noises can come from a large variety of sources, including machines and animals. Living or working near an airport, where the loud sounds of airplanes landing and taking off are often heard, is one way that a person may be exposed to noise pollution on a regular basis. Most of the people deal with loud or constant noise on a daily basis. However, what may seem like a simple annoyance in your everyday life may actually have serious effects on your health in both the long and short term. Noise pollution can be measured in decibels – noises above 45 decibels can prevent sleep while ear pain is caused around 120 decibels.

According to Environment (Protection) Rules, 1986 maximum permissible noise limits are listed in table 1 below

Table 1: Permissible Noise Limits

Category	Maximum dBA	
	DAY	NIGHT
Silence Zone	50	40
Residential Zone	55	45
Commercial Zone	65	55
Industrial zone	75	70

Source: Environment (Protection) Rules, 1986 Govt. of India

A noise level more than the maximum dBA is very dangerous and can cause bad effects on people's health. Some individuals are more sensitive even to the maximum permissible noise levels because of different variations in sensitivity.

Drivers are exposed to high noise from their own vehicles, and their working conditions are dominated by noise from all vehicles. Noise damages hearing and health and can frequently exceed levels set for occupational noise.

Table 2: Noise limits for vehicles at manufacturing stage applicable on and from 1stApril, 2005 according to The Environment (Protection) Rules, 1986 amendment in 2002

S.NO.	Types of Vehicle	Noise Limit(dBA)
1	Two wheelers	
1.1	Displacement up to 80 cc	75
1.2	Displacement more than 80 cc but up to 175 cc	77
1.3	Displacement more than 175 cc	80
2	Three wheelers	
2.1	Displacement up to 175 cc	77
2.2	Displacement more than 175 cc	80
3	Vehicles used for the carriage of passengers and capable of having not more than nine seats, including the driver's seat	74
4	Vehicles used for the carriage of passengers having more than nine seats, including the driver's seat, and a maximum Gross Vehicle Weight (GVW) of more than 3.5 tonnes	
4.1	With an engine power less than 150 KW	78
4.2	With an engine power of 150 KW or above	80
5	Vehicles used for the carriage of passengers having more than nine seats, including the driver's seat : vehicles used for the carriage of goods	
5.1	With a maximum GVW not exceeding 2 tonnes	76
5.2	With a maximum GVW greater than 3 tonnes but not exceeding 3.5 tonnes	77
6	Vehicles used for the transport of goods with a maximum GVW exceeding 3.5 tonnes	
6.1	With an engine power less than 75 KW	77
6.2	With an engine power of 75 KW or above but less than 150 KW	78
6.3	With an engine power of 150 KW or above.	80

Source: The Environment (Protection) Rules, 1986 amendment in 2002 Govt. of India

1.1 Excessive Noise

Excessive noises are one of the leading causes of occupational health problems in drivers. It affects the health condition of the workforce in various ways such as in the form of varying blood pressure, reduced performance, sleeping difficulties, annoyance and stress (Nelson et al. 2005). Exposure to excessive level of noise may lead to noise induced hearing loss (NIHL). NIHL still counts for 57% of all incidents of occupational diseases reported in Austria and is the number-one job-related disease (AUVA 2013). Research reveals that transport noise can cause many diseases like temporary and permanent hearing loss. Sleep disturbance, cardiovascular disease, elevated hormone levels, psychological problems may arise, and even death is possible in some cases in the long run.

1.2 Effects of Excessive Noise on Human Health:

Excessive Noise causes many functional disorders in the organs of human body. But mainly it hampers the audiological system of the human body. Several effects of noise pollution on the human body are listed below

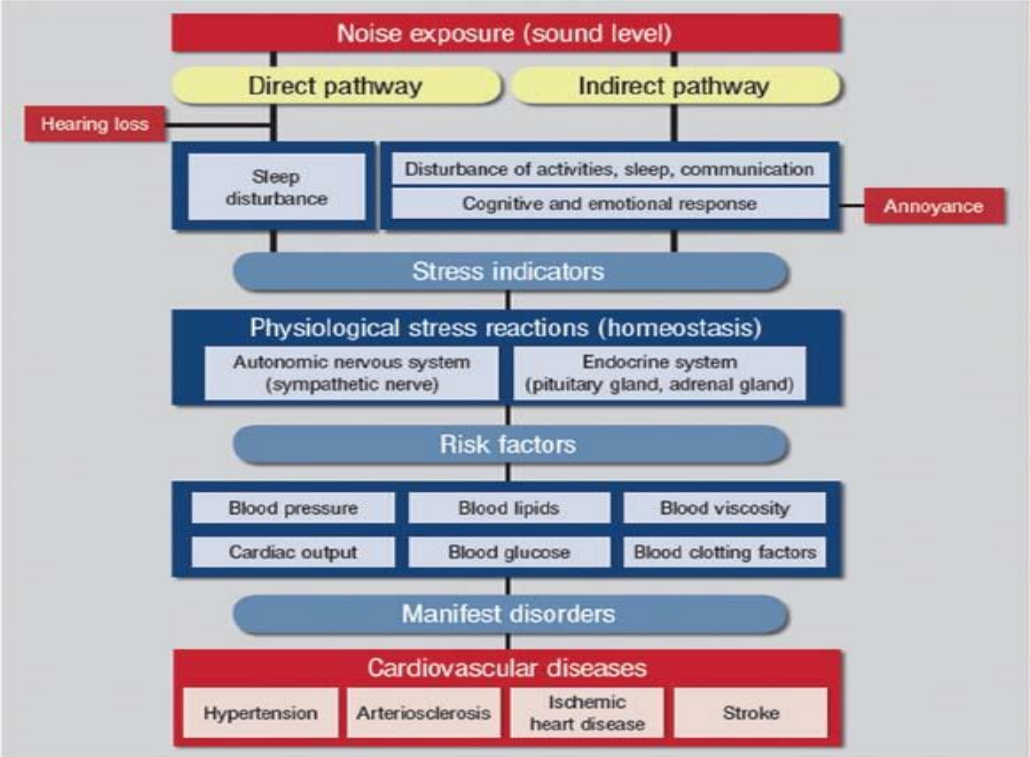
a) **Audio-Logical Effects:** If the noises are not very loud then the driver gradually recovers from the partial hearing problem and the driver experiences Temporary Threshold Shift (TTS). But when the exposure of noises are louder, and duration of noise exposure is very large, then driver's hearing ability does not recover, and the driver experienced Permanent Threshold Shift (TTS).

b) **Biological Effect:** Biologicelly to Noise may effect the driver. Some of them are listed below-

- **Heart rate:** During the long duration of noise exposure high and low heart rates could also cause problems to drivers. Quicker heart beats can be a shrink of blood path and blood taking vessels which cause inrising of the blood pressure are the results of continuous exposure to high-intensity noise ultimately producing heart afflictions.
- **Blood Circulations:** Poor circulation results from other severe health issues. So it’s crucial to rectifying the underlying causes, more than just the

symptoms. Some of them can lead to poor circulation. The most common causes include obesity, diabetes, heart conditions, and arterial issues.

- **Effects on Brain:** Somewhat louder sound (75-95 dB (A)) has been shown to affect the secretion of most of the hypo-physical hormones. This is known as the hypothalamus, a part of the brain that receives input from many other parts of the brain through a very complicated system allowing ample possibilities of interaction between different external and internal stimuli.
- **Effects on Hormones:** Adrenocorticotropic hormone (ACTH) in turn stimulates the adrenal gland, which secretes several different hormones. These hormones also affect the human body in several ways i.e. 1. Enhance the body's sensitivity to adrenaline, 2. Increase blood sugar level, 3. Suppress the immune system, and 4. Decrease the liver's ability to detoxify the blood.



Source: Babisch, W. and I. van Kamp (2009)

Fig 1: Effects of Noise on Cardio-Vascular Diseases

- **Effects on Other Biological Functions:** Sound in the range of 120-150 dB(A) can affect the respiratory system and affect balance to the extent of dizziness, disorientation, nausea and vomiting. It also affects the skin. Besides at 85-120

dB(A) noise levels, blood vessels constrict, pupil dilate, voluntary involving involuntary muscles become tense.

c) **Psychological Effects:** Noise is one kind of mental torture to all intellectual people. Due to loud and prolonged noise, it does hamper their concentration to think and study thus causing communication disruption, frustration, sleeplessness, lack of co-operation and social conflicts. Negative mental consequences include paranoia, suicidal, and homicidal tendencies. This can cause nervous irritability, strain and tension in muscles. Intolerable agony may result when the source of noise is not known.

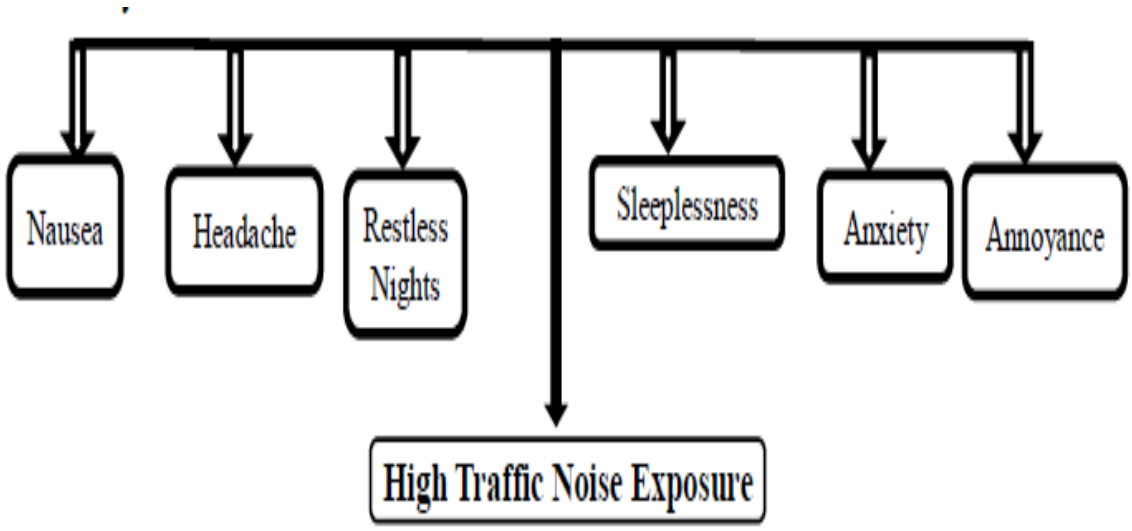


Fig 2: High Traffic Noise and Psychological Disorders

d) **Behavioural Effects:** The undesired sound might be the caused of annoyance. High noises can distract a driver and can create nervous within the driver. Certain abnormalities like the inability to think, analyze, solve problems, etc. are found in human being due to high noise pollution. Accumulate tension and uneasiness to settle down also occurs because of this. The unwanted sound can influence unborn babies producing malformation of the fetus nervous system that may effects on behavioral pattern later in life.

1.3 Jaipur city transport service limited (JCTSL)

Jaipur Low Floor bus services were introduced on 2007.Jaipur city transportation service limited (JCTSL) were Jaipur city bus service for peoples of Jaipur. It was introduced by the Rajasthan state roadways transport corporation of Rajasthan RSRTC. In 2009 a new armada of Jaipur Non AC low floor Buses and Jaipur AC low floor buses was introduced. RSRTC covered transport facility to the suburban town, colonies, urban towns, historical and tourist places around Jaipur. JCTSL and RSRTC have an armada of 400 low floor buses out Off them 20 are AC Low floor buses, and 380 are Non AC Low floor in Jaipur. There are 7 radial low floor bus routes and 7 additional Jaipur low floor bus routes, 3 circular low floor bus routes, 3 Jaipur AC low floor bus routes and 6 suburban low floor bus routes. The Low Foor buses are running in Jaipur functions under JCTSL of RSRTC. RSRTC provide public transport in the Jaipur in a very convenient mode.

1.4 Low Floor Bus

Low floor buses are heart and soul of Jaipur. The Jaipur city transit authority JCTSL operates the largest fleet of Low-floor bus route map direction in Jaipur – 400 Low Floor buses serving more than a million people per year. There are around 25 Low Floor bus routes in Jaipur

Main reasons for choosing low floor bus for study purpose are;

- **Ease of assessment:** It is very easy to take data in low floor buses because it has fix path to follow. Low floor buses are maintained and regulated by govt. of Rajasthan. Drivers are educated and always ready to help.
- **Time limitation:** There is a time limitation of completing the project, and low floor buses are known for their timely schedule.
- **Systematic and Scheduled timing:** All low floor buses follow the precise route. Their routes are predefined and for different routes, there are different buses. Apart from this low floor buses have a tight and scheduled timing, so it is very convenient for data collection and all other necessary information.

1.5 Road Accidents in Jaipur

According to a report of MINISTRY OF ROAD TRANSPORT & HIGHWAYS TRANSPORT RESEARCH WING, 2015 Jaipur ranked 20 among the 50 million plus city. A total of 1894 accidents recorded in Jaipur in 2014-2015, out of which 452 were fatal accidents with severity percentage of 25.1. In these accidents, 476 people were killed, and 1661 were seriously injured.

Motorized vehicles accounted for 95.5 percent of the total road accidents during the calendar year 2015. Buses were responsible for 41832 (8.3 %) road accidents in which 10450 (7.9%) were fatal accidents. In these accidents 12133 (8.3%) persons killed and 55083 (11%) were seriously injured.

National Highways accounted for a share of 28.4 percent in total road accidents and 35.0 percent of a total number of persons killed in road accidents during 2015. The State Highways accounted for a share of 24.0 per cent of total accidents and 28.0 per cent in the total number of persons killed in road accidents during the same period of time. Whereas Other Roads accounted for the highest share of 47.6 per cent in total road accidents and 37.0 percent in a total number of persons killed in road accidents during 2015.

Table 3: Number of Accidents, Persons Killed & Injured as per Road Classification (2015)

Road Classification	National Highways	State Highways	Other Roads
No. of Accidents	1,42,268(28.4)	1,20,518(24.0)	2,38,637(47.6)
No. of Persons Killed	51,204 (35.0)	40,863(28.0)	54,066(37.0)
No. of Persons Injured	1,42,268(29.1)	1,31,809(26.3)	2.23,129(44.6)

Source: MINISTRY OF ROAD TRANSPORT & HIGHWAYS TRANSPORT RESEARCH WING

For framing strategies for prevention and provision of medical care for accident victims, the timing of accidents is a relevant factor. During 2015 high rate of accidents took place between 3PM to 6PM followed by 6PM to 9PM.

Table 4: Road Accidents as per the Time of Occurrence (2015)

Time	Number of Accidents	Percent share in total accidents
6 AM to 9 AM (Day)	55518	11.1
9 AM to 12 PM (Day)	81964	16.3
12 PM to 3 PM (Day)	79616	15.9
3 PM to 6 PM (Day)	87819	17.5
6 PM to 9 PM (Night)	86836	17.3
9 PM to 12 AM (Night)	51425	10.3
12 AM to 3 AM (Night)	27954	5.6
3 AM to 6 AM (Night)	30291	6.0

Source: MINISTRY OF ROAD TRANSPORT & HIGHWAYS TRANSPORT RESEARCH WING

The drivers' fault is the single most important factor responsible for accidents, followed by the fault of drivers of other vehicles, defects in motor vehicles, defect in road conditions and faults of pedestrians. Drivers' fault accounted for 77.1 percent of total road accidents, 72.6 percent of the total number of persons killed and 80.3 percent of the total number of persons injured in road accidents during 2015. Faults of the cyclists and pedestrians appear to be of marginal consequence having a share of 0.7 percent and 1.5 percent, respectively, in road accidents during 2015.

1.5 Objectives

The purpose of this study is to find out the effects of noise level inside the vehicle cabin on Low Floor driver's performance. Fatigue is taken as the health factor. It will also show how the duration of noise exposure and age of driver affect the fatigue level of the driver. This study will also relate to driver's hearing problem and their irritation problem caused by continuous noise exposure.

1.6 Structure of Dissertation

The following seven chapters are in the dissertation report:

- **Chapter 1 – Introduction –** Discusses the background of the research, overview of the study, and it's relevance to the industry. Objectives of the research are also included in this chapter and at the end of the chapter the structure of the dissertation are described.
- **Chapter 2 – Literature Review –** This chapter covers the literature review on noise and its ill effects if someone exposed to noise higher than the permissible limit. Factors are identified from previous studies and effect of these factors on driver's health. Different factors proposed by various authors are also discussed in this chapter.
- **Chapter 3 – Research Methodology –** Describes the methodology followed in conducting this research work. Discusses the subjective measurement technique. This chapter describes the area of research. A fatigue questionnaire for drivers and how it is rated are also discussed here.
- **Chapter 4 – Data collection –** Describes the procedure of data collection using fatigue questionnaire for drivers. Discusses about the assumptions considered during the questionnaire survey.
- **Chapter 5 – Data analysis -** Responses from the survey are analyzed in this chapter. IBM SPSS Statistical 16 is used for Descriptive analysis, multiple regression and Pearson correlation study.
- **Chapter 6 – Result and Discussion –** In this chapter after the analysis of the data, the results drawn from the analysis is discussed. The difference of the current study from other studies is explained in this chapter.

- **Chapter 7 – Conclusion –** This is the last chapter of the dissertation which contains what can be concluded from the results of the current study and how can it help in further research and industries.

CHAPTER 2: LITERATURE REVIEW

2.1 Noise in Scientific Literature

Noise pollution was the result of the urban/city environmental pollution. It is responsible for negative impacts that are harmful to the environment and the quality of community health. Several comprehensive types of research have shown numerous adverse effects of noise exposure, including hearing impairment, annoyance, sleep disturbance and hypertension. Among the several abnormalities under high noise intensity environment, systolic and diastolic pressure, are one of the very most important indicators, and we all know that BP is increased after exposure to industrial noise level greater than 95 dBA. Some longitudinal and cross-sectional studies showed that bus drivers had a high risk of cardiovascular morbidity and mortality. Low floor bus drivers are the obligatory victim of such noise of high intensity for a long duration. Keeping in view of above occupational hazards, a comparative study has been undertaken that deals with the cardiovascular phenomenon effect between bus and truck drivers who are constantly exposed to such heavy engine noise (Naba Kumar Mondal , Madhumita Dey, Jayanta Kumar Datta, 2014)

2.2 WMSD Related To Drivers

Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders of muscles, tendons, and nerves. Carpal tunnel syndrome, tendonitis, thoracic outlet syndrome, and tension neck syndrome.

Most WMSDs are cumulative disorders, resulting from repeated exposure to high- or low-intensity weights over a long duration of time. WMSDs can also be acute traumas, such as fractures, that occur during an accident. The symptoms may vary from discomfort and pain to reduced body function and invalidity. MSDs cause harm and suffering to the worker as well as financial loss owing to disability, treatment costs and lost income. They also have an extensively negative impact on society as a whole. At the workplace level, the disorders result in costs due to reduced human capacity and disturbances to production. The costs to society are increased due to the need for treatment and rehabilitation, in addition to the compensation costs paid through social insurance.

Both business and leisure drivers may experience back pain after prolonged driving. Even more, people find that driving Might irritate an existing back problem. Sitting in the same position for a very large duration of time gripping the steering wheel and exposed to noise from the roadside traffic can contribute to the hearing ability.

Typical problems from frequent driving:

- Neck, back, shoulder pain, leg cramp, and side ache.
- After long driving, there are chances of increase in low back injury from lifting the heavy weight
- Long-term potential for degeneration of spinal discs and disc herniation
- Carpal Tunnel Syndrome (CTS)
- Repetitive motion damages
- Repetitive strain incapacity.
- Cumulative trauma disorders.
- Occupational cervicobrachial disorders.
- Overuse syndrome.
- Regional musculoskeletal disorders.
- Soft tissue disorders.

(Skanberg, A. and Ohrstrom, E. 2002, Dalton Brian H., Behm David G. 2007, Aslam Muhammad Javed, Aslam Muhammad Azeem, Batool Amna, 2008)

2.3 Human Fatigue

Human fatigue is a nonspecific psycho-physiological phenomenon. It is a complex state characterized by a lack of alertness and reduced mental and physical performance, often accompanied by drowsiness. It is a state marked by reduced efficiency and a declination to work. The fatigue of a driver can be manifested directly or indirectly. Direct manifestation means behavioral or facial or physiological changes, whereas indirect manifestation can be detected through performance. Both types of manifestations are widely used by researchers for predicting fatigue. After sustained work like driving, the subject (here driver) gets cumulative attention impairment due to:

a) Cognitive load,

b) External distractions.

The result of attention impairment is found in Driving Behavioral Observation, for example, the 'brake time' becomes relatively longer. Mental response time, movement time and device response time all together defines Driver Response Time. In a state of mental fatigue, the brain gets tired, and miscommunication between lobes occurs due to deactivation of the regional cortex, include in auditory cortex, etc. So, Auditory Vigilance Test (AVT) and Visual Response Test (VRT) is some of the preferred vigilance tests for fatigue detection.

The onset of fatigue may be manifested in any oculomotor activity. Oculomotor activities include movement of pupil, eyelids, variation in pupil diameters, head and body movement associated with visual information intake. These manifestations can be broadly classified into two groups; movement of eyelids (blink) and changes in size and motion of the pupil. Driving involves various physical and mental activities. It is also influenced by emotion, anxiety and some other psychological factors. All these physical and psychological activities associated with driving are reflected in EEG signals. This is the reason for considering the EEG signal as a significant manifestation of fatigue.

In the present work, we have applied three objective methods for assessment of fatigue in the human operator. These methods are based on Auditory Vigilance test (AVT) and Visual Response Test (VRT), facial image based measurement of fatigue, and Electroencephalographic (EEG) signal analysis. The present paper concludes that the human fatigue should be assessed by Meta-Analysis as it is a complex psychophysiological phenomenon. (Supratim Gupta, Sibsambhu Kar, Shakuntala Gupta, Aurobinda Routray, 2010)

2.3.1 Fatigue measurement

In one case in which an experimental subject is driving a train simulator fell asleep in the simulator cab after about ten hours of driving, the exponent calculated from his uttered voice indicated that his cerebral activity was very low before he lost consciousness. Our system will enable us to enter a new paradigm of human stress management. (Kakuichi Shiomi, Kiyoshi Sato 2008)

2.4 Fatigue Measurement Scales

One of the primary sources of pilot performance decrement in the airlift mission is the increment of fatigue due to long flights and duty days, loss of or poor quality sleep, and circadian rhythm disruption resulting from transiting multiple time zones.

2.4.1 Visual Analogue Scale (VAS)

.Operationally a VAS is usually a horizontal line, 100 mm in length, anchored by word descriptors at each end, The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimeters from the left-hand end of the line to the point that the patient marks.

2.4.2 Fatigue Fighter Index

Wayne Goldsmith described that several fatigue factors that can be excellent indicators of driver's level of fatigue. This Fatigue Index is not a reliable indicator of overtraining. It is a simple tool which makes drivers conscious of the physical aspect, mental aspect, technical aspect and emotional aspect that are involved in the fatigue process. (Wayne goldsmith, 2008)

2.4.3 The Samn- perelli Seven Point Scale (SPS)

Drivers often have to rely on self-assessment in order to decide if they are fit to drive. Another measure that a Driver can use to more precisely determine his fatigue level is the Samn- Perelli Seven Point Fatigue Scale (SPS). The evaluation has a scale of 1-7, 1 described as "Fully, Alert and Wide Awake" and 7 "Completely exhausted, unable to function effectively". All levels in between have descriptions aiding the driver with his decision.

2.5 Health factors

Health is important for all. If our Health is not good, then we can't concentrate on our work. Our Performance level starts declining. Noise adversely affects the health of drivers in many ways. From the previous researches, this is known that there are some areas which can be related to the health of drivers which were affected by noise. These are

- Systolic pressure
- Diastolic pressure
- Pulse rate
- Hearing loss
- Irritation

2.6 Questionnaire

Survey is done on the questionnaire which was self-made. Some help were taken from the transport department. Transport department had their own self-assessment tests which have no. of question related to driver's physical and mental health. Some questions were taken from there, but some modifications were made which is necessary for the survey perspective.

CHAPTER 3: RESEARCH METHODOLOGY

There were two parts of this study i.e., pre-study and main study to know the effect of noise on bus driver's performance. All possible factors which can affect the driver performance and cause him fatigue were collected from the literature and checked whether different factors would affect their fatigue level and due to this their performance level has been affected or not. Then in the main study, the factors are analyzed, and the relationship between these factors with Fatigue was calculated.

3.1 Pre-Study

In the pre-study the main aims were to

1. Compose a 'complete' list of factors that could possibly affect driver's health and his performance from the literature.
2. Find out which factors could be studied were chosen by considering available resources.

The pre-study consisted of following three steps:

In the first step, many searches were made for papers containing "noise", "health problem of drivers", "comfort in driving", "discomfort", "comfort", "fatigue", "fatigue measurement scales" and "sitting posture of drivers". All the factors that could possibly cause fatigue and ill effect on the health and affect performance level of drivers were collected. Factors with the same meaning and synonyms were left out of the list.

In the second step, all the factors were studied and tried to relate to each other. Some factors were easy to rate, but some factors were not at all relate to each other

In the last step, some factors were finalized for the main study that was; Noise level, duration of noise exposure, the age of the driver, the age of the vehicle, BMI of driver and driving experience. These all were taken as independent factors and fatigue were taken as dependent variable. Because of lack of instruments vibration and sitting postures were not considered. 70 low floor bus drivers were choosen for the purpose of this study.

3.2 Main Study

The objectives of the main study were to:

1. Determine the relationship between fatigue and the different factors.
2. Identify which factor(s) contribute most the fatigue of driver.
3. Develop the relationship with these factors with fatigue.
4. Show the effect of fatigue on performance of the driver

From the literature, 12 factors were collected which could cause fatigue or others ill effects to drivers. Out of 12 only six factors were considered for the main study i.e. noise level, duration of noise exposure, the age of the driver, the age of the vehicle, BMI of driver and driving experience of the driver.

3.2.1 Participants

A convenience sample was obtained by approaching the drivers driving in different buses on different routes in Jaipur. There are 268 low floor buses which run on a scheduled route and scheduled time. 70 drivers from 10 different bus routes participated in this study. The subjects gave their written informed consent. The entire driver's ages were between the ranges between 30 to 45 years.

3.2.2 Apparatus for noise measurement

For the purpose of noise measurement in the bus cabin a sound level meter was used. A sound level meter is used for acoustic (a sound that travels through the air) measurements. It is commonly a hand-held instrument with a microphone.

The diaphragm of the microphone responds to changes in air pressure caused by sound waves. The microphone is identified by the voltage value produced when a known, constant sound pressure is applied. This is known as the microphone sensitivity.

The instrument needs to know the sensitive nature of the particular microphone being used. Using this information, the device is able to accurately convert the electrical signal back to sound pressure level (decibels dB). Sound level meters are commonly used for nloise measurement in industrial, environmental and aircraft noise.

Figure 3: Digital Sound Level Meter

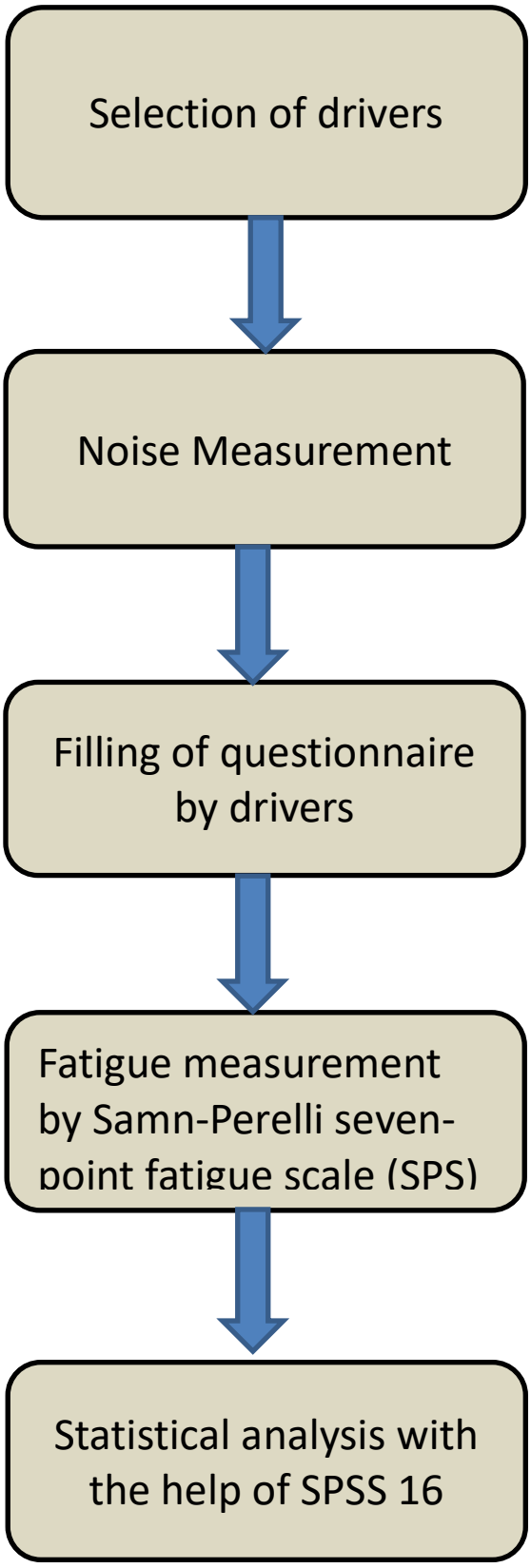
3.2.3 Questionnaire

The questionnaire comprises of two parts.

The first part comprised general socio-demographic data: driver's age(years), driving experiences(years), vehicle age(years), duration of noise exposure and noise level (dBA) at different stops.

The second part of the questionnaire contains questions related to his health related questions like hearing problem, concentration problem, performance problem, etc. An experiment was specially designed to identify the fatigue level of the driver.

3.3 Flow Chart



CHAPTER 4: DATA COLLECTION

Data collection is an important part of this current study and for that data was collected by direct personal interview. Seventy workers were chosen randomly. All the drivers were professionals. All the drivers were also well educated so the data collection and questionnaire fill up were an easy task

4.1 Data Collection

Data were collected from 10 different busiest bus routes in Jaipur. Only Non-Ac type Low Floor buses were chosen in the study because AC buses were somewhat soundproof as it was packed with glasses that's why Non Ac type low floor buses were selected so the other factors can be eliminated. Suburban buses were also excluded from the study because they had entirely different routes and difficult to follow and the suburban roads were not in good condition as in the case of urban roads. Mini buses were also not included in the study because of their unsystematic schedule. Mini bus drivers does not have any fix time duration or duty hours so their duration of driving are different from others. So the mini buses are also excluded from the study.

Table 5: Bus Routes and their main stops

Bus route no.	Route	Main Stops
1	TODI TO BADI CHOPAR	Harmada, chomu pulia, pittal factory, chandpaul, choti chaupar
1A	VKI(ROAD NO. 17) TO BADI CHAUPAR	Chomu pulia, ambabadi, pani pej, pittal factory, chandpaul, choti chaupar
3	PARTAP NAGAR TO CHOTI CHAUPAR	Kumbha Marg, Sanganer Thana,Jawahar circle, Gopalpura Mod, Tonk Phatak, Sms Hospital
3A	SANGANER TO CHOTI CHAUPAR	Sanganer Thana,Jawahar circle, Gopalpura Mod, Tonk Phatak, Rambagh Circle, Sms Hospital, Ajmeri Gate
3B	PANNADHAY CIRCLE TO BRAHMPURI	Haldi Ghati Marg, Shyopur, Jawahar circle, Tonk Phatak, Rambagh Circle, Sms Hospital, Ajmeri Gate, choti chaupar
3C	MGH TO AJMERI GATE	Kalyan Nagar, Citi Plex, Gopalpura Mod, Tonk Phatak, Lal Kothi, Sms Hospital,
6A	AIRPORT TERMINAL NO. 2 TO KHIRNI PHATAK	Malviya Nagar Sec No 10, Malviya Nagar Sec No 15, Kelgiri Hospital Mod, Mnit, Maharani College, Khasa Kothi, Ambabari, Panchayat Samiti
7	HIRAPURA BYPASS TO TRANSPORT NAGAR	Dharmkanta, Gurjar Ki Thadi, Ridhi Sidhi Tiraha, Tonk Phatak, Trimurti Circle, Rajapark
8	JAGATPURA TO JAGATPURA	Modal Town, Rto Office, Sms Hospital, 5 Batti chauraha, Civil Lines Chauraha, Sanjeevani Hospital, Agarwal Farm, Jawahar Circle
9A	AGARWAL FARM TO DADI KA PHATAK	Maharani Farm, Gopalpura Mod, Imliwala Phatak, Railway Station, Shashtri Nagar Thana, Vidyadhar Nagar, Murlipura Circle

4.1.1 Noise Measurement

Noise levels inside the bus cabin were measured with the help of Digital Sound Level Meter. Noise levels were measured at all main stops of a particular bus.

Figure 4: noise level measurement when driver was driving the bus

4.1.2 Noise variations in different buses

During noise level measurement, some routes are shown large variations in noise levels were recorded like route no. 1, 1A, 3, 3A, 7 and 8. Buses of route no. 3B, 3C, 6A, and 9A had shown very less variations in noise levels. Tonk phatak (88.1 dBA), choti chaupar (92.5 dBA), badi chaupar (89.5 dBA), ambabari (90.8 dBA), chanpaul (88.4 dBA), Ajmeri gate (90.6 dBA), khasa kothi (93.6 dBA), Riddhi-Siddhi Tiraha (92.5 dBA) etc. were some major stops which shows very high level of noise. Choti chaupar and Badi chaupar were the starting points of some bus routes likes 3, 3A,3C and 1, 1A respectively on which drivers had more exposure of noise.

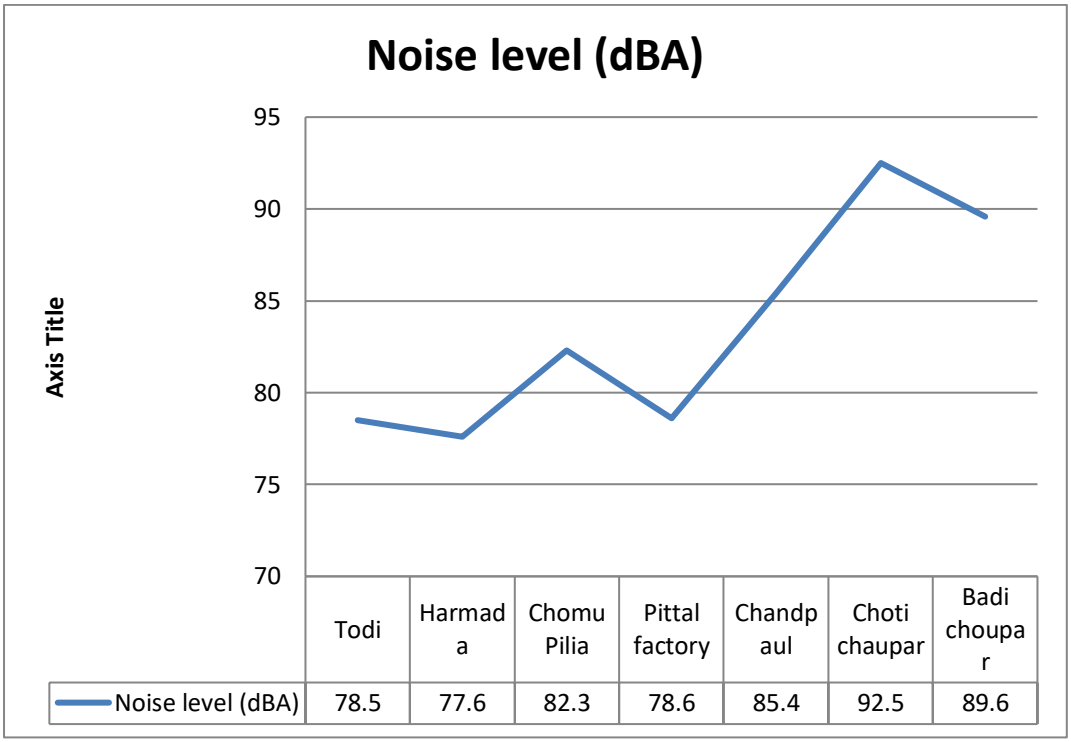


Figure 5: Variation of noise level in Route no. 1 bus

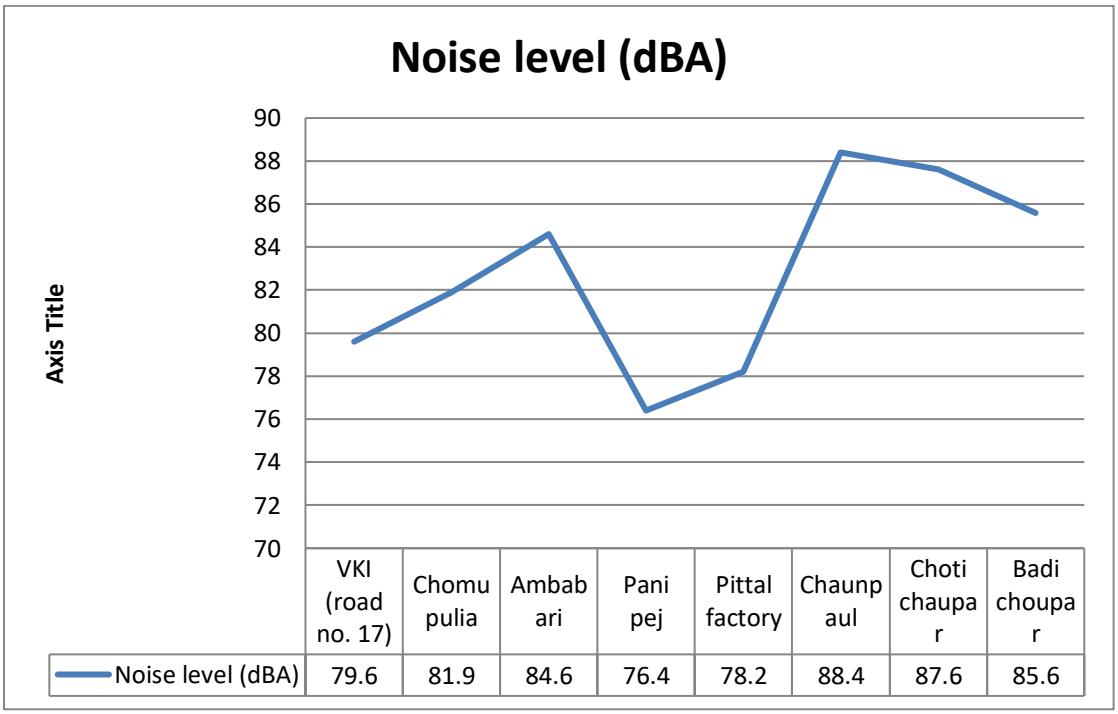


Figure 6: Variation of noise level in Route no. 1A bus

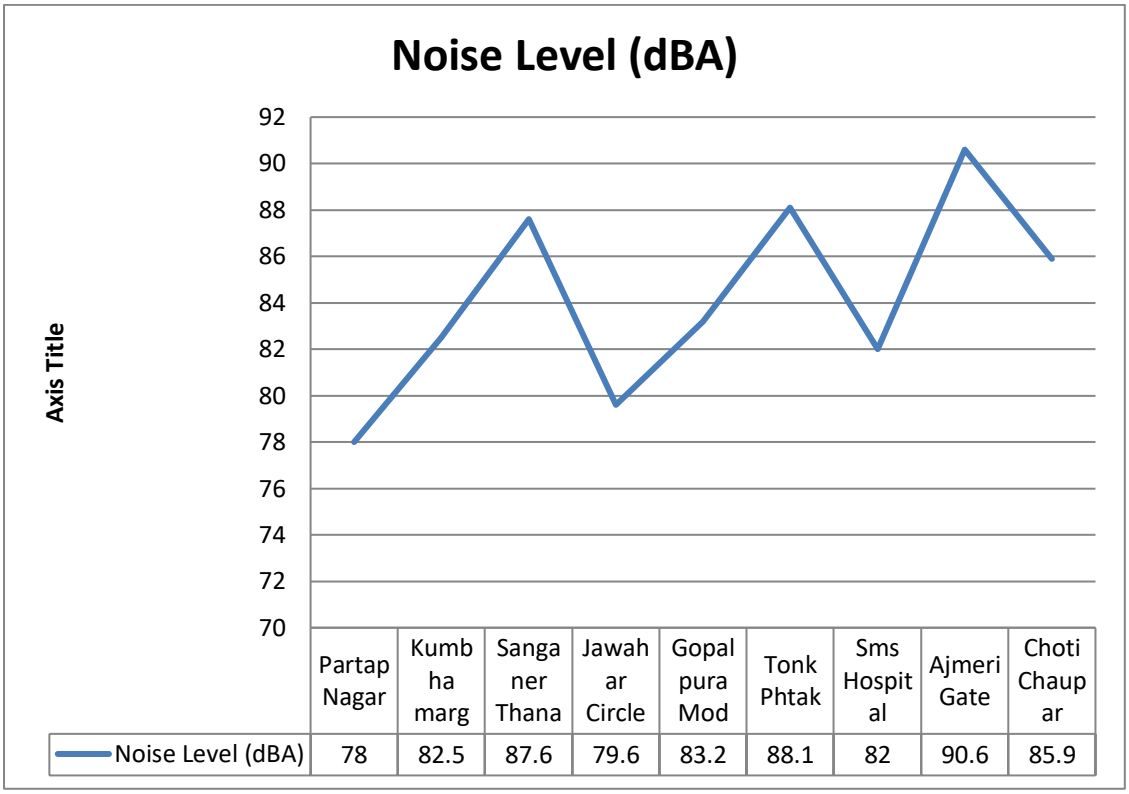


Figure 6: Variation of noise level in Route no. 3 bus

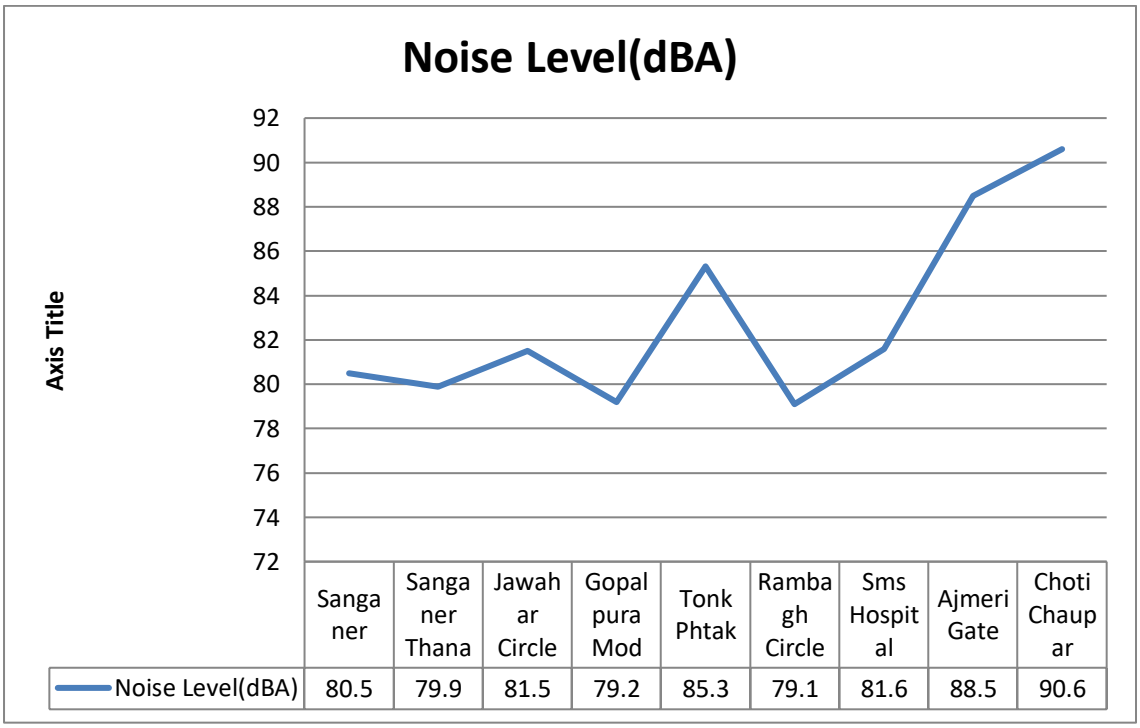


Figure 8: Variation of noise level in Route no. 3A bus

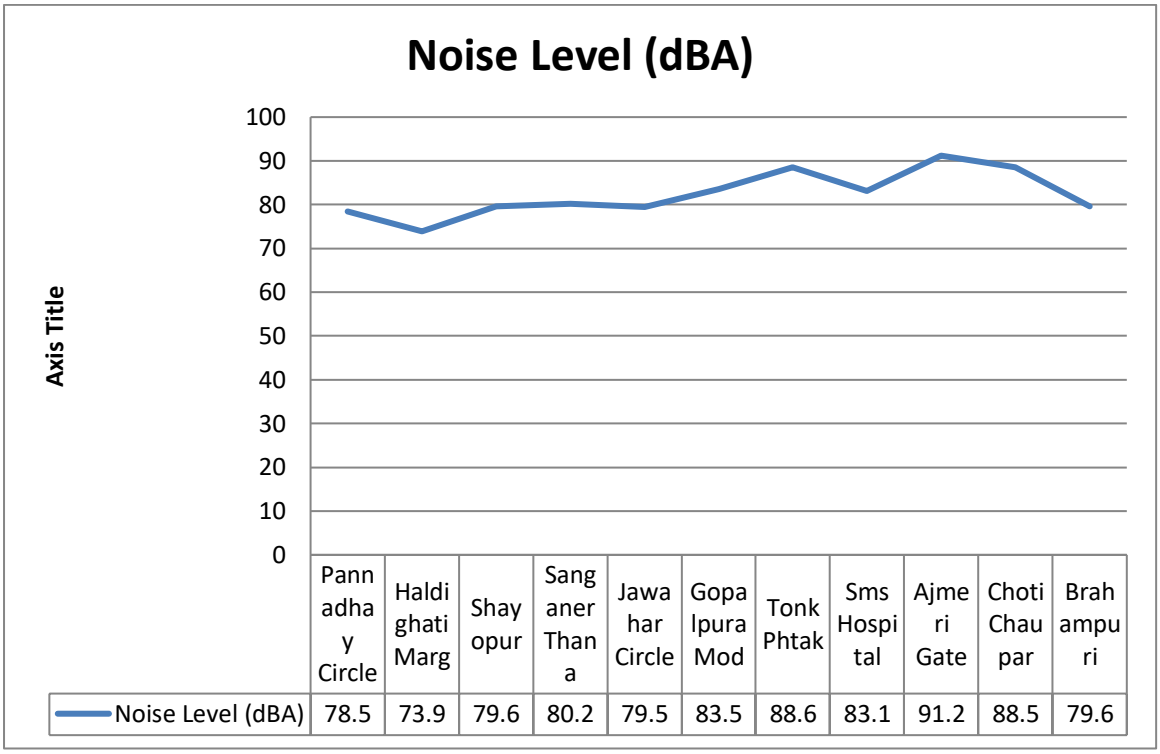


Figure 9: Variation of noise level in Route no. 3B bus

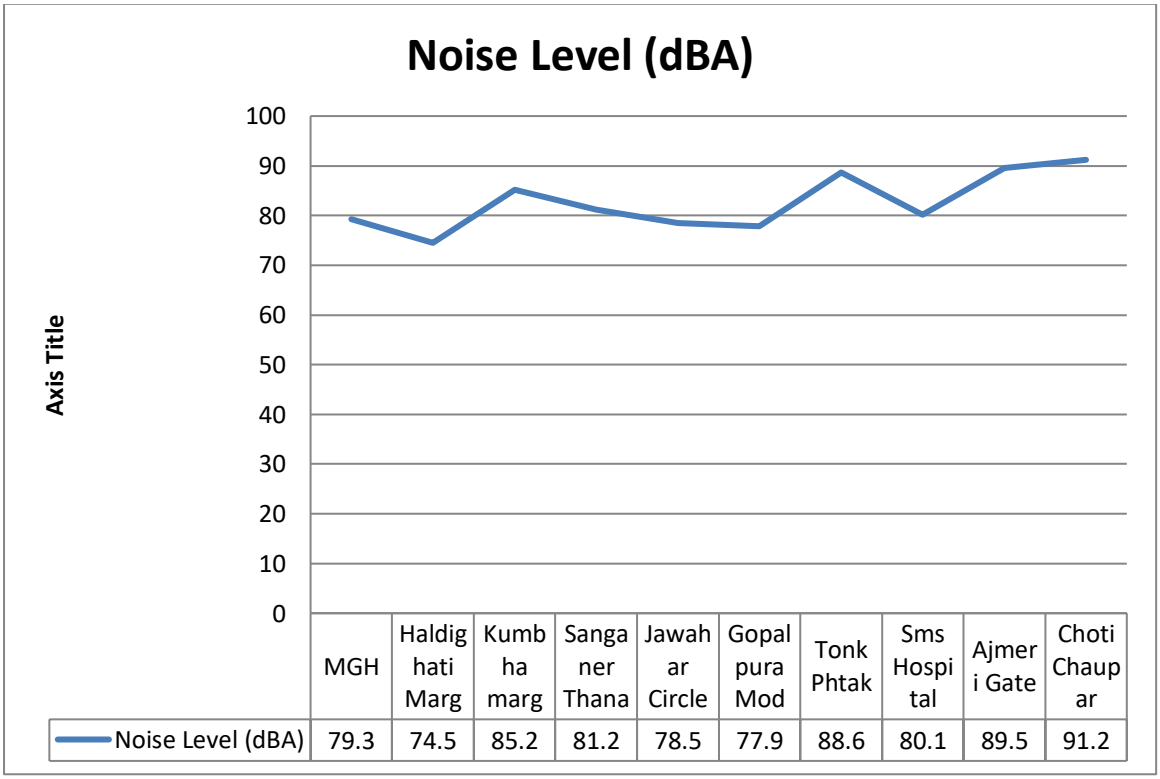


Figure 10: Variation of noise level in Route no. 3C bus

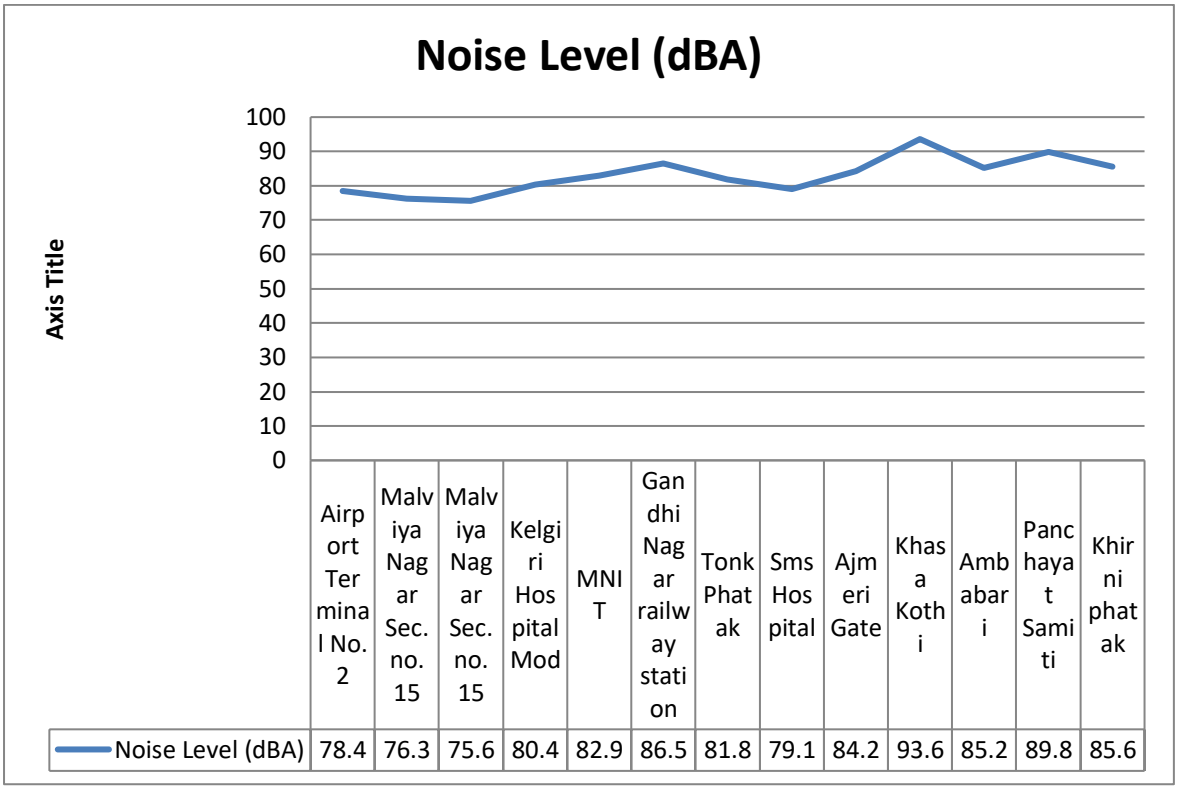


Figure 11: Variation of noise level in Route no. 6A bus

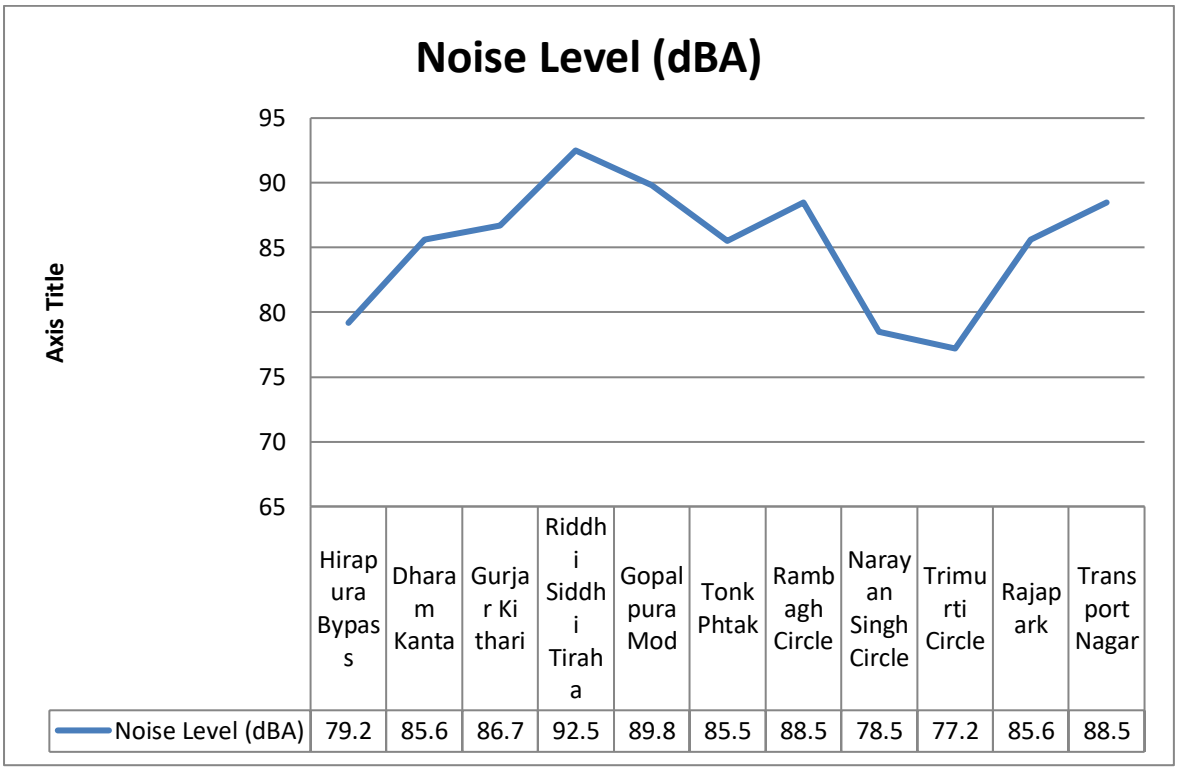


Figure 12: Variation of noise level in Route no. 7 bus

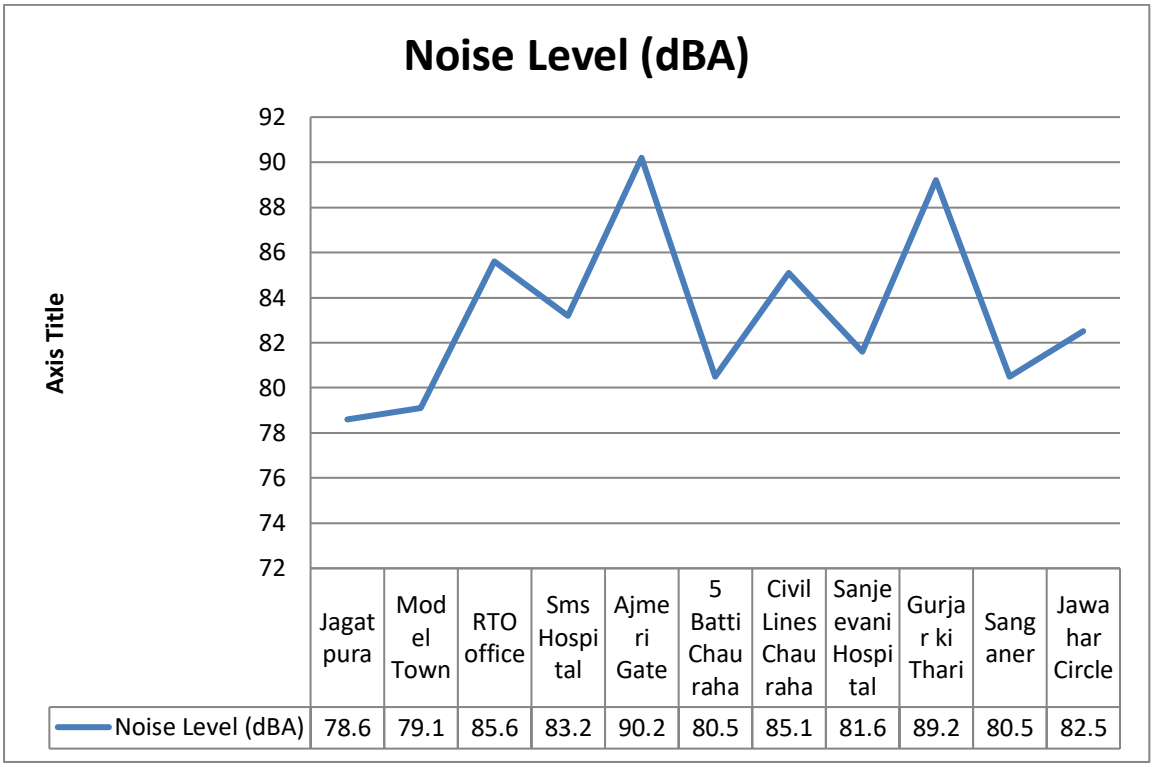


Figure 13: Variation of noise level in Route no. 8 bus

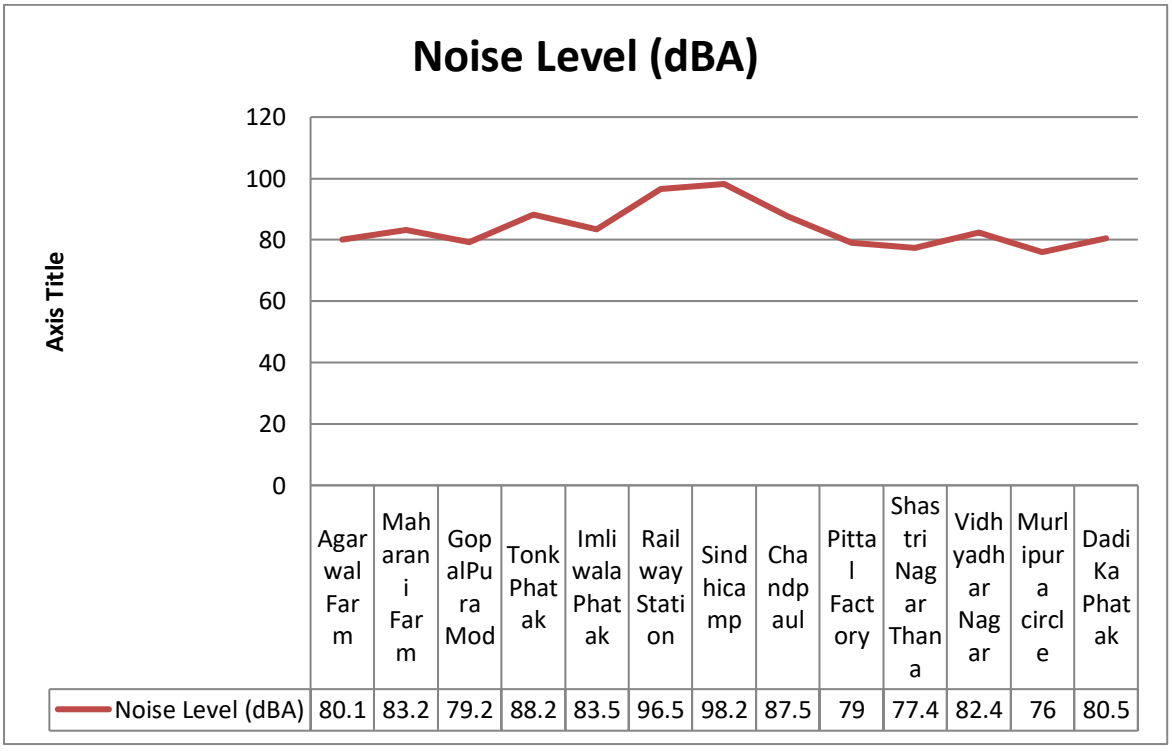


Figure 14: Variation of noise level in Route no. 9A bus

4.1.2 Questionnaire completion

Just after the bus reached the final destination drivers were asked the questions that were in the questionnaire. There were 2 segments of the questionnaire. In first segment, drivers have been invited to give their personal information like name, age, height, weight, and their driving experience.

In the second segment, there were 12 questions which were based on their current physical and mental situation. The questionnaire included questions which described their hearing quality, performance quality, how annoyed they feel after exposing to particular sound level, etc.

An experiment was specially designed to identify the fatigue level of the driver with the help of The Samn-Perelli Seven point scale. In this experiment, drivers were asked to solve some simple mathematical calculations. Drivers had to hear the equation from a distance of 15 feet which was exactly the same as the distance between driver and conductor in the bus. According to the correct answers given by the drivers, their fatigue levels were measured on a scale of 1 to 7.

Appendix I shows the complete questionnaire.

CHAPTER 5: DATA ANALYSIS

Data collection was an important step in this study. After the data collection was over now, it was taken to the further step. data analysis is done on the basis of data which was collected from the 70 participants. Data analysis was done with SPSS 16 software. Data analysis was done in four stages which are

- Analysis of questionnaire
- Descriptive statistics
- Univariate analyses
- Multiple linear regressions

5.1 Analysis of questionnaire:

The questionnaire was the most important part of this study. The questionnaire contained questions based on driver's physical and mental health. Each question was analyzed equally, and all the answers were given by the participants.

5.1.1 Effect of Noise Level on drivers

Noise level : 78 to 81.6 dBA **no. of participants: 39**

1. Do you have a tendency not to realise how tired, or hungry or ill you feel, but instead 'keep going?

Responses	No. of Drivers
1 – Not At All	11
2 – A little	11
3 – Somewhat	16
4 – Quite a bit	1
5 – Very much	0

2. How often do you continue to drive despite fatigue?

Responses	No. of Drivers
1 – Not At All	7
2 – A little	11
3 – Somewhat	11
4 – Quite a bit	10
5 – Very much	0

3. Do you think you were unable to drive as much as you need to because of fatigue?

Responses	No. of Drivers
1 – Not At All	6
2 – A little	12
3 – Somewhat	9
4 – Quite a bit	12
5 – Very much	0

4. Do you feel any problem in hearing voice of conductor?

Responses	No. of Drivers
1 – Not At All	10
2 – A little	5
3 – Somewhat	11
4 – Quite a bit	13
5 – Very much	0

5. How much is your performance influenced at this noise level?

Responses	No. of Drivers
1 – Not At All	6
2 – A little	7
3 – Somewhat	14
4 – Quite a bit	10
5 – Very much	2

6. Are you feeling annoyed by the noise?

Responses	No. of Drivers
1 – Not At All	4
2 – A little	11
3 – Somewhat	17
4 – Quite a bit	5
5 – Very much	2

7. Do you feel this noise level will affect your concentration while driving?

Responses	No. of Drivers
1 – Not At All	4
2 – A little	9
3 – Somewhat	16
4 – Quite a bit	9
5 – Very much	1

Noise level : 82 to 88.9 dBA **no. of participants: 31**

1. Do you have a tendency not to realise how tired, or hungry or ill you feel, but instead 'keep going?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	4
3 – Somewhat	23
4 – Quite a bit	4
5 – Very much	0

2. How often do you continue to drive despite fatigue?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	6
3 – Somewhat	24
4 – Quite a bit	1
5 – Very much	0

3. Do you think you were unable to drive as much as you need to because of fatigue?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	0
3 – Somewhat	19
4 – Quite a bit	12
5 – Very much	0

4. Do you feel any problem in hearing voice of conductor?

Responses	No. of Drivers
1 – Not At All	1
2 – A little	2
3 – Somewhat	16
4 – Quite a bit	10
5 – Very much	0

5. How much is your performance influenced at this noise level?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	0
3 – Somewhat	16
4 – Quite a bit	13
5 – Very much	2

6. Are you feeling annoyed by the noise?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	2
3 – Somewhat	13
4 – Quite a bit	15
5 – Very much	1

7. Do you feel this noise level will affect your concentration while driving?

Responses	No. of Drivers
1 – Not At All	0
2 – A little	3
3 – Somewhat	18
4 – Quite a bit	9
5 – Very much	1

5.1.2 Effect of Duration of noise exposure

1. After driving for _____hrs how fatigued do you feel right now?

Responses	**No. of Drivers**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 – Not At All	1	4	2	0	0	0	0
2 – A little	1	4	1	0	0	0	0
3 – Somewhat	0	0	8	6	2	9	0
4 – Quite a bit	0	0	4	6	7	5	4
5 – Very much	0	0	0	0	0	2	4

2. Do you think your hearing quality is affected after driving for _____hrs?

Responses	**No. of Drivers**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 – Not At All	1	6	2	0	0	0	0
2 – A little	1	2	3	0	0	0	0
3 – Somewhat	0	0	5	9	3	13	0
4 – Quite a bit	0	0	5	3	4	3	6
5 – Very much	0	0	0	0	2	0	2

3. After driving for _____hrs do you like to stop the vehicle and take a rest?

Responses	No. of Drivers						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 – Not At All	1	4	1	0	0	0	0
2 – A little	1	4	2	1	0	0	0
3 – Somewhat	0	0	10	6	3	10	2
4 – Quite a bit	0	0	2	5	5	6	5
5 – Very much	0	0	0	0	1	0	1

4. After driving for _____hrs how fit do you feel for driving?

Responses	No. of Drivers						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 – Very much	1	4	2	0	0	0	0
2 – Quite a bit	0	4	1	1	0	0	0
3 – Somewhat	1	0	10	4	3	10	2
4 – A little	0	0	2	7	5	6	6
5 – Not At All	0	0	0	0	1	0	0

5. Do you think you will become too tired during driving for _____hrs?

Responses	No. of Drivers						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 – Not At All	1	5	1	0	0	0	0
2 – A little	1	2	1	2	0	1	0
3 – Somewhat	0	1	7	2	3	8	0
4 – Quite a bit	0	0	6	7	6	7	2
5 – Very much	0	0	0	1	0	0	6

5.2 Descriptive statistical analysis of factors which affecting the driver's fatigue

In this, we analyzed all the factors and tried to find out their mean and standard deviation. With the help of descriptive analysis maximum and minimum values of all the factors also calculated.

Table 6: result of descriptive statistical analysis

	N	Minimum	Maximum	Mean	Std. Deviation
NoiseLevel	70	78.0	88.9	81.863	2.0201
AgeofVehicle	70	2	6	3.99	.985
AgeofDriver	70	30	45	34.76	2.995
BMIofdriver	70	21.2	26.4	23.890	1.1281
DrivingExperience	70	5	20	9.83	3.176
DurationofNoiseExposure	70	1	7	3.80	1.557
Valid N (listwise)	70				

where N is the sample size

The noise level in the low floor buses varies from 78.0 to 88.9 dBA with a mean value of 81.863 and std. daviation was 2.0201. The noise level inside the cabin of buses ranges from78 to 81.2 dBA with 44.3% and from 81.3 to 88.9 dBA with 55.4%.

Duration of noise exposure was vary from 1 to 7 hours which is different for different drivers. The mean value was 3.8 and the std. deviation

Age of the driver was varied from 30 to 45 years with a mean value of 34.76 and std. daviation was 2.995. Driver's age was 70% in the range of 30-35 years and 30% in the range of 36-45 years.

In this study age of the low floor, buses were varied from 2 to 6 years with a mean value of 3.99 and the standard deviation was 0.985. Among the low floor buses 64.3% buses were 3 or 4 years old and remaining 35.7% were 5 or 6 years old.

Driving experience of drivers were vary from 5 to 20 years in which 65.7% drivers had 5 to 10 years driving experience and remaining 34.3% drivers had 10 to 20 years driving experience.

The study includes 70 drivers with the BMI (body mass index) varying from 21.2 to 26.4 Kg/M^2. 55.7% of bus drivers had a BMI in the range of 21.9 to 24 Kg/M^2 (normal weight range) and remained 44.3% had a BMI in the range of 24.1 to 26.4 Kg/M^2.

5.3 Univariate analysis of factors which affecting the driver's fatigue

In this analysis, each independent variable analyses and their relationship with the fatigue was found out. After this, we were able to identify all the factors which actually cause fatigue to the drivers.

With the help of R^2 and adjusted R^2 value, we identify the factors. These factors were analyzed by Multiple regression analysis.

5.3.1 Noise level and Fatigue

Table 7 : Result of univariate analysis between noise level and Fatigue

Tests of Between-Subjects Effects

Dependent Variable:Fatigue

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	75.938[a]	42	1.808	6.232	.000
Intercept	542.165	1	542.165	1.869E3	.000
NoiseLevel	75.938	42	1.808	6.232	.000
Error	7.833	27	.290		
Total	690.000	70			
Corrected Total	83.771	69			

a. R Squared = .906 (Adjusted R Squared = .761)

5.3.2 Duration of noise exposure and Fatigue

Table 8 : Result of univariate analysis between duration of noise exposure and Fatigue

Tests of Between-Subjects Effects

Dependent Variable:Fatigue

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	47.304[a]	6	7.884	13.620	.000
Intercept	511.458	1	511.458	883.569	.000
DurationofNoiseExposure	47.304	6	7.884	13.620	.000
Error	36.468	63	.579		
Total	690.000	70			
Corrected Total	83.771	69			

a. R Squared = .565 (Adjusted R Squared = .523)

5.3.3 Age of Driver and Fatigue

Table 9 : Result of univariate analysis between duration of noise exposure and Fatigue

Tests of Between-Subjects Effects

Dependent Variable:Fatigue

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.014[a]	10	2.501	2.512	.014
Intercept	384.973	1	384.973	386.559	.000
AgeofDriver	25.014	10	2.501	2.512	.014
Error	58.758	59	.996		
Total	690.000	70			
Corrected Total	83.771	69			

a. R Squared = .299 (Adjusted R Squared = .180)

5.3.4 Age of Vehicle and Fatigue

Table 10: Result of univariate analysis between duration of noise exposure and Fatigue

Tests of Between-Subjects Effects

Dependent Variable:Fatigue

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23.515[a]	4	5.879	6.342	.000
Intercept	265.382	1	265.382	286.276	.000
AgeofVehicle	23.515	4	5.879	6.342	.000
Error	60.256	65	.927		
Total	690.000	70			
Corrected Total	83.771	69			

a. R Squared = .281 (Adjusted R Squared = .236)

As the result shown from the table no. 5, 6, 7 and 8 it was clear that the noise level had the great significance as its R^2 value was 0.906 and adjusted R^2 value was 0.761.

After the noise level Duration of noise exposure had the maximum R^2 value was 0.565 and adjusted R^2 value was 0.523 which was more than the age of driver (R^2- 0.299 and adjusted R^2- 0.186) and age of vehicle(R^2- 0.281 and adjusted R^2- 0.236)

So for the next step i.e. Multiple Regression Analysis was done on these factors because these factors had the more R^2 value than the others.

5.4 Multiple Regression Analysis

After obtaining the correlation coefficients of the descriptors with fatigue after short time use multiple regression (forward selection procedure) was performed. Multiple regression (forward selection procedure) was carried out to see which of the descriptors predict fatigue.

The results obtained by performing multiple regression (forward selection procedure) for fatigue are shown in table 11.

Table 11: Result of multiple regression analysis for fatigue

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Noise Level	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Duration of Noise Exposure	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Age of Driver	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
4	Age of Vehicle	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Fatigue

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.870[a]	.757	.754	.547	.757	212.133	1	68	.000	
2	.898[b]	.806	.800	.492	.049	16.946	1	67	.000	
3	.913[c]	.833	.826	.460	.027	10.750	1	66	.002	
4	.920[d]	.847	.838	.444	.014	5.812	1	65	.019	2.505

a. Predictors: (Constant), NoiseLevel

b. Predictors: (Constant), NoiseLevel, DurationofNoiseExposure

c. Predictors: (Constant), NoiseLevel, DurationofNoiseExposure, AgeofDriver

d. Predictors: (Constant), NoiseLevel, DurationofNoiseExposure, AgeofDriver, AgeofVehicle

e. Dependent Variable: Fatigue

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-35.913	2.669		-13.458	.000			
	NoiseLevel	.475	.033	.870	14.565	.000	.870	.870	.870
2	(Constant)	-28.911	2.943		-9.823	.000			
	NoiseLevel	.380	.037	.696	10.187	.000	.870	.780	.548
	DurationofNoiseExposure	.199	.048	.281	4.117	.000	.711	.449	.221
3	(Constant)	-27.933	2.766		-10.099	.000			
	NoiseLevel	.340	.037	.623	9.201	.000	.870	.750	.462
	DurationofNoiseExposure	.209	.045	.296	4.618	.000	.711	.494	.232
	AgeofDriver	.065	.020	.177	3.279	.002	.457	.374	.165
4	(Constant)	-27.489	2.677		-10.270	.000			
	NoiseLevel	.329	.036	.603	9.151	.000	.870	.750	.444
	DurationofNoiseExposure	.183	.045	.259	4.068	.000	.711	.451	.197
	AgeofDriver	.065	.019	.176	3.361	.001	.457	.385	.163
	AgeofVehicle	.143	.059	.128	2.411	.019	.453	.286	.117

a. Dependent Variable: Fatigue

The model summary table shows the R-square values for model 1, model 2, model 3, model 4. Among these four models, model 4 has the highest R-square value of 0.920 which implies that the model four fits better to the data than the other models, and it explains 92% of the variability of the response data around its mean.

The other part of this table 11, i.e., coefficients table is shown below. The coefficients table shows the standardize coefficients (beta) values for the descriptors associated with the different models. Model 4 fits better than the other models and its underlying descriptors, i.e., noise level, duration of noise exposure, the age of the driver and age of the vehicle have the beta values of 0.603, 0.259, 0.176, 0.128, respectively.

5.4.1 Multiple Regression Equations

Model 1 Equation

$$Y = B_0 + B_1X_1$$

Where

Y – Fatigue

B_0- Constant

B_1- standardized beta coefficients for noise level

X_1- Noise level

Model 2 Equation

$$Y = B_0 + B_1X_1 + B_2X_2$$

Where

Y – Fatigue

B_0- Constant

B_1- standardized beta coefficients for noise level

X_1- value of Noise level

B_2- standardized beta coefficients for duration of noise exposure

X_2- duration of noise exposure

Model 3 Equation

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3$$

Where

Y – Fatigue

B_0- Constant

B_1- standardized beta coefficients for noise level

X_1- value of Noise level

B_2- standardized beta coefficients for duration of noise exposure

X_2- duration of noise exposure

B_3- standardized beta coefficients for age of driver

X_3- age of driver

Model 4 Equation

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4$$

Where

Y – Fatigue

B_0- Constant

B_1- standardized beta coefficients for noise level

X_1- value of Noise level

B_2- standardized beta coefficients for duration of noise exposure

X_2- duration of noise exposure

B_3- standardized beta coefficients for age of driver

X_3- age of driver

B_4- standardized beta coefficients for age of vehicle

X_4- age of vehicle

CHAPTER 6: RESULTS & DISCUSSION

From the user interviews, it was found that none of the respondents did add any new descriptors to the list of descriptors obtained from the literature. In the pre-study around six factors were collected from the literature. From the result of the test it was found that almost every factor was rated by the majority of the respondents except 'BMI of the driver', and 'driving experience of the driver.' Therefore, an apparent assumption can be made that fatigue did not depend on these two factors.

6.1 Result from the questionnaire

6.1.1 Hearing Problem

39 drivers came in contact with the noise level which was in the range of 78 to 81.6 dBA.Out of 39 drivers, 24 drivers complained that they were not listening to the voice of conductor clearly. This no. was further increased when the noise level increased more than 82. 31 drivers came in contact with the noise level which was in the range of 82 to 88.9 dBA. Out of 31 drivers, 26 drivers complained that they were not listening to the voice of conductor clearly. From the responses of the driver, it is clear that out of 70 drivers 50 drivers have the hearing problem due to excessive noise.

The hearing problem become more severe when the duration of noise exposure also included. It was shown that the drivers who are driving more than 3 hours are having the more chances of hearing impairment than the drivers which are driving for less than 3 hours. 45 drivers out of 70 were having a problem in hearing the voice of conductor.

6.1.2 Irritation Problem

Noise can make any person feel irritate if he will come in contact of noise for a long time. Out of 70 drivers, 56 drivers are feeling the noise annoying and become irritate due to continuous exposure to high level of noises

Duration of noise exposure become more important in this aspect because the driver is having a mood swing because of noise.

6.1.3 Tiredness

When a driver becomes too tired and unable drive than he wants to take a break. From the responses from the drivers, 45 drivers were ready to stop the vehicle for taking rest after continuous driving of 3 hours or more.

6.2 Predicting Factors which affects Health of Low Floor Bus Drivers

The aim of the study is to identify the predicting factors which influence the health of bus drivers. The results of multiple regression (forward selection procedure) show that the fatigue level of drivers is influenced by the Noise level in the bus cabin and how much duration he came in the exposure of noise. The result also shows that Noise level is more relevant to fatigue of driver.

We get 4 models by using multiple regression analysis

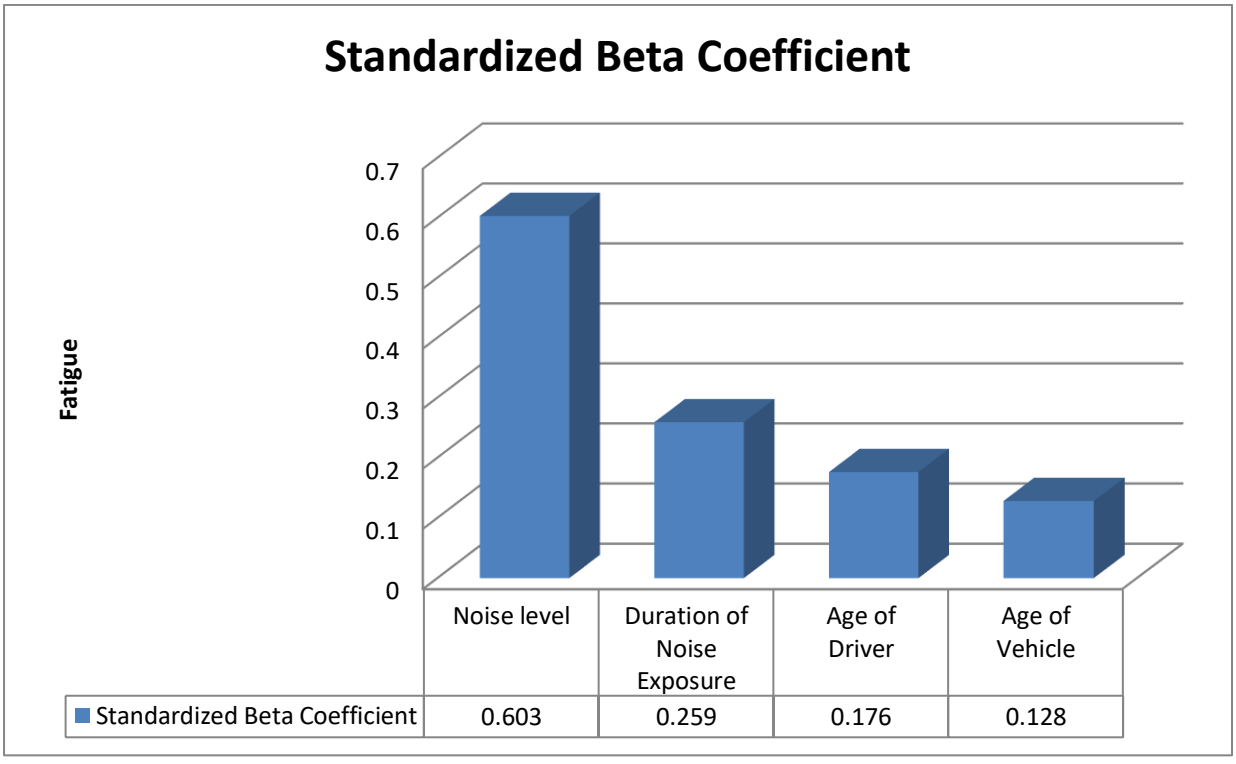


Figure 15: Beta values predicting fatigue of drivers

Noise level beta coefficient is 0.603 which is greater than the beta coefficient value of Duration of noise exposure (0.259), Age of the driver (0.176) and age of vehicle (0.128). So it is clear that the noise level has the more effect on drivers causing fatigue and other health effects.

6.3 Result of Samn-Perelli seven-point fatigue scale (SPS)

Samn-perelli seven point scale is a scientific measure of fatigue which is used in aviation from 1990. The result of Samn-Perelli seven-point fatigue scale is individually analyzed for each factor.

6.3.1 Noise and Fatigue

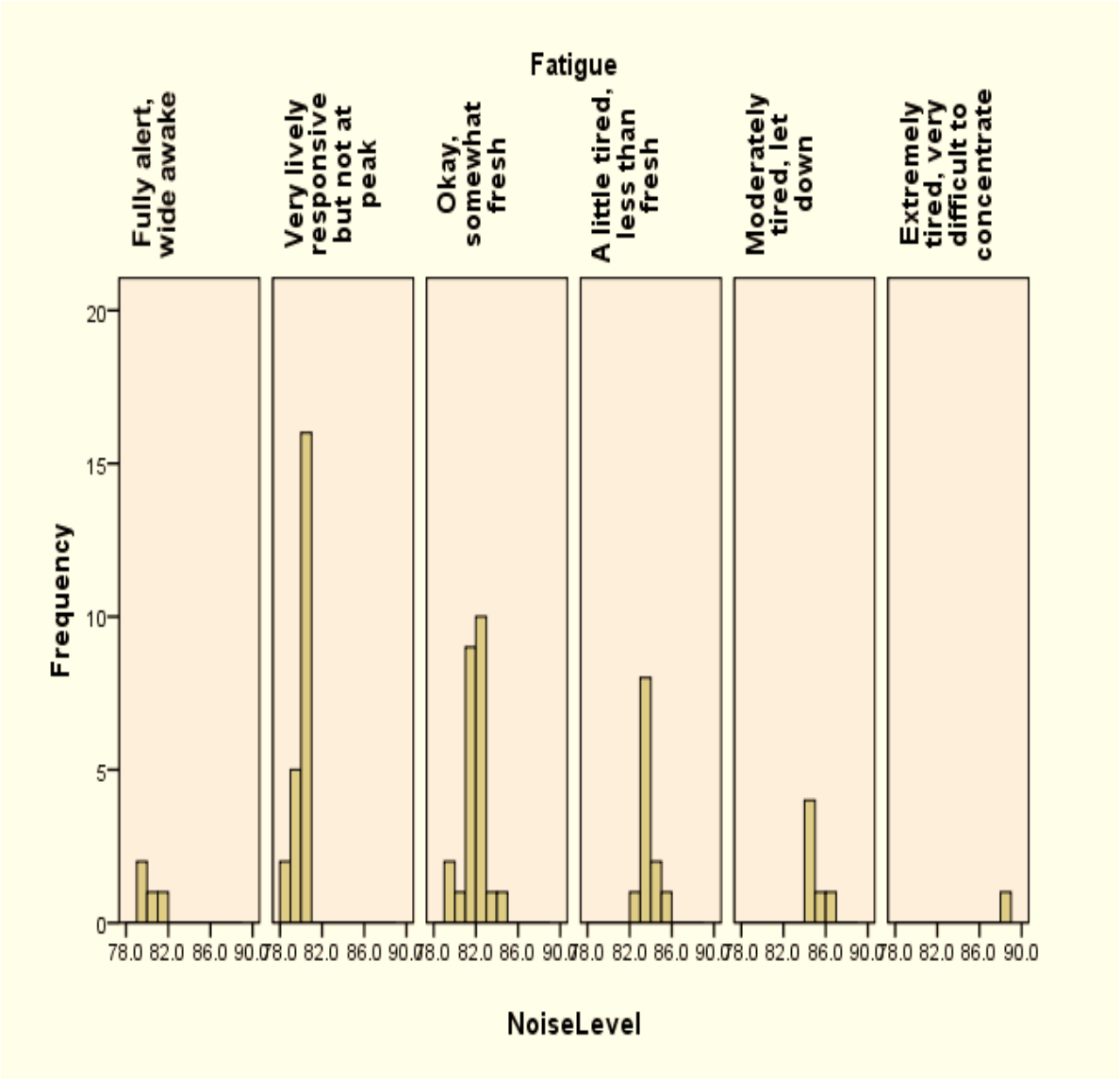


Figure 16: Histogram between noise level and fatigue

6.3.2 Duration of noise exposure and Fatigue

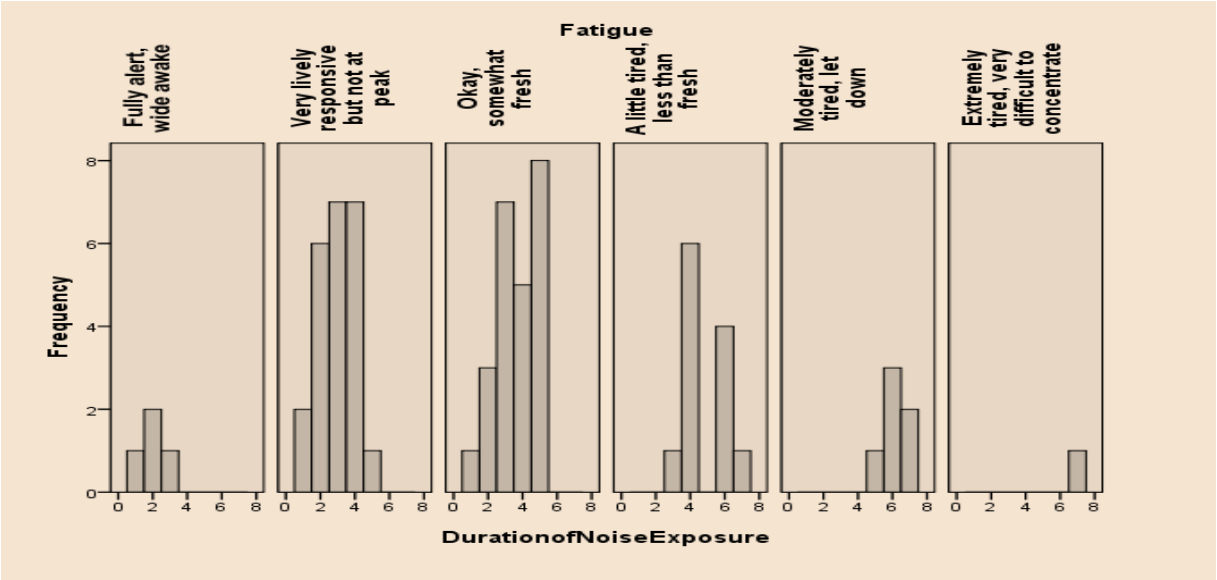


Figure 17: Histogram between duration of noise exposure and fatigue

6.3.3 Age of driver and Fatigue

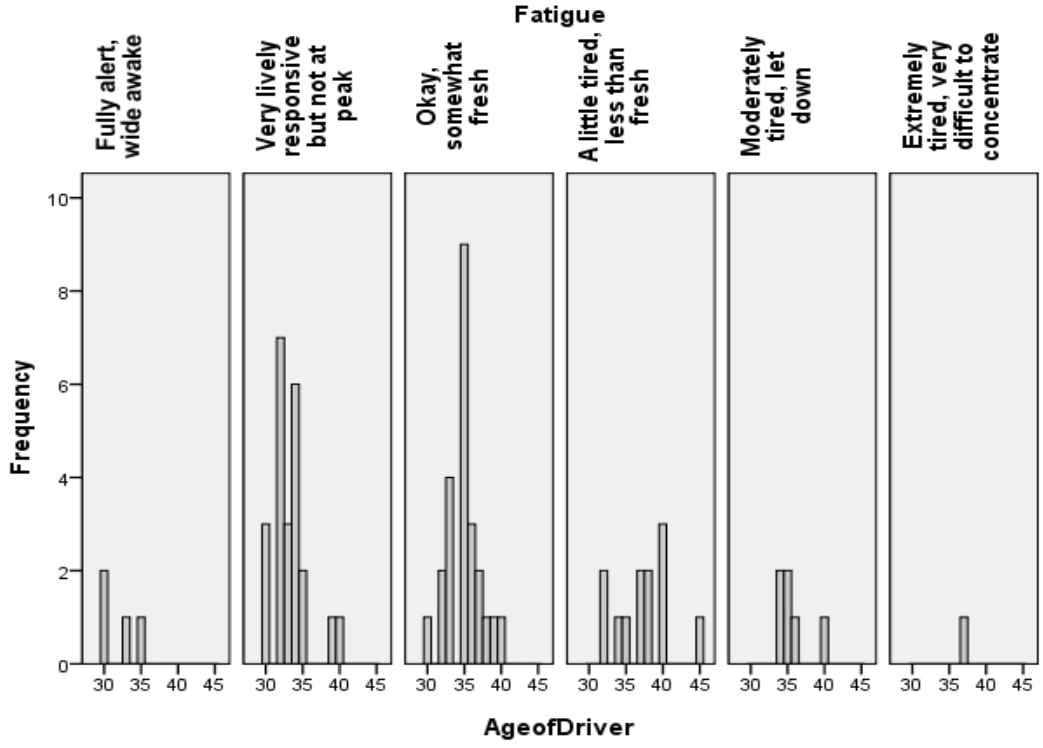


Figure 18: Histogram between age of driver and fatigue

6.3.4 Age of vehicle and Fatigue

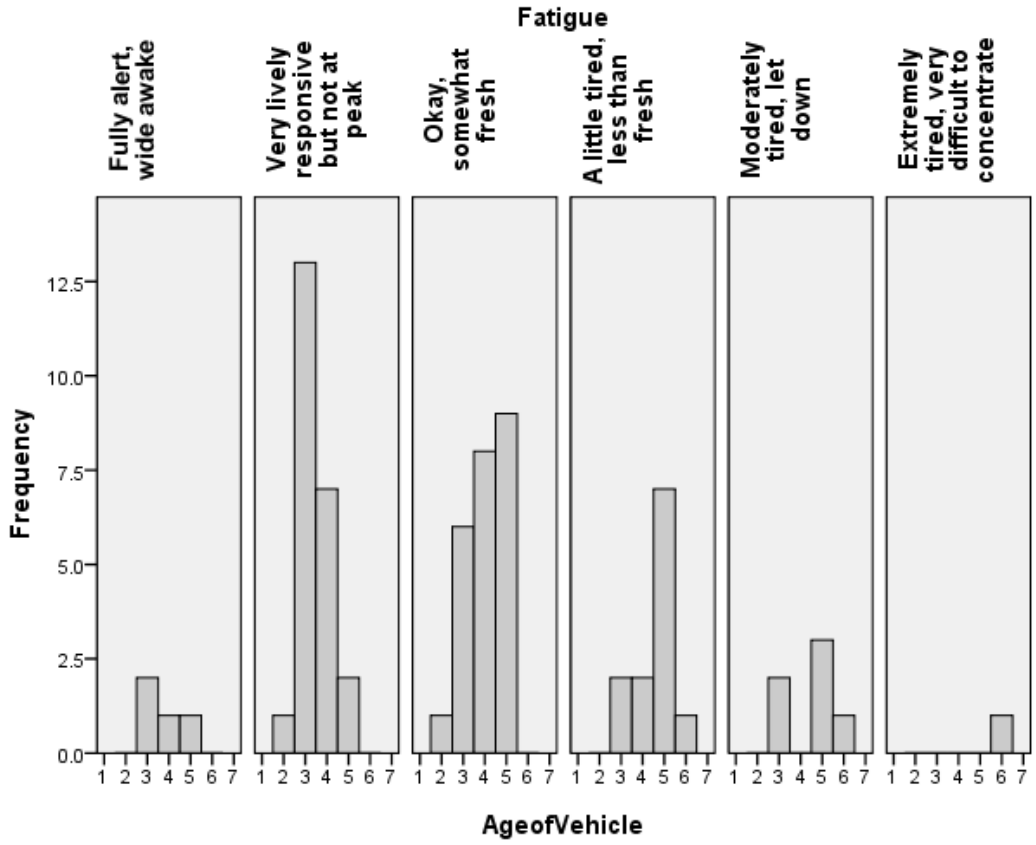


Figure 19: Histogram between age of driver and fatigue

CHAPTER 7: CONCLUSION

The results of the study may have a contribution to the discussion of the fatigue level of low floor bus drivers in Jaipur. The results show that the bus driver's health is mostly affected by noise level produced in their bus cabin and how much time they exposed to high noise level. Furthermore, the age of the driver can also affect their health in many ways. Fatigue level also depends on the vehicle they are driving if the vehicle is too old then it can adversely affect the driver's health.

Low floor buses are the main transportation medium for Jaipur localities. The health of the bus driver is a major problem because the driver can take leave from driving if they are not fit for driving than the local people suffer. So driver's health should watch out by the concerned department.

Most of the drivers are complaining about the hearing problem, an annoyance which is caused by noise exposure. Driver's performance level also decreases as the result of noise because due to high noise level they are unable to concentrate on the road and other vehicle which can cause accidents of the bus.

As earlier mentioned that Driver's fault accounted for 77.1 percent of total road accidents. Driver's fatigue is the major problem which is responsible for the most of the accidents. Due to high noise level and large duration of exposure to noise produce mental stress to drivers. They unable to concentrate on their driving and their performance level decreased by this.

7.1 Possible solution

- Drivers are unable to hear clearly the voice of conductor after exposed to high noise level (more than 80 dBA). There should be an arrangement in the bus like some sort of signal which can be easily detected by drivers.

- Duration of noise exposure also affects the drivers so Another solution which may be helpful is that if both driver and conductor have the driving skill so they can switch their roles after each trip.

- Noise proof cabin can also use in the buses so the drivers can get some relief from the high noise level in the bus cabin.

7.2 Future Scope

This study was related to bus driver only. Other city buses like mini buses can also include in the further study. Mini bus drivers were not having any fixed schedule so they might be exposed for more duration to noise. Then both the results may be compared to know which type of drivers have more affected by noise.

Another factor which can affect driver's health like humidity level, vibration, sitting posture and seat design may also, included so its effect can also analyze.

In addition, these results can be of help to understand which factors play a significant role in increasing the fatigue level of the drivers, and it is also helpful for the bus manufacturer to manufacture a low noise emitting bus which is very useful for drivers.

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APENDIX I

Questionnaire

Part: 1

1. Driver no. …
2. Age of Vehicle: ……years
3. Name of Driver: …….
4. Age: ……years
5. Height: …….. Inches
6. Weight: ……..Kg
7. Professional Driving Experience: ……Years
8. Have you been involved in any motor accidents? (YES/NO)
9. Medical History (If any): …….
10. Hearing problem (if any): ……..
11. Hours of driving today ……

Noise measurement:

STOP NAME	NOISE (dBA)

Part 2

1. Do you have a tendency not to realise how tired, or hungry or ill you feel, but instead ‘keep going?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

2. How often do you continue to drive despite fatigue?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

3. Do you think you were unable to drive as much as you need to because of fatigue?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

4. After driving for _____hrs how fatigued do you feel right now?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

5. Do you feel any problem in hearing voice of conductor?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

6. Do you think your hearing quality is affected after driving for _____hrs?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

7. After driving for _____hrs do you like to stop the vehicle and take a rest?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

8. After driving for _____hrs how fit do you feel for driving?

   1 – Very much 2 – Quite a bit 3 – Somewhat 4 – A little

   5 – Not at all

9. Do you think you will become too tired during driving for _____hrs?

   1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

   5 – Very much

10. How much is your performance influenced at this noise level?

    1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

    5 – Very much

11. Are you feeling annoyed by the noise?

    1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

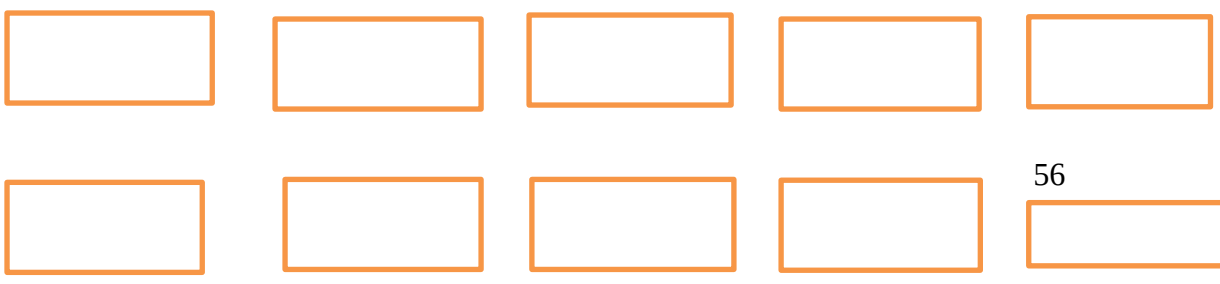
    5 – Very much

12. Do you feel this noise level will affect your concentration while driving?

    1 – Not At All 2 – A little 3 – Somewhat 4 – Quite a bit

    5 – Very much

13. Volunteer says some numbers, listen to them carefully than write down those numbers in blocks given below



The Samn-Perelli Seven point scale

Fully alert, wide awake.	1
Very lively responsive but not at peak.	2
Okay, somewhat fresh.	3
A little tired, less than fresh.	4
Moderately tired, let down.	5
Extremely tired, very difficult to concentrate.	6
Completely exhausted, unable to function effectively	7

Correct answers	Points
10	1
9	2
7-8	3
5-6	4
3-4	5
2	6
1	7

5*3=15 | 13-7=6 | 30/5=6 | 15*5=75 | 13+16=29

9*7=63 | 7-7=0 | 7*5=35 | 60/5=12 | 11+9=20