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Research Article

# Assessment of Noise Pollution in Hospitals along the Major Highways of Kathmandu and Lalitpur, Nepal

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## Abstract
Noise pollution in the hospital area is a significant problem that may cause patients to respond negatively in sever al ways. This study assessed the existing noise condition in 14 hospitals by monitoring noise levels within the hospital compound and at the roadside of the respective hospital. The sound pressure level was measured in A-weighting sound level meters in the morning (8:00 AM -11:00 AM) and in the evening (3:00 PM- 6:00 PM) at 10 seconds of the time interval during the high traffic flow period on working days. The study revealed that the Equivalent Sound Pressure level (Leq) value exceeded 60 dBA, in the morning and the evening at both sites surpassing the standard prescribed by WHO, USEPA, and GoN standards. There was no difference in the measured noise level ($L_{eq}$) in the morning and evening within the hospital compound at 95% confidence intervals. However, a significant difference was observed in the noise within the hospital compound and to the nearest road revealing that the compound wall within the hospital premises attenuates noise level. A survey conducted with 100 respondents revealed that 77% are aware of noise pollution and 79% identified vehicle noise as a major source of noise. The survey also revealed that they had health impacts due to traffic noise, 53% reported an increase in their temper, 45% reported sleep disturbances, 38% reported headaches, 36% complained of lacking concentration, 30% mentioned speech interference, and 6% complained of having chest pain. Hence the study shows that the patients in hospitals and people around are affected by noise pollution though the hospitals are declared as peace zones.

***Keywords***: Hospital premises, Kathmandu, Noise pollution, Sound pressure level, WHO.

## Introduction
Noise is defined as unwanted or excessive sound which is an undesirable by-product of our modern way of life. Noise pollution does not directly damage the environment; nonetheless, like other kinds of pollution, it can impair human health physically and psychologically either by causing permanent hearing damage or by reducing hearing efficiency in urban areas (UNEP, 2001). It can be annoying, can interfere with sleep, reduces work efficiency, disrupts concentration thus impacting performance in work or recreation, and in extremes may cause physical and psychological damage (NHRC, 2003; Durduran et al*.,* 2008; Pathak, 2008; Jadaan et al*.,* 2016).

Florence Nightingale recognized noise as a health hazard in 1859 when she mentioned "Unnecessary noise is the cruelest abuse of care which can be inflicted on either the sick or the well". After the issues gained floor in the public health sector, other research was carried out to study the potential negative impacts of noise pollution in hospitals. Some links have been observed between sleep disturbances, such as reduction of sleep depth, continuity, or duration, cardiovascular response, wound healing, pain management, and other patient responses due to hospital noise. Further, there is also growing concern for staff and visitors altering stress levels, performance impact on the job, and hearing loss due to exposure to high levels of noise settings (Hsu et al*.,* 2012). Further, unsuitable urban locations for some hospitals as well as noise generated from inside the ward's air-conditioning systems, medical devices such as respirators, and occupant sounds such as conversation, impulsive noises, or very loud, short-duration events, are also commonly found in hospitals (e.g., doors slamming, metal-to-metal contact, alarms) (Hsu et al*.,* 2012).

Noise levels in hospitals tend to increase in recent decades potentially causing serious negative effects on staff stress, satisfaction, psychosocial environment, job performance, and health (Ryherd et al*.,* 2008). Hospital noise is a serious issue linked to several potential negative reactions in patients has also been reported by (Hsu et al*.,* 2012). In general, sleep is fundamental to human health and critical to patient recovery. Furthermore, noise has also been reported as a primary cause of sleep deprivation and disturbance among patients (Cmiel et al*.,* 2004) which increases their anxiety by decreasing their confidence in the clinical competence of the staff. Technological advances in medicine have resulted in potentially harmful levels of sound pressure (Zannin & Ferraz, 2016; Gonzalez et al*.,* 2019).

Globally there are several studies on noise pollution in the hospital environment (Sobotova et al*.,* 2007; Durduran et al*.,* 2008; Juang et al*.,* 2010; Jadaan et al*.,* 2016; Zannin and Ferraz 2016; Montes-Gonzalez et al*.,* 2019) but all the studies reveal exceedance in noise limit

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for both day and night standard of the World Health Organization (WHO, 1999). However, such studies in sensitive zones like hospitals are limited in the context of Nepal. A case study conducted in a patient ward of Kirtipur and Bir Hospital of Nepal reveals that noise exceeded both national and international standards (Shrestha, 2016). Similarly, a study conducted in Siddharthanagar Municipality of Rupandehi district observed a noise level of 54.5 dB(A) at the Medical College area (Bhattarai, 2014), which also exceeds the national and international standards. The World Health Organization (WHO) suggests that sound levels should not exceed $L_{eq}$ 35 dB (A) in the daytime and $L_{eq}$ 30 dB (A) to $L_{max}$ 40 dB(A) at night in the hospital environment (WHO,1999). The United States Environmental Protection Agency (USEPA) also recommends daytime and nighttime sound levels of less than Leq 45 and 35 dB (A), respectively (USEPA, 1974). Nepal has set a standard of 50 dB (A) for day and 40 dB (A) for night at the peace zone.

Generally, most of the hospitals and health centers located in Kathmandu are found to have operated in and around the busy networks of transportation, and some of them are located even within less than 50 meters of the main road. As hospital areas are considered as one of the sensitive zones, noise pollution in and around the hospitals may cause serious health hazards (Andrade et al., 2021). Hence, they must be situated in a quiet place so that Medicare givers, patients, and staff can work in a peaceful environment. Therefore, this study has been conducted to investigate the extent and status of noise levels of the major hospitals that are located around the ring road of Kathmandu Valley, Nepal as well as to find out the effect of noise pollution on the people in and around the hospital environment. This study will serve as baseline information related to the noise level condition at the hospitals which may help the concerned authority (decision makers) to rethink before the construction of hospitals in such localities in the future.

## Materials and Methods

### Study Area

Kathmandu Valley, the capital city of Nepal, is a bowl-shaped valley, located at Latitudes 27°32′13″ and 27°49′10″ North and Longitudes 85°11′31″ and 85°31′38″ East. The climate varies from sub-tropical to temperate zone. The study was conducted in the spring season (March – April) under suitable meteorological conditions with no rain or wind to minimize the background noise error. The fourteen (14) major hospitals were selected along the main road and the ring road of Kathmandu Valley to check the noise level status (Fig. 1) simultaneously at two sites. The traffic volume survey was also carried out with the noise level measurement outside the hospital area. The total monitoring time for the data collection was 6 hours a day i.e., 8:00 AM – 11:00 AM and 3:00 PM - 6:00 PM, respectively at 10-second time intervals. The sound pressure level of hospital noise was measured in A-weighting sound pressure level with a sound level meter of TM-103 and TM-107 respectively. The meter was mounted on a stand at a height of 1.25 meters above the ground level at both sites. The sound pressure level meter's instrumentation, calibration, and sensitivity have been done following the manufacturer's recommended process.

### Calculation Method

Equivalent noise level (Leq) is the steady sound pressure level, which has the same total energy as the actual fluctuating noise, over a given period. Since the measurement begins and ends in the background noise, the resulting Leq depends on the measurement period. In contrast, the Sound Exposure Level (SEL) is important as it eliminates the influence of the measurement duration. The Equivalent Continuous Sound Level (Leq), noise pollution level (NPL), and Traffic Noise Index (TNI) of each station are obtained with the following formulas:

$$L_{Aeq} = 10 \log [1/T (10^{L_1}/10 + 10^{L_2}/10 \ldots\ldots\ldots\ldots + 10^{L_n}/10)] \ldots\ldots (1)$$

Where,

$L_{Aeq}$ is equivalent A-weighted sound pressure level in decibels (dB)

T=total or actual time
n=number of events
L=noise level in dB

Total annoyance caused by noise level was estimated using the noise pollution level index (NPL)

$$L_{NP} = L_{eq} + k\sigma \ldots\ldots\ldots\ldots \text{(ii)}$$ (Robinson, 1971; Joshi et al., 2015)

Where $L_{eq}$ is the equivalent noise level measured in dBA and "k" is a constant which is provisionally given the value 2.56, and "$\sigma$ is the standard deviation of instantaneous sound levels in time. This measurement system applies to any environment, unlike those specifically concerned with aircraft and traffic.

$$\text{Traffic Noise Index (TNI)} = 4 (L_{10}-L_{90}) + (L_{90} - 30) \quad \text{(iii)}$$ (Langdon and Scholes, 1968)

Where, $L_{10}$: A-weighted Decibel levels exceeded 10% of the time; $L_{90}$: A-weighted Decibel levels exceeded 90% of the time.

The measured equivalent noise level (Leq) data are then mapped in a GIS with the noise value as point data.

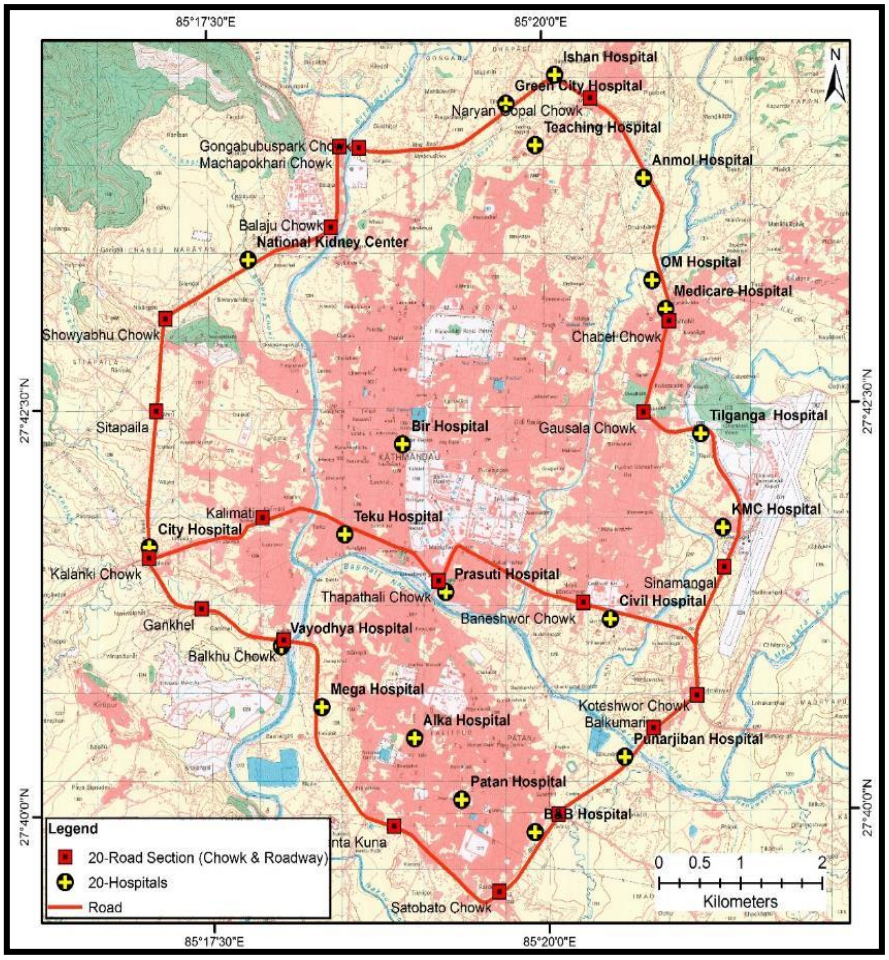


**Figure 1.** Study area along with the sampling sites

### Questionnaire survey

A survey was conducted in and around the hospital area using a structured questionnaire to understand the public's opinion regarding the effect of noise on their daily life. The major focus of this survey was to know the awareness related to noise pollution, its sources, and its health effects. In total, a hundred respondents were selected randomly to use the questionnaire including people walking near the hospital, staff of the hospital, and visitors. Twenty respondents were selected from each hospital. Prior consent was taken with the selected respondents.

### Hypothesis Setting

The t-test hypothesis was applied for the morning and the evening noise level data assuming that the two means are equal. Similarly, same t-test statistic was applied to the various noise descriptor such as equivalent noise level (Leq), the sound level in dB that exceeded 10% of the time over measurement period ($L_{10}$), the sound level in dB that exceeded 50% of the time over measurement period ($L_{50}$) and sound level in dB that exceeded 90% of the time over measurement period ($L_{90}$) Minimum Sound Level ($L_{min}$), Maximum Sound Level ($L_{max}$) at 5 % level of significance. Further, two-tailed test was applied to check the significant difference between the noise level at the two sites of the hospital compound.

## Results and Discussion

### Status of noise pollution based on noise descriptors within the hospital compound in the morning

The various noise descriptors along with the distance of the hospital from the road have been measured to study the status of noise pollution as depicted in Table 1. Among the fourteen hospitals surveyed, the noise level indices were found to vary (Table 1). Various noise descriptors such as Leq, Lmax, and Lmin, reveal that people residing within the hospital areas as well as people within the hospital areas might have suffered from slightly uncomfortable feelings to a position of noise annoyance.

Similarly, noise descriptors like noise pollution level (NPL), which takes account of the variations in the sound signal, thus serving as a better indicator of pollution in the environment, is found to be the maximum at Medicare (84 dBA) and minimum at Civil hospital (67.7 dBA). Likewise, the Traffic Noise Index

(TNI) was also found to be maximum at Medicare hospitals (75.3 dBA), while the minimum was found to be at Green City Hospital (61.2 dBA) (Table 1, Fig. 2). These values of TNI indicate that there was annoyance in hospital areas due to traffic noise (Griffiths and Langdon, 1968). At all the hospitals of the Kathmandu valley, both TNI and NPL (Fig. 2) exceeded the noise level standard of 60 dBA (Banerjee, 2009). However, among all the hospitals the highest equivalent sound pressure level (Leq) was recorded at Global Hospital and the lowest at Punarjivan Hospital at both times (Fig. 3) At all the hospital's locations, the Leq value exceeded 60 dBA at different time zones as shown in Fig. 3 indicating the exceedance limit at the sensitive zone as per the Government of Nepal (CBS, 2019) as well as WHO standards.

**Table 1.** Noise descriptors at the hospital compound (in dBA)

| SN. | Hospitals | Lat. | Long. | Leq | Lmax | Lmin | TNI | NPL | Distance of hospital from the road |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Punarjiban | 85.34 | 27.67 | 60.8 | 77.5 | 49.5 | 63.3 | 69.5 | 36.0 |
| 2 | Mega | 85.30 | 27.67 | 69.8 | 92.5 | 55.3 | 67.0 | 76.0 | 27.0 |
| 3 | Green city | 85.32 | 27.73 | 70.9 | 93.3 | 58.2 | 61.2 | 73.7 | 20.0 |
| 4 | Global | 85.33 | 27.66 | 76.5 | 102.1 | 57.5 | 73.8 | 80.8 | 20.0 |
| 5 | Sahid Memorial | 85.28 | 27.69 | 65.5 | 86.4 | 54.1 | 64.6 | 71.4 | 40.0 |
| 6 | Medicare | 85.34 | 27.71 | 75.3 | 92.9 | 60.6 | 75.4 | 84.0 | 30.0 |
| 7 | National kidney center | 85.29 | 27.72 | 64.1 | 81.7 | 51.2 | 71.8 | 73.7 | 30.0 |
| 8 | Tilganga | 85.34 | 27.70 | 73.2 | 86.3 | 62.2 | 73.2 | 79.6 | 44.0 |
| 9 | Teaching | 85.33 | 27.73 | 65.9 | 82.2 | 55.1 | 67.7 | 74.5 | 66.0 |
| 10 | Maternity | 85.31 | 27.68 | 68.1 | 90.2 | 53.4 | 66.6 | 72.0 | 22.0 |
| 11 | Civil | 85.33 | 27.68 | 61.6 | 75.6 | 53.8 | 56.0 | 67.8 | 50.0 |
| 12 | Bir | 85.31 | 27.70 | 70.4 | 85.9 | 63.4 | 63.1 | 76.5 | 15.0 |
| 13 | Teku | 85.30 | 27.69 | 64.1 | 81.9 | 49.0 | 74.0 | 74.7 | 25.0 |
| 14 | Alka | 85.31 | 27.67 | 69.5 | 86.1 | 59.0 | 71.4 | 77.1 | 30.0 |

*Source: Field Survey, 2017*

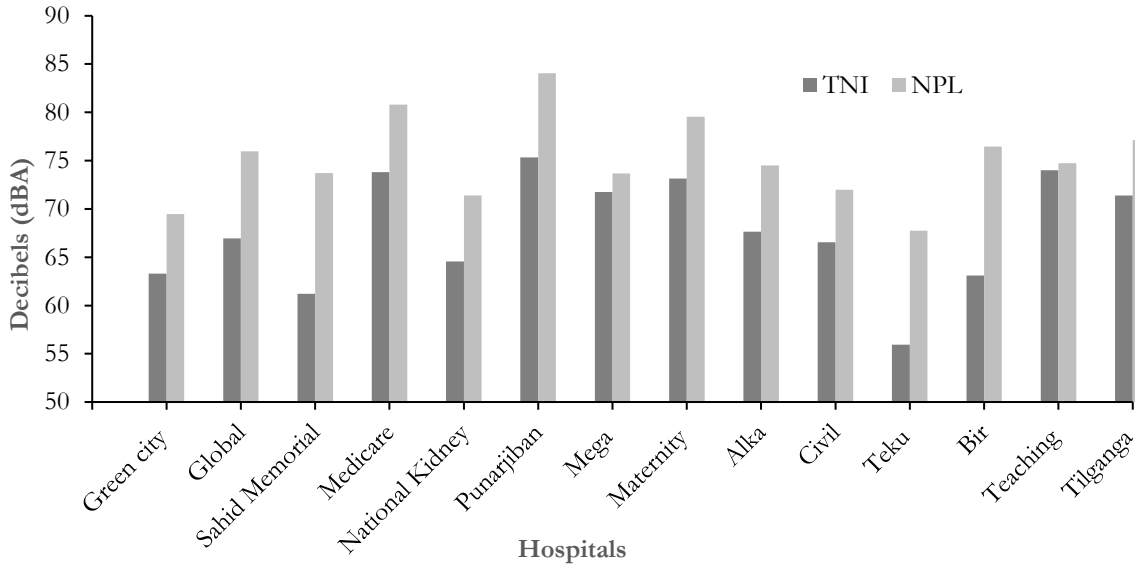


**Figure 2.** Comparison of Traffic Noise Index (TNI) and Noise Pollution Level (NPL) at the hospital compound in the morning

Further, the maximum sound level (Lmax) was observed to be highest (102 dBA) at Global Hospital and the minimum sound level (Lmax) was found to be 77.5 dBA at Punarjivan Hospital. Similarly, the minimum sound level (Lmin) was observed to be highest at Bir Hospital (63.4 dBA) and the lowest was 48.9 dBA at Teku Hospital (Table 1, Fig. 4).

**Statistical analysis**

The Leq in the morning (Mean = 67.40, SD=4.67, n = 14) was hypothesized to be equal to the Leq in the evening (Mean = 69.08, SD=5.89, n=14) in such case as the null hypothesis is accepted at 5% level of significance ($\alpha_{0.05}$), indicates that there is no difference in the noise level in the morning and evening data within the hospital compound. Likewise, the hypothesis was also accepted for Lmax and Lmin in the morning and in the evening at 5% level of significance ($\alpha_{0.05}$), t (26) = 0.37 and t-critical = 2.05, p-value = 0.71 (two-tailed test) indicating there is no difference in maximum and minimum noise levels at the respective sites.

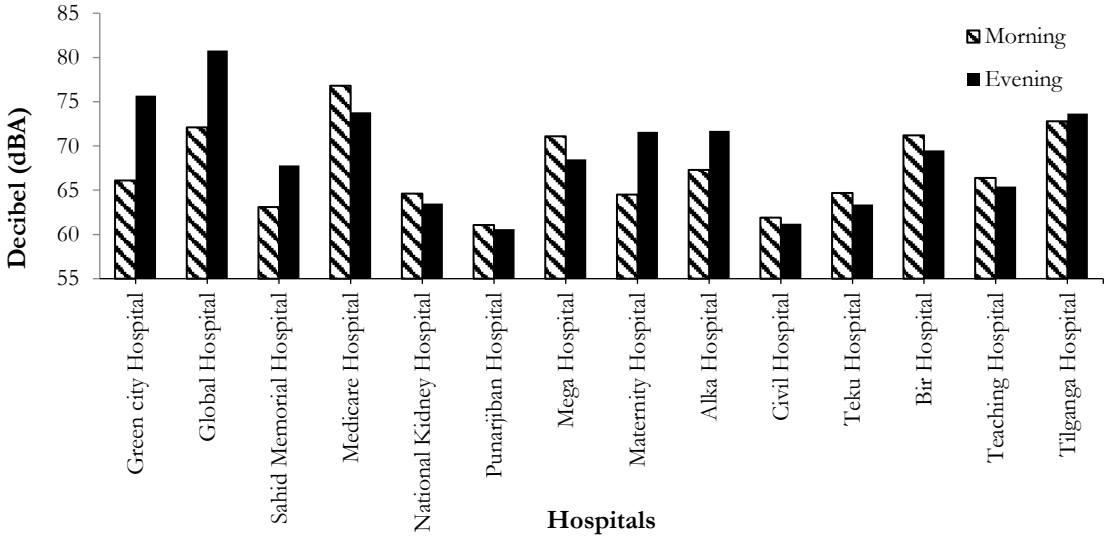


**Figure 3.** Equivalent Sound Level (dBA) in Hospitals in the Morning and Evening

Paired t-test was performed assuming a mean of noise level inside the hospital compound and the nearest road to the hospital are equal in the morning as well as in the evening. The null hypothesis was rejected with p=0.00012 ( alpha = 0.05) in the morning and with a p-value of 0.005 revealing there is a significant difference in the noise at both sites during the specified time of the measurement period. This indicates that compound wall has some influence on attenuation of the noise level in the hospital premises.

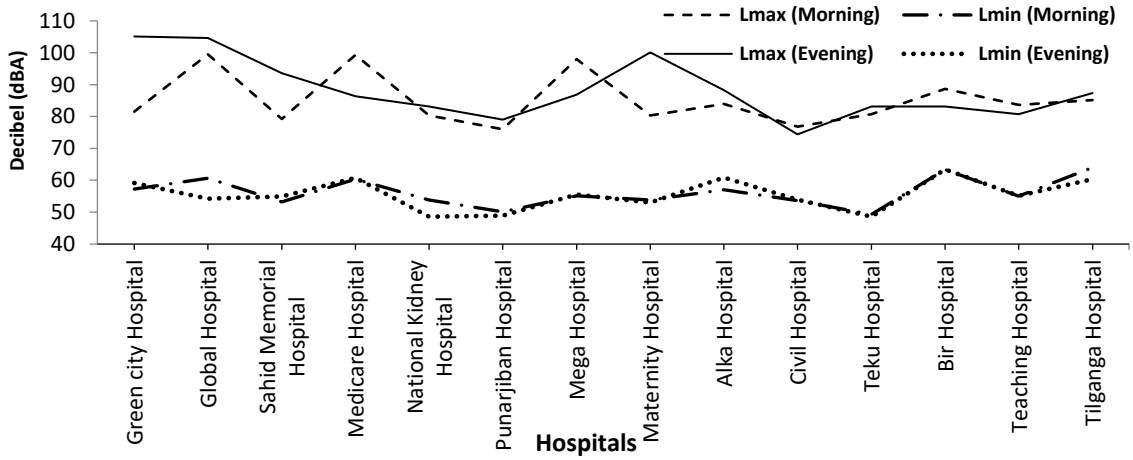


**Figure 4.** Maximum and minimum sound levels (dBA) at hospital compound

Overall noise pollution level in the hospitals was found to be in the range of 67.75 dBA to 84.04 dBA, which can be considered higher as compared to Nepal's noise pollution standard (CBS, 2019). Such a higher noise level surpassing the noise limit has also been observed by Bhattarai (2014) and Shrestha (2016) in the hospital

environment of Nepal. Similarly, at the hospitals in Baghdad, Jaleel (2014) and Rahman (2016) also observed that the daily average sound level measured inside the hospitals at Mymensingh Sadar Upazila, district of Bangladesh in Dhaka is beyond the permissible limit of WHO. Further, different researchers (Sobotova et al., 2007; Durduran et al., 2008; Juang et al., 2010; Jadaan et al., 2016; Zannin and Ferraz, 2016) also observed maximum sound levels at the hospital's premises in Slovakia, Turkey, Taiwan, Jordan, and Curitiba cities respectively. These research studies indicate that the sound level recorded in hospitals of various countries significantly exceeded the recommendations made by the WHO and USEPA as well as local regulations indicating a high level of annoyance (Khaiwal et al., 2016; Montes-Gonzalez et al., 2019; Zannin & Ferraz, 2016).

Excessive noise levels in the nation's cities have been reported to have a negative impact on people's health and productivity. Results demonstrated that the exposed group (above the 55 dBA sound pressure level) had more cases of noise-induced hearing loss than the non-exposed group (above the 55 dBA sound pressure level). Comparably, the audiogram and medical examination results of the Kupandole area residents, both the exposed and non-exposed groups, show that the exposed groups had noise-induced hearing loss 4.25 times higher than the non-exposed groups. According to the study's findings, road noise was the main factor contributing to people's increased noise levels (NHRC, 2003). This conclusion is supported by a survey conducted by Bhattarai and Sapkota (2014) that demonstrated a comparable health effect on human health due to aircraft noise. Similarly, Carter and Rauniyar (2011) suggested that all traffic police should implement a hearing protection program as noise levels varied from 70 to 120 dBA in high-density traffic areas on and inside the Ring Road.

As the noise level is so alarming in sensitive areas like hospitals that are expected to increase rather than decrease, the situation should be taken control with immediate appropriate measures of noise reduction. Otherwise, we wouldn't be able to predict how the noise level will affect patients and visitors to the hospital in the future. A widely accepted scientific fact is that living in "black acoustics zones" where the equivalent sound level is higher than 65 dBA, puts an urban population in a high-risk category for numerous noise subjective effects, including psychological, sleep, and behavioral disorders (Belojevaie et al., 1997; Maschke, 1999).

Noise-induced hearing loss (NIHL) is one of the significant health problems among workers exposed to prolonged high noise. Similar cases have been reported by Barbosa and Cardoso (2005) in a study conducted in the City of São Paulo, Brazil indicating 28.5% had suspected noise-induced hearing loss on audiometric assessment. Their studies also reveal that those working in noisier areas were more affected (38.8%) than those in areas with lower noise levels (24.2%). Similarly, Siddiqui et al. (2015) studied the effect of road traffic noise on human beings in busy places in Karachi, Pakistan, which also suggested that traffic authorities should initiate to take measures to reduce the noise levels in the noisy places of the city as they found the direct link between NIHL and duration of exposure to noise above permissible levels. In Nepal, Joshi (2003) reported that environmental noise-induced hearing loss in the majority of cities in Nepal. Besides NIHL, different authors have reported noise as a primary cause of sleep deprivation and disturbance among patients (Cmiel et al., 2004; Cunha and RN, 2015; Jaddan et al., 2016).

**Status of noise pollution based on noise descriptors outside the hospital compound in the morning.**

The noise level status outside the hospital compound based on noise descriptors has been pr presented in Table 2.

**Table 2.** Noise level indices (dBA) outside the hospital on the roadways in the morning

| S.N | Stations | Long | Lat | Leq | Maximu | Minimum | TNI | NPL |
|---|---|---|---|---|---|---|---|---|
| 1 | Punarjiban | 85.34 | 27.67 | 75.30 | 92.80 | 66.15 | 83.95 | 86.30 |
| 2 | Mega | 85.30 | 27.68 | 73.80 | 92.80 | 62.90 | 71.50 | 80.98 |
| 3 | Greencity | 85.32 | 27.74 | 72.25 | 92.80 | 58.65 | 74.50 | 81.14 |
| 4 | Global | 85.33 | 27.67 | 89.65 | 92.80 | 66.85 | 120.60 | 105.63 |
| 5 | Sahid Memorial | 85.28 | 27.69 | 79.25 | 92.80 | 57.70 | 113.05 | 98.13 |
| 6 | Medicare | 85.35 | 27.72 | 76.75 | 92.80 | 64.35 | 78.55 | 84.88 |
| 7 | National kidney center | 85.30 | 27.72 | 71.70 | 92.80 | 58.65 | 68.10 | 78.62 |
| 8 | Tilganga | 85.35 | 27.71 | 73.65 | 95.90 | 60.70 | 73.60 | 80.18 |
| 9 | Teaching | 85.33 | 27.73 | 74.75 | 84.55 | 62.85 | 73.40 | 81.89 |
| 10 | Maternity | 85.32 | 27.69 | 70.60 | 102.90 | 55.95 | 80.45 | 82.70 |
| 11 | Civil | 85.34 | 27.69 | 76.85 | 99.60 | 58.05 | 83.15 | 83.21 |
| 12 | Bir | 85.31 | 27.71 | 76.40 | 92.45 | 63.00 | 75.25 | 83.79 |
| 13 | Teku | 85.31 | 27.70 | 69.85 | 90.70 | 55.30 | 67.00 | 75.98 |
| 14 | Alka | 85.32 | 27.67 | 74.75 | 97.25 | 64.35 | 68.40 | 81.29 |

*Source: Field Survey, 2017*

The maximum value of Leq was also found to be 89.65 dBA outside the hospital premises at the Global Hospital and the minimum at Teku Hospital was 69.85 dBA. The maximum and minimum sound observed outside of the hospitals was 102.90 dBA at Maternity Hospital and 55.30 dBA at Teku Hospital as presented in Table 2. Similarly, the maximum and minimum traffic noise index (TNI) were noted for Global Hospital and Teku Hospital as 120.60 dBA and 67.0 dBA respectively. The TNI in the present study was used to determine the noise pollution level (NPL). The NPL of 105.63 dBA was recorded maximum at Global Hospital and the minimum noise pollution level was recorded as 75.98 dBA at Teku Hospital. It is apparent from Table 2 that the noise pollution level among the 14 hospitals surveyed was found to be in the range between 76 dBA – 106 dBA outside of the hospital premises. According to the results of the current study, the noise pollution index (NPL) was a better indicator of environmental pollution for both the physical and psychological effects of traffic noise on people.

The noise pollution level (NPL) measured at 14 hospital compounds, presented in Table 2, was found to be in the range between 84.04 dB – 67.75 dB(A). The highest NPL was observed at the compound of Medicare Hospital and the lowest NPL was recorded at Civil Hospital (Table 2). Leq was found to be maximum at Global Hospital which was recorded as 76.45 dB(A) and minimum Leq was found in Punarjivan Hospital which was recorded as the value of 60.83 dB(A) as shown in Table 2. This observation indicates that the noise generated by traffic vehicles was quite high, which might be due to the roadways nearby. A study carried out by Chen et al. (2009) on noise levels in the lobbies of 11 hospitals in the central part of Taiwan found that noise levels averaged from 60 dB(A) to 65 dB(A). Similarly, a study conducted in a 222-bed hospital in Parana, a state of Brazil, found a mean value of 63.7 dB(A), which exceeds the maximum allowed values agree with the World Health Organization (1993) that recommends a noise level up to 40 dB(A) for the day shift and 35dB(A) for the night shift in hospitals (Otenio et al., 2007).

**Perception of the Impact of Noise Pollution Based on Questionnaire Survey**

The noise survey of 100 respondents at hospital premises revealed that about 77% of them were aware of noise and 63% of them agreed noise is environmental pollution. Similarly, about 84% of respondents answered that their health has been affected including social impacts due to road traffic noise. The major source of traffic noise has been identified as vehicle noise by 79% of the people followed by a crowd of people (67%) and due to construction and demolition noise activities, as reported by 55% of people (Fig. 5). The present study also revealed that they had health impacts due to traffic noise, causing an increase in the temper, as reported by 53% of people, 45% of people admitted having problem of sleep disturbances, while 38% of people mentioned experiencing headaches and 36% of them complained of lacking concentration and 30% of people mentioned of speech interference whereas 6% of people complaint of having chest pain (Fig. 6).

Similarly, a study led by Khaiwal et al. (2016) concluded that almost all the respondents (97%) regarded traffic as the major source of noise in the hospitals of North India. Kadel et al. (2003) also reported mental health problems (96.6%) caused by highly noisy areas of the Kathmandu Valley. They selected 100 people from noisy sites of Kathmandu Valley to find out the mental health impact of traffic noise on public health. Mental health problems were found to be in 96.6% of people from highly noisy sites, 88.9% from moderately noisy sites, and 38% from low noisy sites. Some kind of mental health problems were reported from highly noisy sites such as 60% felt unhappy and depressed, 69% of them felt constantly under stress, 56% were unable to face their problem and felt incapable of making their decisions, and 52% of people lost their sleep, felt unreasonably happy, unable to enjoy day-to-day activities, lost confidence and think themselves as worthless people. Thus, it is concluded that this relation of mental health due to traffic noise might cause a huge impact of noise pollution on public health in Kathmandu city for which a detailed investigation is necessary.

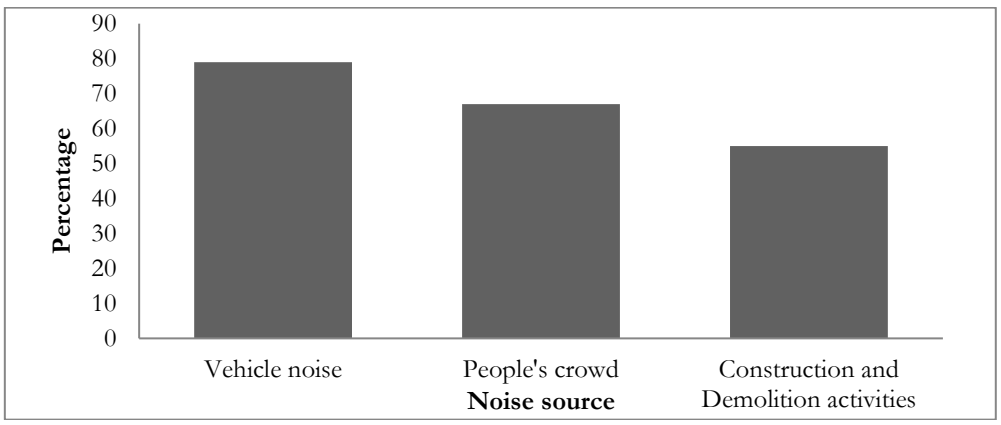


**Figure 5.** Source of noise in the study area

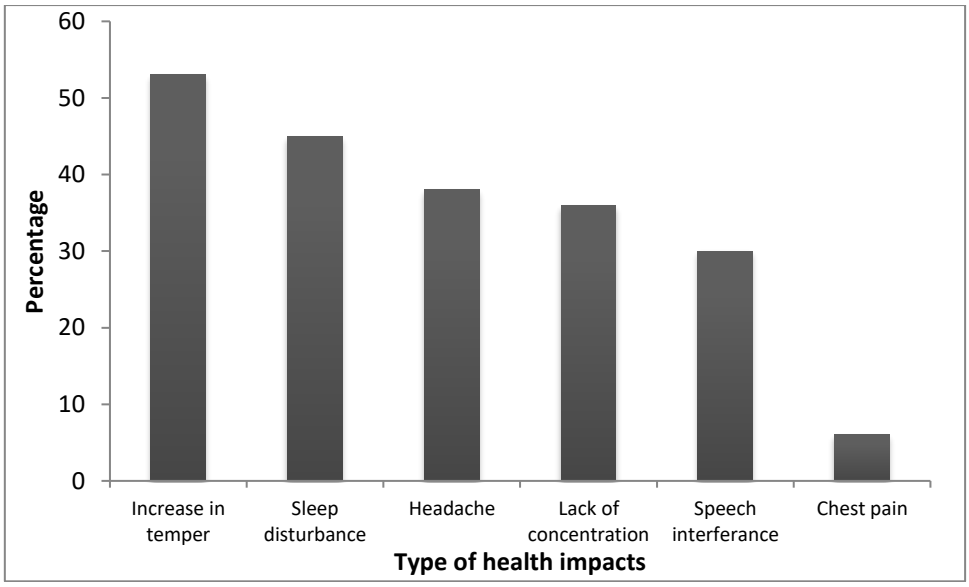


**Figure 6.** Health impacts due to traffic noise

Noise pollution in urban areas is one of the growing concerns, not only in Nepal but also worldwide because of the rapidly increasing advancement of science and technology together with industrialization, urbanization, and commercialization. Most of the respondents through questionnaire survey also revealed that traffic noise has caused various health impacts and to mitigate such adverse impact of noise pollution on health they have suggested setting up rules and regulations in the country to control noise, planting trees on both sides of the roads, restriction of horns, removing noisy and old vehicles, enclosing the noise source which produces much noise from the device, increase public awareness about the effect of traffic noise on public health, improvement of road conditions and parking system as well as marking of the silent zone for hospitals.

## Conclusions

This study has been conducted to investigate the extent and status of noise levels of fourteen hospitals located around the ring road of Kathmandu Valley, Nepal, and find out the effect of noise pollution on the patients and residents around hospitals. Among all the surveyed hospitals the highest sound pressure level (Lmax) of 102.1 dBA was observed at the Global Hospital, while the lowest sound pressure level (Lmax) of 75.5 dBA was observed at the Punarjiban Hospital. The equivalent sound pressure level (Leq) both at the hospital's compound and outside the hospital was found to be above the noise level standard prescribed by the Government of Nepal and WHO. Statistically, there was no significant difference between the noise levels measured in the morning and in the evening. However, significant differences in noise levels within and outside the hospital compound revealed that the wall of the hospital compound could be an effective barrier in reducing the noise level. Hence the distance of the hospital from the road could be one of the solutions to reduce the noise level in such sensitive areas.

The questionnaire survey identified that vehicle noise is a major source of traffic noise followed by a crowd of people and construction and demolition noise. The study also revealed that traffic noise causes health impacts such as an increase in the temper, problem of sleep disturbances, headaches, lacking concentration, speech interference, and chest pain.

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**Author Contributions:** RS conceptualized, performed fieldwork, and wrote the first draft of the manuscript. SPK contributed to data curation, and review of the draft; AJ edited the manuscript and proofread; AL performed the statistical analysis and proofread the article.

**Conflict of Interest:** The authors declare no conflict of interests.

**Data Availability Statement:** The data supporting this study's findings are available from the corresponding author, upon reasonable request.

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