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Investigation & Examination of Noise Pollution - Definition, Sources, Effects, Monitoring and Control

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Keywords:

- Noise Pollution
- Environmental Noise
- Noise
- Environmental Sound
- Harmful effects of Noise
- Human Health Effects
- Environment
- Sustainability
- Mitigation
- Decibel (dB)

Abstract

Purpose – The study examines and investigates the problem of noise pollution in relation to its harmful effects on the human life. This study provides most appropriate definition of noise, identifies various sources of noise, investigates awareness level of public for noise, examines harmful effects of excessive noise and provides valuable suggestions for controlling the noise level. ***Methodology*** - This study is based on primary data collected from population of Delhi through a structured online questionnaire with sample of 350 respondents. The analysis has been carried out based on "cross-classifications' in terms of 'age' as well as 'gender'. ***Findings*** – This study revealed that male community is more aware about the noise pollution compared to female community. Most of the community is ignorant of what constitutes noise pollution as well as its adverse socio-economic & health impacts. Further the control of noise pollution has been hampered by insufficient knowledge of its harmful effects on human. The sound from traffic and loudspeakers is turned out major sources of outdoor noise pollutants. Primarily "traffic volume" expanded by road, rail and air traffic as a noise has gained wider recognition in terms of increasingly serious risk to human health. In case of indoor pollutants, television and different home appliances are reported as major noise sources. Even youngsters are also victim of noise at large scale. Noise extensively results in annoyance, disturb sleep, harmful effect on hearing, reduce working efficiency and interfere with communication. Public awareness programmes, education and technological solutions appeared to be the best methods to achieve the goal of noise reduction. Government can also play a significant role in putting efforts towards reduction of noise level by establishing & enforcing noise guidelines, standards and strict regulatory framework. ***Research Limitations and Practical implications*** – This study is limited to population of Delhi metro city in India. The findings in this study have several policy implications. Government should develop management strategies and action plans for noise control. The empirical evidences gathered through this study can be employed for developing appropriate legal and public action programs and awareness programs to disseminate knowledge about harmful effects of noise on human health and routine life.

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1. Introduction

The word 'Noise' is originated from the Latin word "nausea" implying – 'Unpleasant Sound', Unwanted Sound', 'Sound that is loud', 'A Harsh Sound, and 'Sound that is unexpected'. A sound becomes noise when it is unpleasant, unwanted, loud and unexpected and detrimental physiological and psychological effect on human. A sound can be unpleasant due to intensity of sound, time of exposure, continuity of sound and its frequency. In general, noise is any sound that humans do not want to hear. Noise is one of the environmental pollution that affects the quality of life of particularly of population at urban areas worldwide. It has increased in the modern age of industrialization and technological advancement. According to recent publication by the World Health Organization (WHO, 2018) at least 100 million people are affected by road noise in the European Union and at least 1.6 million years of healthy life are lost every year. In such noisy urban areas, people seem to have become accustomed to the higher noise levels. According to European Commission (1996), it is affecting human behaviour, well-being, productivity and health. Urbanization, economic growth and motorized transport are some of the driving forces for environmental noise exposure and adverse health effects. In India, noise is one of the most pervasive pollutant and growing problem because Indian people generally have traditional liking for noise, consequently noise is often regarded with the lowest priority for control and management. Most of our happy and sad moments of life are expressed through noise. It may be in the form of busting of crackers, playing loud music in parties and marriages, recitation of religious scriptures and hooting in events etc. Thus there is a silent compromise by us to take noise as a normal part of our routine life without realizing its adverse effects on our life and health. That is the one of main reason that the movement against noise pollution is weak in India. The health impacts of environmental noise are a growing concern among both the general public and policy-makers in India. Currently, limited research studies exist on the exposure-effect-response of noise and its sources & controls in the Indian scenario. In view of this, the present research has been carried out in metro city Delhi of India to synthesize noise definition, empirically investigating public reactions towards sources of noise, noise-induced-effect-response of public and control of noise.

2. Purpose

Aiming at studying the noise pollution for its definition, sources, effects and control; this study has following research objectives:-

a. Understanding and definition of noise in respect of environmental pollution.
b. Exploring the indoor and outdoor sources of noise pollution
c. To investigate the awareness level of public.
d. To investigate the public reactions on sources of noise.
e. To examine the public reactions on noise induced health impacts.
f. To explore the solutions to control the noise.

3. Understanding and Definition of Noise

Synthesis of noise is carried out to arrive at a most appropriate definition of noise. Noise is a "sound without value" or "any noise that is unwanted by the recipient". The loudness of noise varies from person to person so no precision definition is possible. Sound/noise is measured in dB (Decibel). The difference between sound and noise are often subjective and is a matter of personal opinion, however author has attempted to

explain this difference with the help of Figure-1. Sound (or noise) is the result of pressure variations, or oscillations, in an elastic medium (e.g., air, water, solids), generated by a vibrating surface, or turbulent fluid flow. Sound propagates in the form of longitudinal (as opposed to transverse) waves, involving a succession of compressions and rarefactions in the elastic medium. Sound becomes noise when the three elements (as shown in Figure-1) (i) Sound Pattern, (ii) Sound Intensity and (iii) exposure duration are having values other than specified norms. The general perception of sound in term of intensity of loudness (dB) is provided in Figure-2 and general noise exposure limits are shown in Figure-3. What is pleasant to some ears may be extremely unpleasant to others depending up on number of psychological factors.

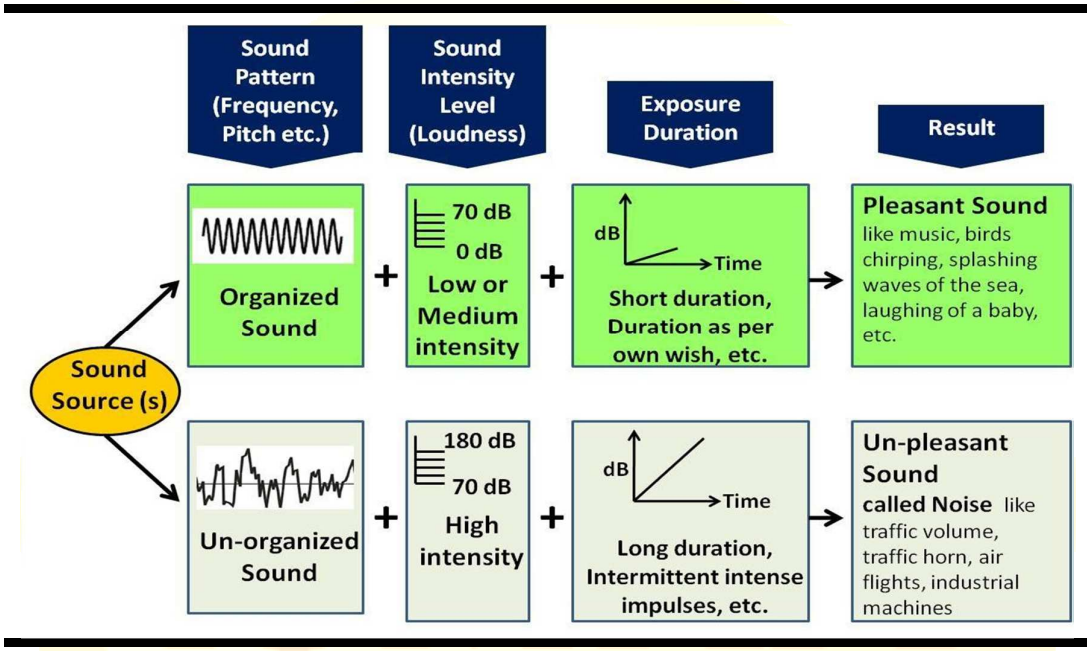


Figure -1 : Understanding Noise
Source:- Authors' creation

Singh, K.P and Singha, S. (1983) defined noise as a type of atmospheric pollution in the form of waves. It is a shadowy public enemy. According to encyclopedia Britainica (1968), noise is defined as any undesired sound in acoustics. Usually, noise is a mixture of many tones combined in a non-musical manner. According to encyclopedia Americana (1968), noise is defined as unwanted sound. The sweetest music, if it disturbs a person who is trying to concentrate or to sleep, is a noise to him, just as the sound of a pneumatic riveting hammer is noise to nearly everyone. In other words, any sound may be noise if circumstances cause it to be disturbing. In its guidelines for community noise (1999), the WHO defined environmental noise as "noise emitted from all sources except for noise at the industrial workplace". European Union (EU) Directive 2002/49/EC on the management of environmental noise (2002) defined environmental noise as "unwanted or harmful outdoor sound created by human activities, including noise from road, rail, airports and from industrial sites". W. W. Seto (1971) and B.G. Liptak et al. (1997) also argued that noise is simply anything that we hear and is subjectively defined as unpleasant or unwanted sound. Consequently, a sound can be noise to one person and not to others, or noise at one time and not at other times. So we can say that sound loud enough to be harmful is called noise without regard to its other characteristics. According to Environmental Health Criteria-126 'noise is considered as any unwanted sound that may

adversely affect the health and well-being of individuals or the populations'. H. S. Bhatia (1998) defined noise as any sound independent of loudness that can produce an undesired physiological or psychological effect in an individual and that may interfere with the social ends of an individual or group. These social ends include all of our activities like communication, work, and sleep etc. The Wilson committee of Britain (1963) defined noise as sound which is undesired by the recipient.

Perception Level of Sound	
Intensity Level in dB	**Perceptibility**
0	Threshold of Hearing
10	Just Audible
10-30	Very Quiet
30-50	Quiet
50-55	Normal Sound
60-70	Moderate Sound
70-100	Very Loud
100-130	Uncomfortable
130-140	Painfully Loud
140-180	Severely Loud

Figure -2 : Perception level of sound
Source:- Compilation by Authors

Noise Exposure Limits	
Possible exposure Limits [dB(A)]	**Duration per day [In hours]**
90	8
92	6
95	4
97	3
100	2
102	1.5
105	1
110	0.5
115	0.25 or less

Figure -3 : Noise exposure limits
Source:- Compilation by Authors

Therefore, in this study, we can arrive at following **most appropriate definition of noise** in respect of ambient air quality:-

"Noise, in context of environmental pollution, is an unpleasant & unwanted excessive sound (or combination of sounds) above than specified limits [dB(A)] in a particular area emitted from any source; which is undesired & disagreeable to the recipient due to 'adverse effects on his health' like damage to hearing, disrupt sleep, hypertension, high blood pressure, cognitive impairment & other diseases and 'bad effects on his routine life' like annoyance, discomfort, interference with speech & communication, reduction in efficiency of work performance & disturbance to his normal activities."

4. Literature Review

4.1 Sources of Noise Pollution

There is a need to first identify sources of noise to deal effectively with problem of noise. In India, the increasing ambient noise levels in public places are resulted from various sources like industrial activity, construction activity, fire crackers, sound producing instruments, generator sets, loud speakers, public address systems, music systems, vehicular horns, other mechanical devices, stone crushing machine, defence equipment, television, refrigerator, air conditioners and other home appliances etc.

As shown in Figure-4, all these sources of noise pollution can be broadly categories as indoor and outdoor noise pollutants. The indoor noise pollutants are associated with human activities within the building, operation of building services and office equipment. These may include door slam, footfall (especially in multi-story buildings), conversation, radio and television sets, fans and air-conditioners, home appliances and motorized appliances such as power generating sets (Ogunsote, 2010). Outdoor noise pollutants constitute the major sources of environmental noise. The noise caused by outdoor pollutants may be

difficult to control from the source. They include, but are not limited to the following:- noise from traffic and automobiles; noise from industries like quarries and mining industries; noise from pedestrians; noise from religious institutions like churches and mosques; noise from advertising agents and hawkers; noise from rallies like political campaigns, and so on (Ogunsote, 2010).

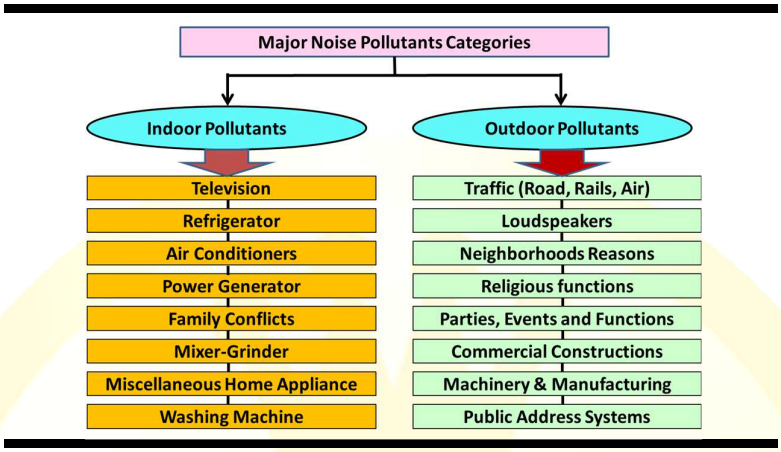


Figure - 4 : Various Indoor and Outdoor Noise Pollutants

Source: Authors' compilation

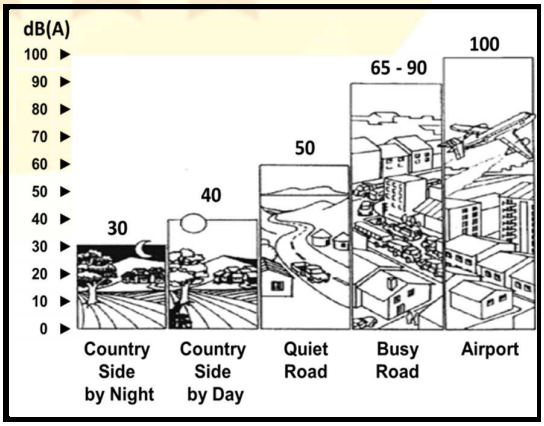
Further population, unawareness about harmful effects of noise pollution, industrialization advancement and advance motorized transport are some of the major contributors for environmental noise. Day & night, a large number of cars, trucks, motorcycles, air-flights and other motorized vehicles criss-cross the cities and resulting noise pollution.

Table-1 : Typical sound levels encountered in daily life and industry

Activity	*Sound Level dB(A)*
Desert	10
Rustling Leaves	20
Room in a quiet dwelling at midnight	32
Soft whispers at 5 feet	34
Men's clothing department of large store	53
Window air conditioner	55
Conversational Speech	60
Household department of large store	62
Busy restaurant	65
Vacuum cleaner in private residence	69
Ringing alarm clock at 2 feet	80
Loudly reproduced orchestral music	82
Prolonged exposure - hearing damage	85
Lorry or motorbike close by	90
Rock concert , loud disco	100
Pneumatic Drill	110
Jet aircraft take-off	130
Gunshots, explosions	140

Source: Tam 2000

Graphical scale of sound level in respects of transport oriented sound levels



Source :World Bank, 1997

According to Birgitta and Lindvall (1995), road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes, and lawn mowers are some of the major sources of this unwanted sounds that are routinely broadcasted into the air. Ritovska et al., (2004) also emphasized that improper use of horn by the traffic and wide use of loudspeakers in Indian religious and social ceremonies are major noise pollutants causing health risk to human. As per Goines and Hagler (2007), noise is a major environmental risk of the global world, originating from a different variety of sources including traffic, which plays main role in noise pollution. It is important to have an understanding of sound levels we typically encountered in our daily routine life. Table-1 provides a list of sound levels from typical situations along with a graphic scale of transport oriented sound levels.

4.2 Effects of Noise Pollution

Noise impacts health. The role of noise as an environmental pollutant and its impact on health are being increasingly recognized. The effect of noise on any human being may be psychological or physiological (Ogunsote, 2010; Adedeji and Folorunsho, 2010). Generally, sound is considered as noise pollutant having intensity more than 60 dB. Environmental noise is a psycho-social stressor that affects subjective well-being and physical health (WHO 1999; van Kamp I et. al 2012; EPoN 2010). Noise degrades environment and also causes health hazard to human beings. Exposure to noise for a continuous period of time will have many serious health issues, which may be temporary or permanent. Table-2 provides the details of different sound levels and their harmful effects. Even relatively low levels of noise affect human health adversely (Kiernan, 1997). It may cause hypertension, hearing loss, sleep disruption, cognitive impairment in children, tinnitus, reduced productivity, absenteeism and accidents, cardiovascular disease, annoyance & frustration reactions, social handicaps, negative social behaviour, high blood pressure, anxiety & stress related illness, memory loss, severe depression, and panic attacks.

Table-2 : Different sound levels and harmful effects

Noise level (dBA)	*Possible psychological and physiological effects.*
65	Annoyance, mental and physical fatigue.
90	Very long exposure may cause permanent hearing loss.
100	Short exposure may cause temporary damage; long exposure may cause permanent damage.
120	Pain.
150	Immediate loss of hearing.

Source: : Ogunsote (1991)

Epidemiological studies on the relationship between transportation noise (particularly road traffic and aircraft noise) and cardiovascular effects have been carried out on adults and on children. Both road traffic noise and aircraft noise increase the risk of high blood pressure. At the same equivalent noise level, annoyance and self-reported sleep disturbance are usually highest for aircraft noise, and higher for road compared with rail traffic noise (*Miedema and Oudcshoorn, 2001*). Bond (1996) revealed that the effects of excessive noise could be so severe that either there is a permanent loss of memory or a psychiatric disorder .It disturbs and interferes with activities of the individual, including concentration, communication, relaxation and sleep. Children may be exposed to noise for many of their childhood years and the consequences of long-term noise exposure on reading

comprehension and further cognitive development remain unknown. Many studies have shown negative effects of noise on reading and memory in children (Evans GW, Hygge S, 2007; Evans GW, Lepore SJ, 1993). Tasks affected are those involving central processing and language, such as reading comprehension, memory and attention (Haines MM et al. 2007). A study in London found that 340 children are exposed to the air craft noise of ages 8-11 resulting in annoyance, poor reading and comprehension (Hagler, 1999). In another research, children who were exposure to noise levels above 55 dB they have low attention, less social adaptability, and have opposite behaviour to others compared to children (Costa et al., 2013). Therefore exposure during critical periods of learning at school could potentially impair development and have a lifelong effect on educational attainment.

Noise disturbs communication, concentration, relaxation and sleep. Chronic long-term exposure to transportation noise has been shown to be associated with the prevalence and incidence of cardiovascular diseases, including hypertension, ischemic heart diseases and stroke (Babisch W, 2014). Large scale epidemiological studies have been carried out for a long time (Babisch, 2000). Figure-5 shows a proposed reaction scheme for the effects of noise on the organism (Babisch W, 2002).

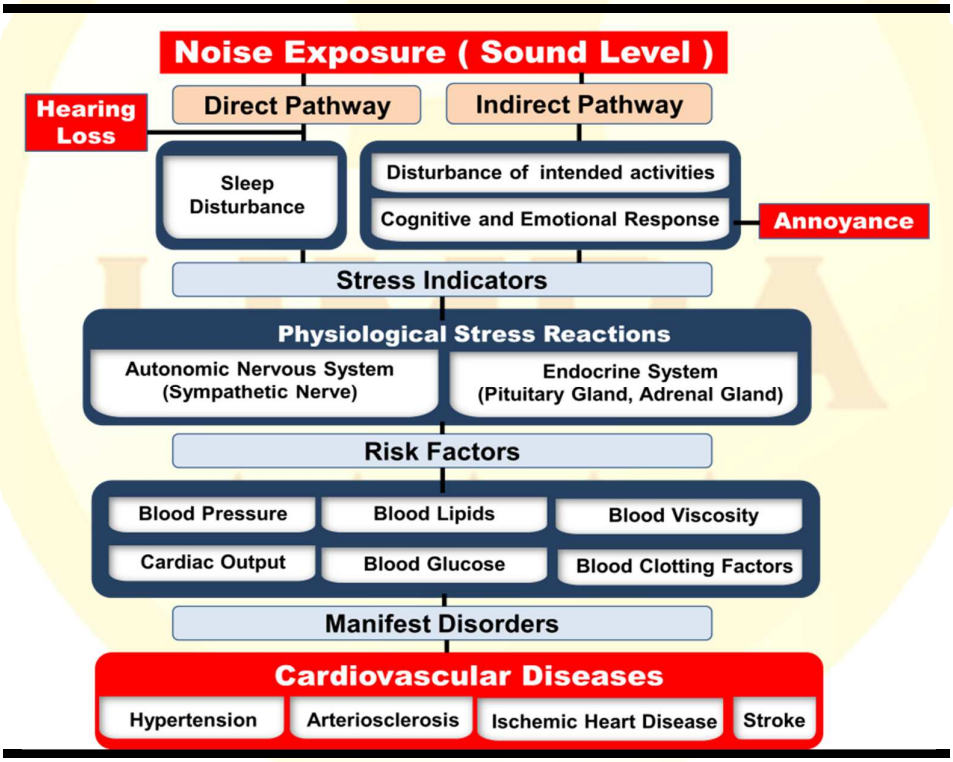


Figure-5 : Noise effects reaction scheme

Source: Adopted from Babisch W (2002), Authors' re-creation

Sufficient undisturbed sleep is necessary to maintain performance during the day as well as for general good health (Banks S, Dinges DF, 2007). The human organism recognizes, evaluates and reacts to environmental sounds even while asleep (Oswald I et al., 2007). Environmental noise may badly affect the restorative ability of sleep by means of repeatedly exposure to disrupt sleep due to noise. The repeatedly acute and chronic sleep disturbance due to noise may further affect other things like energy of body to perform various tasks, ability to receive and understand other's communication, signal detection ability, memory consolidation, creativity, risk taking ability and risk of accidents.

Another noise induced bad effect on health is tinnitus. To put it in terms of auditory abilities, tinnitus is the inability to perceive silence (Leroux T, Lalonde M., 1993). Thus tinnitus is the general term for sound perception (for instance, roaring, hissing or ringing) that cannot be attributed to an external sound source. It is widely believed that mild, occasional or acute temporary tinnitus is experienced by nearly everybody in their lifetime at some time or another (MacFadden D., 1982). The severity of health effects due to noise versus the number of people affected is schematically presented by Figure-6.

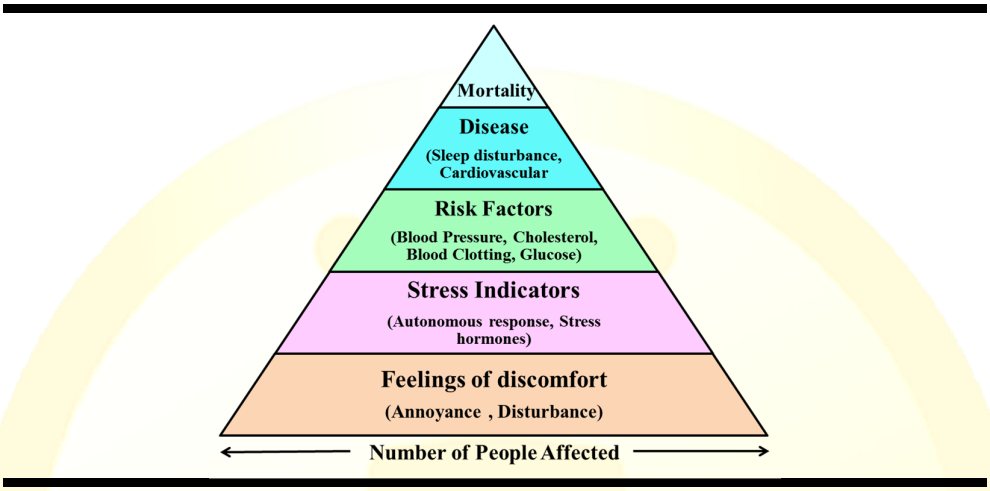


Figure-6 : Severity of health effects of noise and number of people affected
Source: Babisch

Based on the systematic review of evidence produced by epidemiological and experimental studies, the relationship between night noise exposure and health effects can be summarized as below (Table -3).

Table-3 : Effects of different levels of night noise on the population's health

Average night noise Health effects observed in the population level over a year $L_{night,outside}$	***Health effects observed in the population*** *(Note. The guidelines assume an average attenuation of 21 dB(A) between inside and outside noise levels.)*
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

Source: Night noise guidelines for Europe (38).

From above literature review, it is evident that noise pollution results many bad effects on human health and it is therefore of utmost importance to take practical action to limit and control excessive environmental noise.

4.3 Controls of Noise Pollution

It is considered necessary to regulate and control the noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise. In India, the Noise Pollution (Regulation and Control) Rules, 2000 have been framed under the Environment (Protection) Act, 1986. These are a set of guidelines with the standard prescribed limits for regulation and control of noise. The ambient levels of noise for different areas / zones specified in the rules are indicated in Table-4.

Table-4 : Ambient air quality standards in respect of noise

Area Code	*Category of Area/ Zone*	*Limits in dB**	
		Day Time	*Night Time*
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Source: Environment (Protection) Act, 1986 as amended in 2002.

Notes regarding Table-4 :-

*The limit in dB denotes the time-weighted average of the level of sound in decibels on Scale A which is relatable to human hearing.

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by competent authority.

The Central Pollution Control Board (CPCB) has the responsibility to regulate and control sources of Noise Pollution with the objective of maintaining the ambient air quality standards. From above literature review it is observed that experimental knowledge related to noise is available in literature but less research studies were found based on interaction with real life and practical world like how noise pollution is understood by human/public, how much knowledgeable they are for its harmful effects and what they are doing to reduce and control it. To fill gap, author has tried to attempt this study.

5. Research Methodology

5.1 Location

Location is very important factor for this study. Many researches have indicated high levels of sound pollution in different urban areas. Delhi is the capital city of India and is regarded as the heart of the nation. Delhi's urban area is now considered to extend beyond the NCT (National Capital Territory of Delhi) boundaries, and include the neighbouring satellite cities of Ghaziabad, Faridabad, Gurgaon and Noida in an area now called National Capital Region (NCR) and had an estimated population of over 26 million people, making it the world's second-largest urban area according to the United Nations (2016). Apart from country's largest urban agglomerations, Delhi is an important commercial, transport, and cultural hub. Therefore Delhi is chosen for this study.

5.2 Sample, Data and Techniques

This empirical study is based on *primary data* collected through a structured online questionnaire. The sample represents a cross-section of different age groups, gender and educational levels. Total 350 responses were collected. The analysis has been carried out with the help of *'percentages technique'* and *'cross classifications'* in terms of '*age'* as well as '*gender'* on awareness of noise pollution, sources of noise, effects of noise, and suggestions to control noise.

6. Analysis, Results and Findings

6.1 Respondents Demographics

The study is based on cross-classification in term of age and gender. The demographics details of respondents are shown in Table-5.

Table-5 : Respondents Demographics

Characteristics		***Value***	***%age***
Total Respondents		350	100%
Gender			
Male		199	57%
Female		151	43%
Age-Group			
Up to 20	*(Say $A1_{<20}$)*	66	19%
20-40	*(Say $A2_{20-40}$)*	120	34%
40-60	*(Say $A3_{40-60}$)*	91	26%
Above 60	*(Say $A4_{>60}$)*	73	21%
Education			
Doctorate		45	13%
Post-Graduation		148	42%
Graduation		126	36%
Diploma		7	2%
Others		24	7%
Source: Authors' Survey Data			

6.2 Awareness about Noise Pollution

6.2.1 In terms of Male and Female

Awareness is major agent which can contribute to control and hence reduce the noise pollution. The awareness level of respondents based on gender is sown in Figure-6, which presents the %age of male and female respondents answering questions Q1, Q2, Q3 and Q4 as Yes/No.

It is evident from Figure-7 that in general, male respondents are more aware about the noise pollution as compared to female (see % age "Yes" response for $Male_{Q1}$-80%, $Male_{Q2}$-43%, $Male_{Q3}$-77%, $Male_{Q4}$-74%) except $Male_{Q5}$-65% where female are more aware; $Female_{Q5}$-68%. However %age difference in "Yes" responses of male and female is not significant (e.g. 80-64 = 16%, 43-37 = 6%, 77-70 = 7%, 74-66 = 8%, 68-65 = 3%); which implies that on an average, the awareness of noise pollution is almost equal among male and female community. The "No" response of 23% by male community and 30% by female community against question Q3 implies that almost one third of the community,

especially in the Indian subcontinent, is not aware that noise can cause any health damages although environmental noise has severe negative impact on human health. This calls for implementations of actions and initiatives to spread the awareness among Indian population about harmful effects of noise pollution. The "No" response of 57% of male community and 63% of female community towards question Q2 also calls for dissemination of knowledge of limits of noise level.

Thus, there is less awareness in Indian population regarding noise impacts human health negatively and hence there is need to increase the awareness about noise pollution among both male and female for better understanding of noise pollution and hence it's monitoring & control.

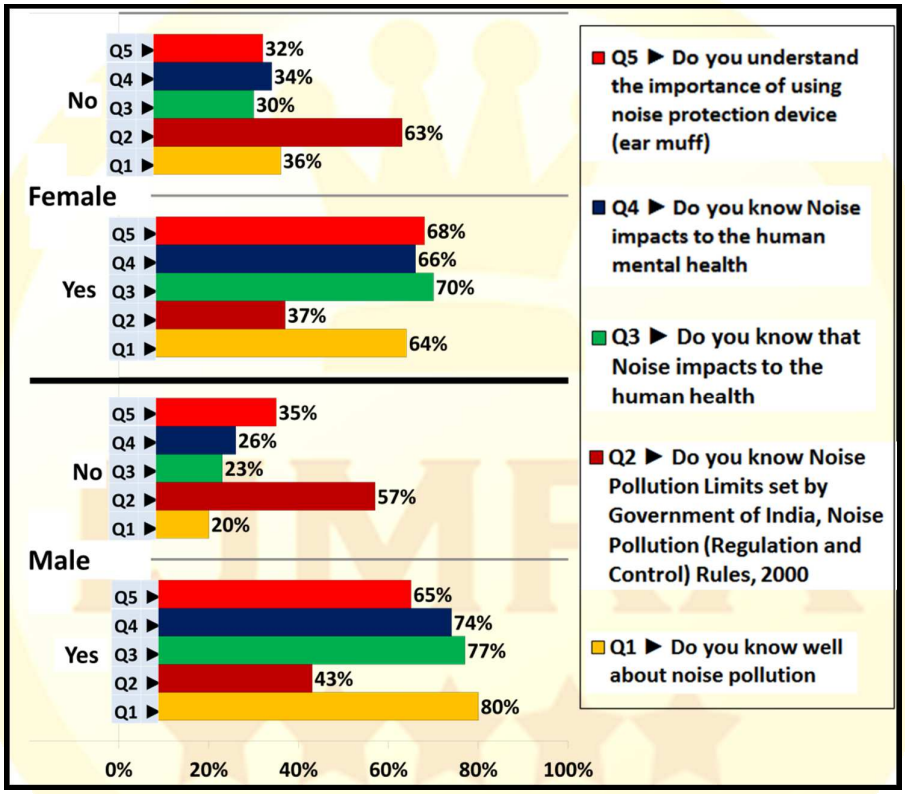


Figure-7 : Awareness about noise pollution in terms of male and female respondents
Source: Authors' Work

6.2.2 In terms of different age group

The awareness level of respondents based on age groups is sown in Figure-8, which presents the %age of various respondents from age groups $A1_{<20}$, $A2_{20\text{-}40}$, $A3_{40\text{-}60}$ & $A4_{>60}$ answering questions Q1, Q2, Q3 and Q4 as Yes/No. The analysis indicates that very large proportion of population in *age group* $A2_{20\text{-}40}$ (valuing "Yes" as 85%, 55%, 91%, 87% & 74% for all questions Q1,Q2,Q3,Q4 & Q5 respectively) and *age group* $A3_{40\text{-}60}$ (valuing "Yes" as 89%, 54%, 92%, 88% & 71% for all questions Q1,Q2,Q3,Q4 & Q5 respectively) are more aware about noise pollution as compared to population in *youngest age group of* $A1_{<20}$ (valuing "Yes" as 53%, 24%, 56%, 53% & 62% for all questions Q1,Q2,Q3,Q4 & Q5 respectively) and *oldest age group* $A4_{>60}$ (valuing "Yes" as 47%, 86%, 91%, 87% & 74% for all questions Q1,Q2,Q3,Q4 & Q5 respectively). The awareness about the most important question Q3 (Do you know that noise impacts to the human health?) is poor in

respondents in age group of $A1_{<20}$ & $A4_{>60}$ (%age of "Yes" population is A1-56%, A4-41%). The response against question Q2 implies that significant population in all age groups does not know the about norms of noise limits in their areas. The above analysis brings out most important point that noise pollution is increasing day by day due to one of major reason of lack of awareness of noise pollution and its harmful effects.

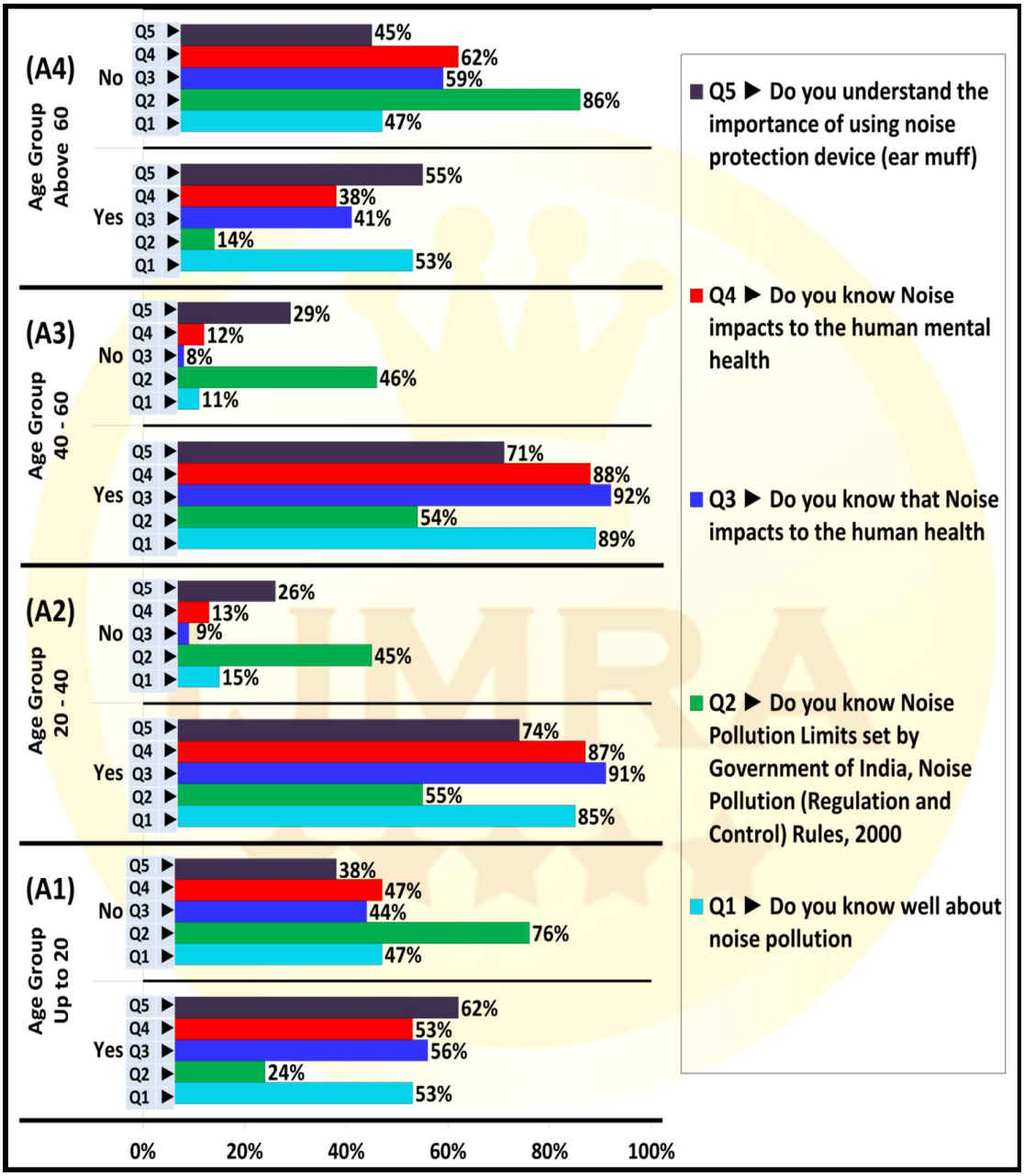


Figure-8 : Awareness of noise pollution based on different age groups
Source: Authors' Work

6.3 Reactions of respondents towards Outdoor Noise Pollutants

6.3.1 In terms of Male and Female

The analysis of impact of outdoor sources of noise pollution on male community and female community differently is shown in Figure -9. The Figure-8 presents the % age of

male and female respondents affected by different outdoor sources of noise. There are significant differences in population (more than 10%) affected by noise generated from *"Loudspeakers"* and *"Parties, Events & Functions"* where male population (70% and 50% respectively) is more affected over the female population (54% and 38% respectively). In terms of remaining sources of noise, there is no significant difference in % age (less than 10%) of male population and female population. It implies that other sources of noise (*Traffic, Industrial Manufacturing Noise, Religious Functions, Commercial Construction Noise and Neighbourhoods*) affect equally to male population as well as female population. Ranking wise, male and female population are highly affected by *(1) Traffic* followed in descending order by *(2) Loudspeakers, (3) Industrial Manufacturing (4) Noise, Parties, Events & Functions, (5) Religious Functions, (6) Commercial Construction Noise and (7) Neighbourhoods.*

Thus, ***"Traffic Volume"*** expanded by road, rail and air traffic as a noise has gained wider recognition in terms of increasingly serious risk to human health.

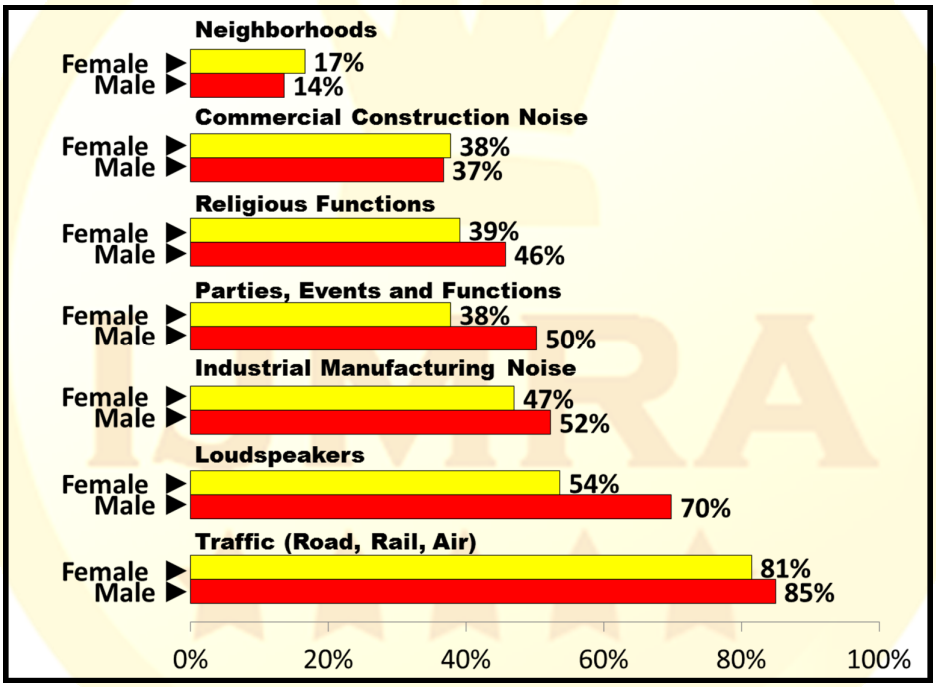


Figure-9 : Impact of various outdoor noise pollutants based on gender

Source: Authors' Work

6.3.2 In terms of different age group

The Figure-10 presents the % age of respondents of different age groups affected by different outdoor sources of noise. The analysis indicates that a very large proportion of respondents (ranging from 79% to 89%) in each age group are being affected by noise emanating from the "*Traffic"*. On the other hand, very less proportion of respondents (ranging from 3% to 26%) in all age groups are affected by "*Neighbourhoods"*. An almost equal proportions of respondents (ranging from 41% to 75%) across different age-groups claim that noise originating from "*Loudspeakers"* affects them. A relatively small proportion of respondents (ranging from 10% to 55%) acknowledge adverse effect of noise generated by "*Commercial Construction"*. Majority of respondents with little %age difference across different age groups feel that noise originating from "*Religious*

Functions", "Parties, Events & Functions" and "Industrial manufacturing" affects their activities.

The highly affected proportion of population due to outdoor noise is from age group $A1_{<20}$ followed in descending order by age group $A3_{40\text{-}60}$, $A2_{20\text{-}40}$ and $A4_{>60}$. The disturbance of the community of youngest age group $A1_{<20}$ at large is obvious due to education/study period of life. The recognition of harmful effects of outdoor noise by the community of oldest age group $A4_{>60}$ at small proportion seems true because till age of 60 years people normally get affected to maximum extent and thereafter they feel less impact of noise pollution on their life and health.

This analysis brings out that ***"Traffic"*** and ***"Loudspeakers"*** act as significant sources of outdoor noise pollution. Thus population at large in Delhi is becoming victim of noise pollution mainly originating from ***"Traffic"*** and ***"Loudspeakers"***.

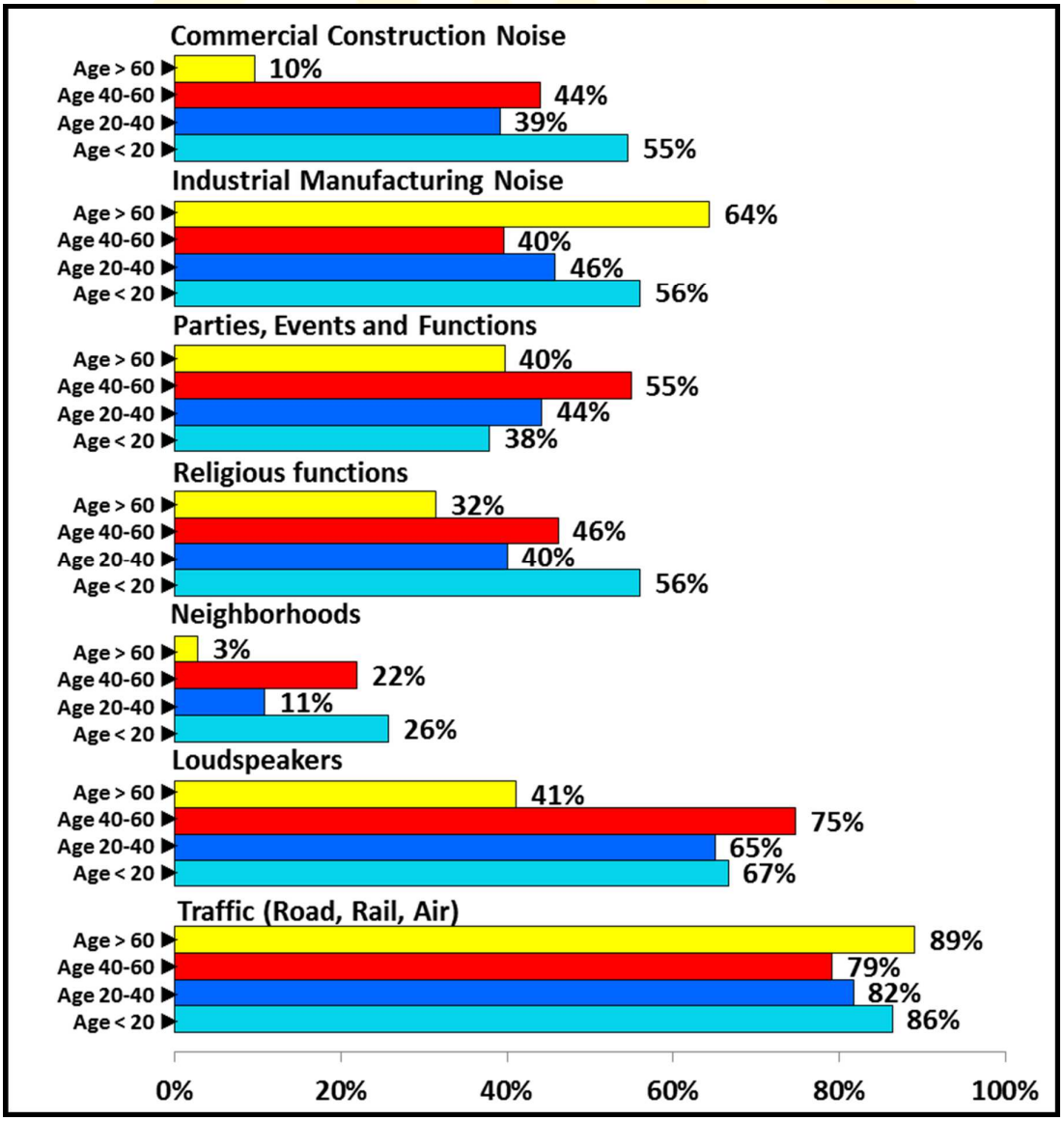


Figure-10 : Impact of various outdoor noise pollutants based on different age groups
Source: Authors' Work

6.4 Reactions of respondents towards Indoor Noise Pollutants

6.4.1 In terms of Male and Female

Figure-11 presents the %age of male and female respondents affected by different indoor sources of noise. The analysis indicates that there are no significant differences in %age of population (all are less than 10%) affected by noise generated from indoor sources. It implies that all indoor sources of noise affect equally to male population as well as female population. Ranking wise, male and female population are highly affected by *(1) TV (Television)* followed in descending order by *(2) Different home appliances, (3) Power Generators, (4) Air Cooler / Air Conditioners, (5) Family conflict, (6) Refrigerators.* An almost equal %age of male and female population has recognised that noise originating from *"TV (Television)"*, and *"Different home appliances"* affects their activities.

Thus, ***"TV (Television)"***, and ***"Different home appliances"***, as a noise are mostly considered high serious risk to human health.

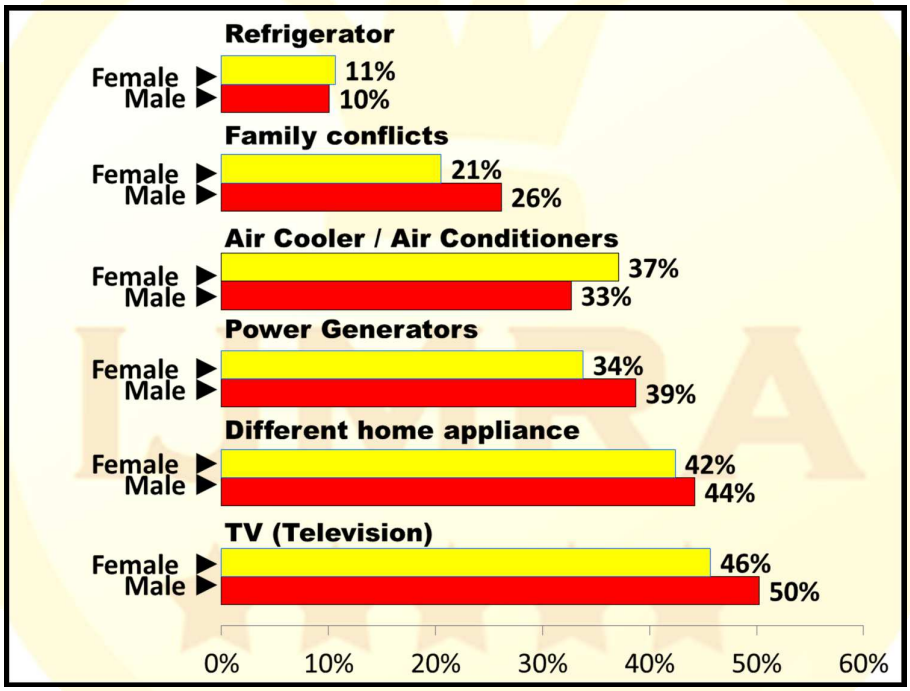


Figure-11 : Impact of various indoor noise pollutants based on gender

Source: Authors' Work

6.4.2 In terms of different age group

The Figure-12 presents the %age of respondents of different age groups affected by different indoor sources of noise. The analysis indicates that a very large proportion of respondents in each age group are being affected by noise emanating from the *"Different home appliances"* ranging from 33% to 60% and from the *"TV (Television)"* ranging from 29% to 58%. On the other hand, very less proportion of respondents in all age groups is affected by "*Refrigerators"* ranging from 5% to 15% and by "*Family conflict"* ranging from 8% to 36%. An almost equal proportions of respondents (ranging from 41% to 75%) across different age-groups claim that noise originating from "*Loudspeakers"* affects them. Majority of respondents with significant %age difference across different age groups feel

that noise originating from "*Power Generators"*, and *"Air Cooler / Air Conditioners"* affects their activities.

The major proportion of respondents (58%) in youngest age group $A1_{<20}$ feel that they are most affected by the noise from "*Air Cooler / Air Conditioners"* however on other hand large proportion (60%) of oldest age group $A4_{>60}$ acknowledge harmful effect due to "*Different home appliance"*. Highest proportion of age groups $A2_{20\text{-}40}$ (58%) and $A3_{40\text{-}60}$ (54%) responded that their life is badly affected by the noise originating from TV (television). The noise originating from "*Refrigerators"* is affecting least population in each age group.

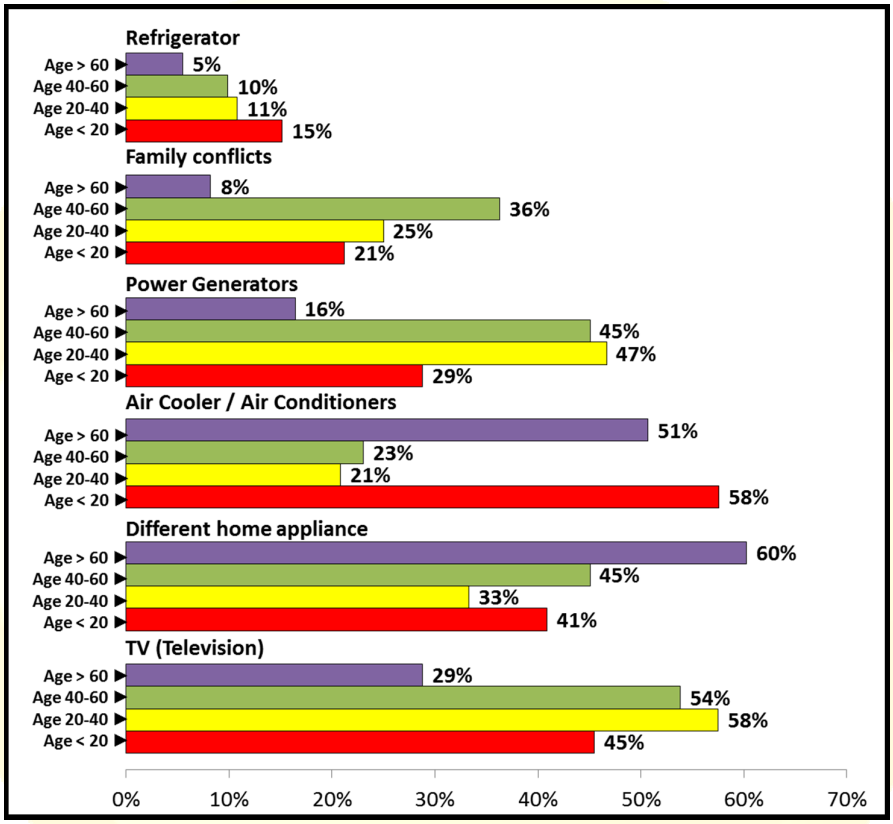


Figure-12 : Impact of various indoor noise pollutants based on different age group
Source: Authors' Work

Therefore ***"TV (Television)"***, and ***"Different home appliances"***, act as significant sources of indoor noise pollution and affect each age group differently. Thus, large population of metropolitan cities is mostly affected by the noise originating from indoor noise pollutants "***TV (Television)"***, and ***"Different home appliances"***.

6.5 Reaction of Respondents regarding effect of Noise Pollution

6.5.1 In terms of Male and Female

Figure-13 shows the perception of male and female populations about the effect of noise. This analysis indicates that male population is higher as compared to female population who has recognised adverse effects of noise in all categories except "Interface with communication" although the %age difference is not significant (not more than 10%, which is in case of mental health disorders). This implies that almost equal proportion of

male and female population is susceptible to adverse effects of noise for each harmful effect considered in this study.

In case of mental health disorders, male population is highly susceptible only by 10%. Both communities, male and female, have almost equally recognised that their work efficiency reduces because of noise pollution, which is very important finding for the industries. The industries must adapt good methods to reduce the noise level at the workplace in view of enhancement of efficiency of workforce and hence productivity. Modern industries have come up with sound enclosures around the industrial machineries being operated by human beings to prevent noise effects.

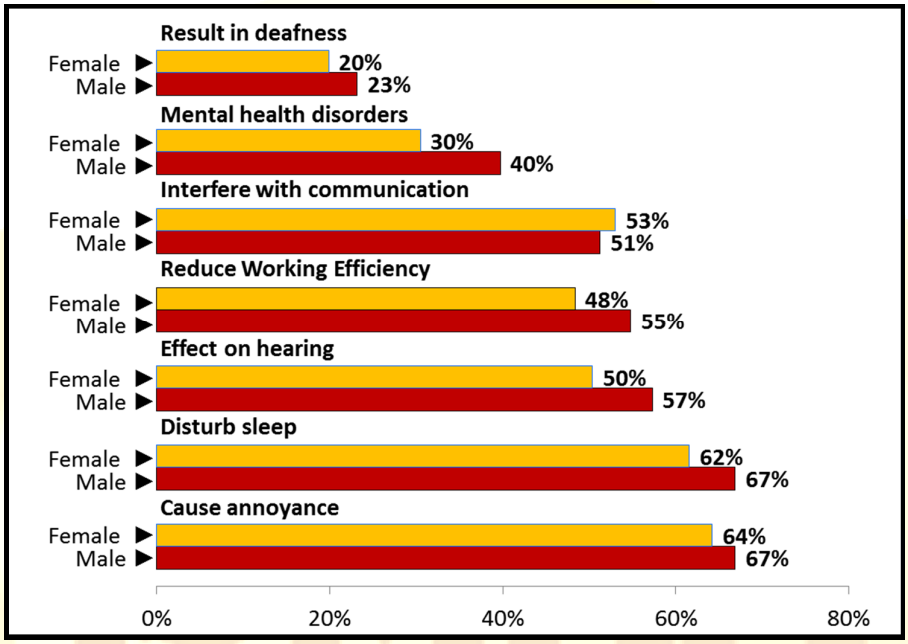


Figure-13 : Harmful effect of noise pollution based on gender

Source: Authors' Work

The response of higher population in both communities indicates that ***annoyance, disturb sleep and hearing impairment*** are the primary health effects of noise. Thus both communities have addressed noise as big menace to human's health and life. Author is treating noise as another form of ***"modern plague"*** causing harmful effects silently on human's health and life.

6.5.2 In terms of different age group

Figure-14 shows the perception of populations from various age groups about the effect of noise. The survey data shows that the effect of noise is not similar among various age groups. Each age group is affected differently by noise.

It can be visualized that higher population (73%, 71%, 61% & 74%) of age group $A1_{<20}$ has reported *"Annoyance", "Disturb sleep", "Effect on hearing"* and *"Interfere with communication"* as adverse effects on human health due to noise.

An almost equal proportion of higher population (51%, 52%, 57%, 60% & 52%) of age group $A2_{20\text{-}40}$ has also reported *"Annoyance", "Disturb sleep", "Effect on hearing", "Reduce Working Efficiency"* and *"Interfere with communication"* as harmful effects of

noise. A mixed proportion of population (63%, 56%, 57%, 74%, 55% & 46%) of age group $A3_{40\text{-}60}$ years has reported *"Annoyance", "Disturb sleep", "Effect on hearing", "Reduce Working* **Efficiency***"* and *"Interfere with communication"* and *"Mental health disorders* as bad effects on human health and life due to noise.

A proportion of higher population (88% & 90%) of age group $A4_{>60}$ years has reported *"Annoyance" and "Disturb sleep"* as negative effects on human health due to noise.

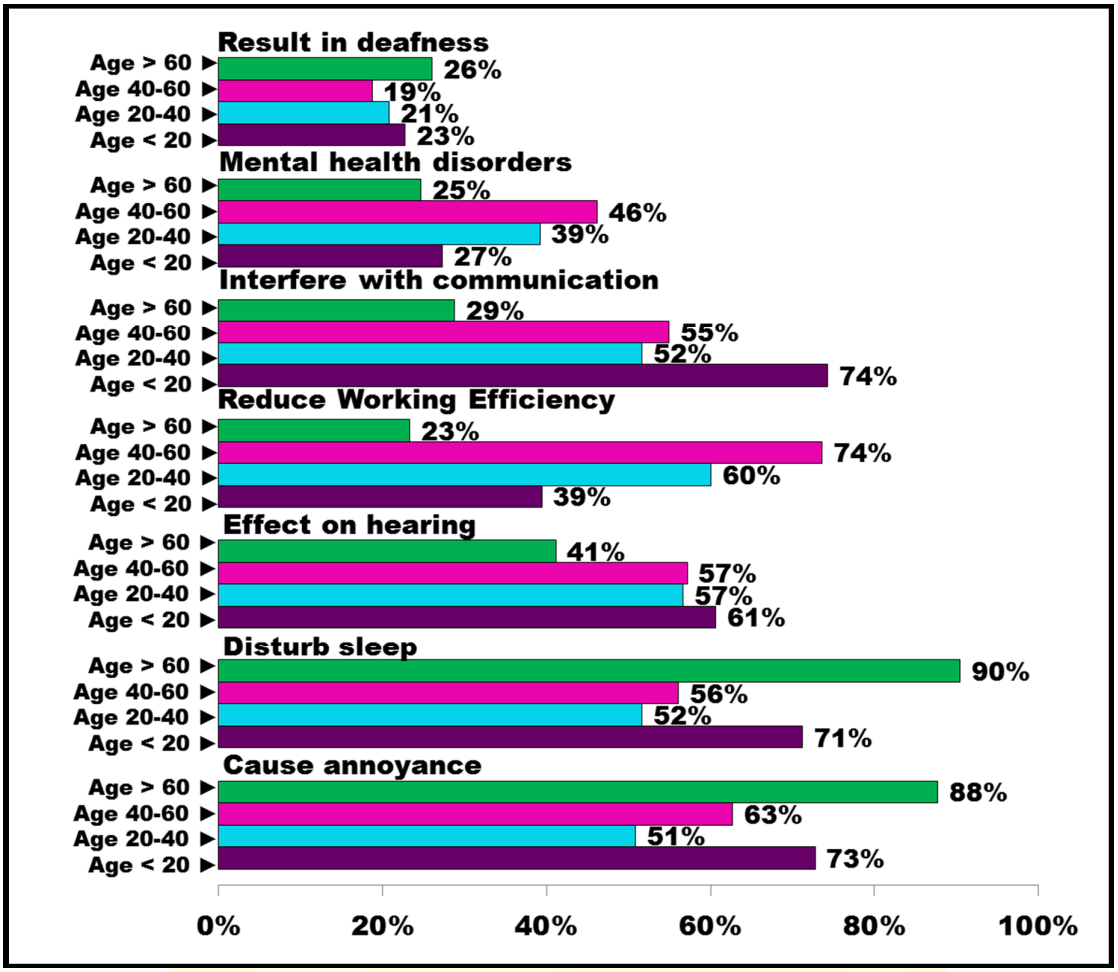


Figure-14 : Harmful effect of noise pollution based on different age group
Source: Authors' Work

It is surprising to note that even youngsters (with a significant population of 61%) have started coming up with hearing adverse impact caused by noise hazard. This implies that youngsters are also victim of noise at large scale. High working efficiency of employees is always a desirable parameter by all industries. The employees working age normally is 20-60 years in the world. The analysis shows shocking results on reduction of Working Efficiency. A proportion of 60% in age group $A2_{20\text{-}40}$ and 74% in age group $A3_{40\text{-}60}$ have reported reduction in working efficiency due to noise. Similarly significant population of the same age group (51% & 63% of $A2_{20\text{-}40}$ and 52% & 56% of $A3_{40\text{-}60}$) have acknowledged annoyance and disturbed sleep which further will reduce the efficiency of the human beings. In nutshell, noise has emerged as the biggest cause of disability at workplace and is becoming big threat & challenge to industries.

6.6 Suggestions to control Noise Pollution

6.6.1 In terms of Male and Female

Figure-15 shows %age of male and female respondents for probable solutions towards noise pollution. The analysis shows that there is no major difference (observed less than 15%) in proportions of male and female populations with regard to proposed set of probable solutions towards noise pollution. In general, a set of a significant proportion of respondents in all age groups feel that education awareness programmes, technological solutions and government efforts can help control the noise level. A small proportion of respondents believe that police and civil administration could also facilitate checking of noise levels, if empowered. A small %age of respondents also suggests engaging NGOs (Non-government organization) for invoking various activities towards reduction of noise level. Thus, Male and female groups do not seem to differ regarding alternative methods of controlling the noise-level. Predominantly, male as well as female respondents advocate public education. The analysis also suggests a multi-dimensional approach to achieve goal of noise level reduction i.e. a single measure cannot achieve the goal of noise-reduction.

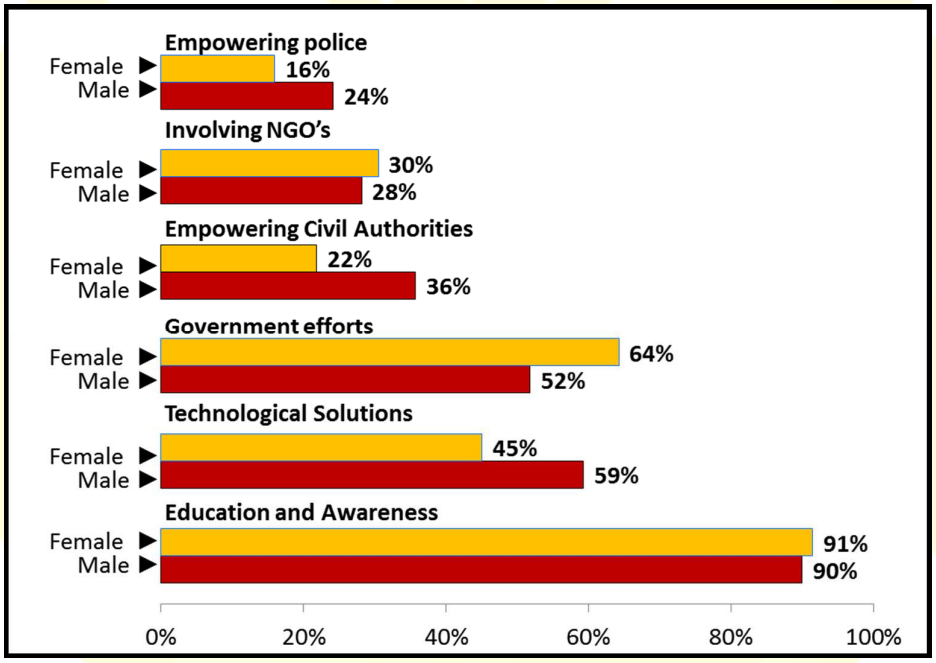


Figure-15 : Responses on suggestions to control noise by male and female

Source: Authors' Work

6.6.2 In terms of different age group

Figure-16 indicates %age of respondents towards a proposed set of probable solutions to achieve noise level reduction. The major response in term of age groups is almost similar to that what we have seen in case of male and female respondents i.e. a significant proportion of respondents in all age groups believe that education awareness programmes, technological solutions and government efforts. Respondents have given less emphasis to solutions of "Empowering Police", "Engaging NGO" and "Empowering Civil Authorities". Empowering the police is rated as a tool for control of noise by smaller proportion of people in total sample. Thus, change in public attitude by awareness programmes of government, various agencies, NGOs and other civil measures (enforcing strict laws) could help us reduce or prevent the noise pollution. The most important

measure for noise reduction is technical solutions. They attack directly the source of the noise. All other measures attack the consequences without removing the noise source.

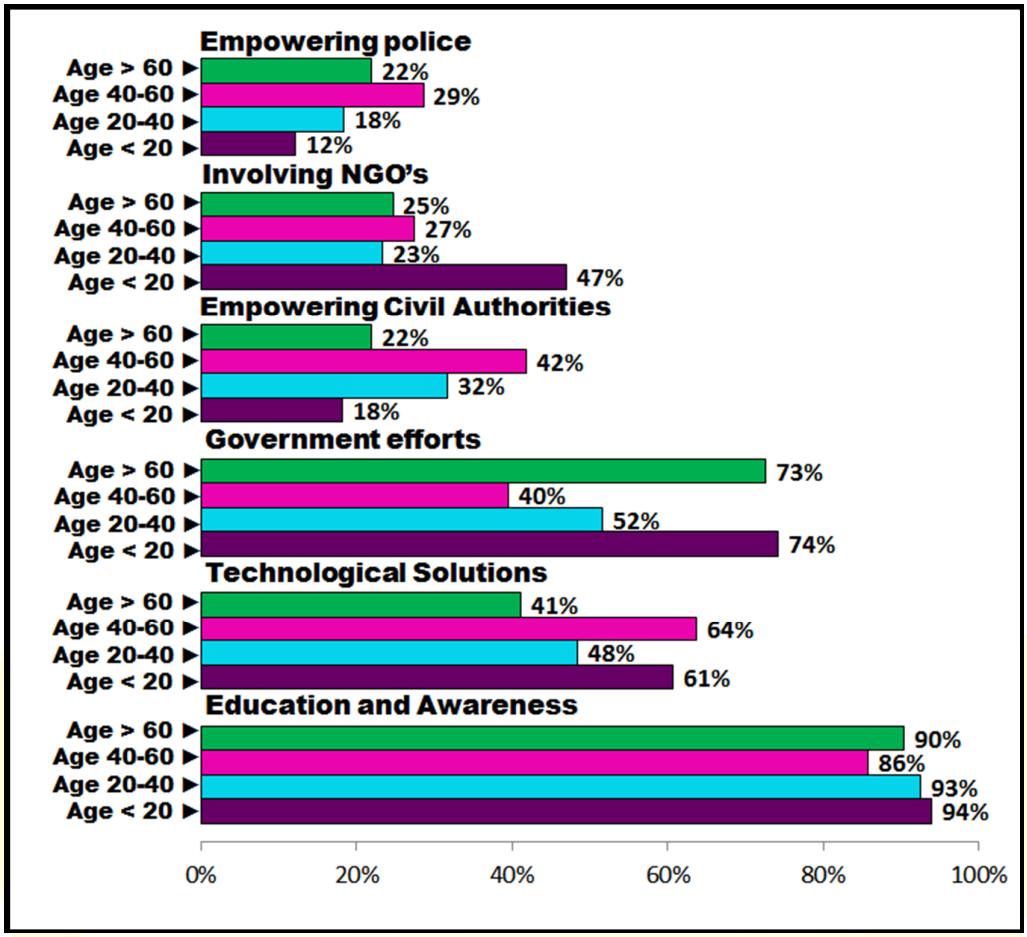


Figure-16 : Responses on suggestions to control noise by different age groups
Source: Authors' Work

6.7 Self-Initiative to control Noise Pollution

The respondents were asked to respond to question - Being a responsible citizen of India, have you taken any self-initiative contributing towards reduction of Noise Pollution (Yes / No).

Figure-17 & Figure-18 show the results of analysis of this survey on the basis of gender and age groups respectively. This analysis indicates that male population (64%) seems more responsible towards reduction of noise as compared to female population (55%), however the difference is not significant (only 9%).

In terms of age-group, we found that population of age-group 40-60 years (mature group of population) are highly responsible (78%) towards noise reduction. However only 36% of population of age-group > 60 years have shown their ability to take self-initiatives for noise reduction. Only 68% of population of age-group 20-40 was found interested to reduce noise level. A surprising result of this study is that only 48% of youngsters (up to 20 years) responded to participate in noise reduction self-initiatives. Thus, above results suggests a need motivating population of all age groups to take self-initiatives towards

noise reduction. It is a collective responsibility and every community member should contribute on different levels.

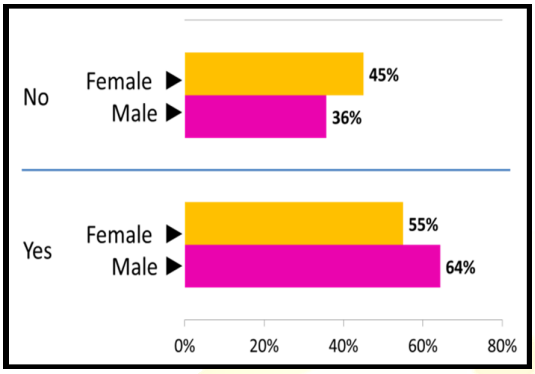


Figure-17 : Self-Initiative to control Noise Pollution based on Gender
Source: Authors' Work

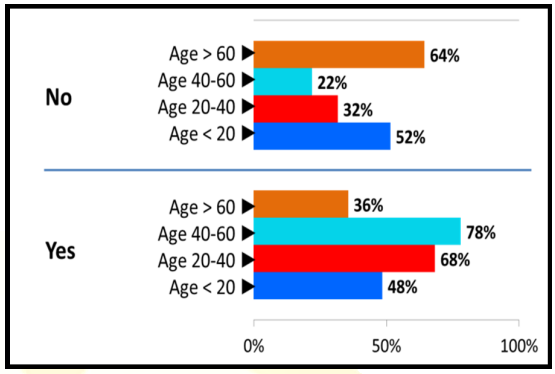


Figure-18 : Self-Initiative to control Noise Pollution based on Age Group
Source: Authors' Work

7. Conclusion

This study revealed that male community is more aware about the noise pollution compared to female community. However most of the community, especially in the metropolitan cities, is ignorant of what constitutes noise pollution as well as its adverse socio-economic & health impacts. The control of noise pollution has been hampered by insufficient knowledge of its harmful effects on human beings. Hence it is established that to curb the noise pollution, people should realise the harmful effects of noise pollution.

In India, noise exposure is increasing. In this study, it is established that traffic and loudspeakers sound as noise are major sources of outdoor noise pollutants. Primarily "traffic volume" expanded by road, rail and air traffic as a noise has gained wider recognition in terms of increasingly serious risk to human health. In case of indoor pollutants, television and different home appliances are turned out to be major noise sources. The examination showed that proportion of female's population as compared to proportion of males' population is almost same with respect to each sources of noise and hence %age variation between male and female population is not significant. In this study, it is important to note that even youngsters are also victim of noise at large scale.

This study also investigated that noise affects human in several ways and male & female population is equally susceptible to adverse effects of noise. Noise extensively results in annoyance, disturb sleep, harmful effect on hearing, reduce working efficiency and interfere with communication however sleep disturbance and annoyance, mostly related to road traffic noise, comprise the main burden of environmental noise.

Public awareness programmes, education and technological solutions appeared to be the best methods to achieve the goal of noise reduction as suggested by the respondents. However, government and NGOs can also play a significant role in putting efforts towards reduction of noise level by establishing & enforcing noise guidelines, standards and strict regulatory framework in the society. A substantial proportion of respondents among various age-groups suggested empowering police and local administration to control and monitor the effort of noise reduction.

8. Practical and Policy Implications

Noise is a complex phenomenon because its adverse effects can be cumulative with prolonged, continuous, or repeated exposure. Consequently, it is practically inevitable to monitor, predict, and analyze noise and evaluate its exposure-effects. The findings in this study have several policy implications.

- Government should develop management strategies and action plans for noise control. The empirical evidence gathered through this study can be employed for developing appropriate legal and public action programme.
- Awareness programs to disseminate knowledge about harmful effects of noise on human health and routine life.
- To regulate the industrial noise originating from machinery using sound enclosure and other technological advancements

9. Recommendations

Noise pollution is very harmful to human health. Preventive and control measures have been recommended in this section

- Education and creating awareness about noise pollution can be the starting point to deal with the underlying problems. Basic and essential information should be extensively disseminated, such as noise levels created by common sources of noise pollution, adverse health effects on both the person creating noise, and the public preventive measures and conditions punishable under law. Graphic displays in public places are a good medium to spread the message. School campaigns, health education programs, and publicizing through print and electronic media can actively address this issue.
- Ban on pressure horns, phasing out of three wheeler autos, maximization of use of electric vehicles and phasing out diesel and petrol vehicles. High elastic roads producing low noise during vehicles at high speed.
- Proper planning of roadways, considering their proximity to human settlements and use of green muffler (extensive plantation of trees on the roadsides) at wider scale.
- Noise attenuation by placing vegetations around buildings has also been recommended. Keep noisy machines way from bedroom and living areas.
- In industry setting, use of personal protective equipment (PPEs) such as ear muffs and ear plugs must be made mandatory. In case of machinery, assessing the root cause and the developing technological solution will deal with reducing noise level.
- Enactment of Policy, Rules and regulations can be another method to deal with it.
- Efficient engineering products, Encouraging use of noise-absorbent materials. Adequate noise barriers (technologically developed) around silence zones. Fitting silencers in car, motorcycles and truck to make their engines quieter.
- Good practices to prevent noise-induced ailments in children should be adopted.
- Monitoring of loudspeaker and generator sets to ensure compliance with prescribed rules. At a time when we are embarking on heavy urbanization and industrialization, we should not ignore regulating unwanted noise. It is good to see doctors take up the important role of environmentalists. The ENT (ear-nose-throat) specialists, doctors and

academicians must be part of the expert panel on noise pollution and must play the role of environmentalists for better regulations and control of noise.

Above all, awareness of the public and stakeholders is the key component in the prevention and control of community noise pollution. Involvement of non-governmental organizations in generating public interest and co-operation, and providing audiological facilities will immensely help the cause.

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