

# Assessment of noise levels in 200 Mosques in Riyadh, Saudi Arabia

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## ABSTRACT

**Introduction:** Noise-induced hearing loss (NIHL) is a recognized concern within the context of occupational and general health. However, noise levels are seldom studied at nonworkplace and nonabode sites that are visited regularly, e.g., places of worship. The purpose of this study was to assess the noise levels inside and outside of mosque prayer rooms and to compare the levels with established noise tolerance limits. **Materials and Methods:** A portable digital sound level meter was used to determine the noise level (measured in dB) inside and outside of mosque prayer rooms. The highest (peak) and lowest noise levels from each recording were tabulated. Statistical analysis was performed using a two-tailed Student's *t*-test ( $\alpha = 0.05$ ). **Results:** Noise levels were measured at 200 mosque prayer rooms from all 15 municipal districts of Riyadh, Saudi Arabia. Of these, 151 prayer rooms (75.5%) had both inside and outside noise measurements and the remaining 49 prayer rooms (24.5%) had only inside noise measurements. There was significantly greater noise outside compared to inside the prayer rooms, for both the highest noise level (outside:  $87.8 \pm 4.8$  dB compared to inside:  $85.8 \pm 5.4$  dB,  $P < 0.0001$ ) and lowest noise level (outside:  $58.4 \pm 3.8$  dB compared to inside:  $56.6 \pm 3.6$  dB,  $P < 0.00001$ ). In all, 112 of the inside highest level measurements (56%) and 113 of the outside highest level measurements (74.8%) were greater than 85 dB, the sound level at which NIHL has been shown to occur in occupational settings. **Conclusion:** A large proportion (56%) of mosque prayer rooms with inside peak noise measurements were above acceptable levels (85 dB), however, prayers certainly do not last for 8 continuous hours. Therefore, the level of noise at mosques is acceptable and in compliance with international norms of hearing safety; moreover, it does not present any risk to hearing in the long run.

**Key words:** Acoustics, hearing loss, mosque, noise, Riyadh, Saudi Arabia

## INTRODUCTION

Noise-induced hearing loss (NIHL) is a recognized concern within the context of occupational and general health. However, noise levels are seldom studied at nonworkplace and nonabode sites that are visited regularly, e.g., places of worship. For example, in 2005 and 2009, Galindo *et al.* studied the acoustic properties of Mudejar-Gothic churches in Spain.<sup>[1,2]</sup> In 1990, Hammad used the speech transmission index (STI) method to assess speech intelligibility in mosques in Amman, Jordan.<sup>[3]</sup> In 1995, El Bashir and Al-Gunaimi reported on the acoustical performance of a “typical mosque” in the Middle East.<sup>[4]</sup> In 1996, Khaiyat

described mosque architecture as it pertains to the acoustical environment.<sup>[5]</sup> In 2003, Abdou measured acoustics of 21 architecturally representative mosques in Saudi Arabia using the STI,<sup>[6]</sup> concluding that the acoustical quality deviated more from the optimum conditions when there were no worshipers (unoccupied) compared to when there were worshipers inside (occupied).

Based on noise exposure over a 40-year working lifetime, the increased risk of NIHL has been estimated at 0–5%, 10–15%, and 21–29% for average daily noise levels of 80, 85, and 90 dB, respectively.<sup>[7]</sup> In addition, occupational noise exposure has been causally linked to adverse health outcomes. For

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example, there is sufficient data to suggest that noise levels above 55 dB (office setting) and 85 dB (industry setting) cause annoyance; 55–116 dB cause hypertension; and 75 dB (adults) and 85 dB (fetuses) cause hearing loss.<sup>[8,9]</sup> There is also limited data to suggest that high noise levels can have an adverse impact on performance, biochemical processes, the immune system, and birth weight.<sup>[8,9]</sup> The purpose of this study was to assess the noise levels inside and outside of mosque prayer rooms and to compare the levels with established noise tolerance limits.

## MATERIALS AND METHODS

A portable digital sound level meter (model AR824, Shenzhen Arco Science and Technology Ltd., Guangdong, China) was used to determine the noise level (measured in dB) inside and outside of mosque prayer rooms. Measurements were obtained by two trained postsecondary students.

The highest (peak) noise level was defined as the maximum noise from a 3-minute recording obtained during recitation of the Qur'an. The lowest noise level was defined as the minimum noise from a 3-minute recording obtained when there was no recitation of the Qur'an, during which time the worshippers were most quiet. Indoor noise levels were recorded from the last row of each prayer room. Outdoor noise levels were recorded from the yard of the mosque.

Statistical analysis was performed using a two-tailed Student's *t*-test ( $\alpha = 0.05$ ).

## RESULTS

Between September and October 2007, noise levels were measured at 200 mosque prayer rooms from all 15 municipal districts of Riyadh, Saudi Arabia. Of these, 151 prayer rooms (75.5%) had both inside and outside noise measurements and the remaining 49 prayer rooms (24.5%) had only inside noise measurements. Each prayer room had 200–300 worshippers.

There was significantly greater noise outside compared to inside the prayer rooms, for both the highest noise level (outside:  $87.8 \pm 4.8$  dB compared to inside:  $85.8 \pm 5.4$  dB,  $P < 0.0001$ ) and lowest noise level (outside:  $58.4 \pm 3.8$  dB compared to inside:  $56.6 \pm 3.6$  dB,  $P < 0.00001$ ). Figure 1 presents a histogram of peak noise levels inside and outside the prayer rooms. In all, 112 of the inside highest level measurements (56%) and 113 of the outside highest level measurements (74.8%) were greater than 85 dB, the sound level at which NIHL has been shown to occur in occupational settings.

## DISCUSSION

Approximately 10 million of the 40 million hearing impaired Americans are suffering from NIHL. The term "noise" indicates unwanted sound. Noise is defined as "fluctuations in the pressure of air (or other media) which affect the human body. Vibrations that are detected by the human ear are classified as sound."<sup>[10]</sup> Noise-induced hearing loss occurs when a person is exposed to harmful levels of sound that damage hearing capacity for the long term. Short-term loss of hearing which is easily reversed by discontinuation of noise or after resting the ears (no exposure to sounds greater than 70 dB for 24 hours) is not considered NIHL.

The healthy human ear can hear frequencies ranging from 20 to 20,000 Hz. Noise damages the tiny hair cells located inside the cochlea. These cells react to mechanical sound vibrations by transferring electrical signals to the auditory nerves. Different sets of hair cells are in control for different frequencies (rate of vibrations). Noise eventually damages or breaks the hair-like stereocilia of the hair cells in the high-frequency area of the cochlea resulting in hearing loss.<sup>[10]</sup>

### Levels of noise

While temperature is recorded in degrees Fahrenheit, sound pressure is measured in decibels (dB) and can have both positive and negative values. As various people's ears vary in their degree of susceptibility to noise, sound exposure levels that are easily accepted by some may cause damage in others [Table 1].

As indicated above, a sound over and above 85 dB can cause permanent damage to hearing or NIHL. NIHL occurs due to numerous factors such as one-time exposure to loud sound (a sudden burst of fire crackers or an explosion) or repeated exposure to noise over an extended period of time (listening

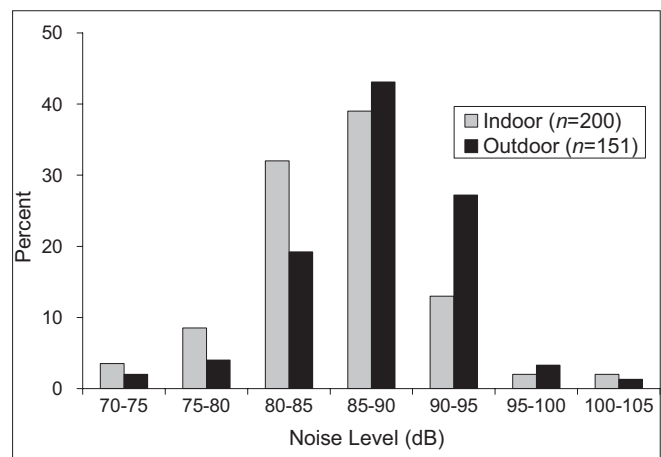


Figure 1: Histograms of mosques' indoor and outdoor peak noise levels

**Table 1: Listing of some common sounds, their measurements, and potential risk to hearing**

Sound	Noise level (dB)	Risk
Normal conversation	60	Not loud enough to cause damage
Bulldozer that is idling	85	Loud enough to cause damage after only 1 work day (8 hours)
Music on earphones at a standard volume level 5	100	Loud enough to cause damage after 15 minutes per day
Clap of thunder	120	Immediate damage
Gunshot	140–190	Immediate damage

**Table 2: Lists the maximum recommended noise dose exposure levels as recommended by the NIOSH**

Noise level (dB)	Maximum exposure time per 24 hours
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7.5 minutes
106	3.7 minutes
109	112 seconds
112	56 seconds
115	28 seconds
118	14 seconds
121	7 seconds
124	3 seconds
127	1 second
130–140	Less than 1 second
140	No Exposure

Source: (NIOSH, 1998)<sup>[11]</sup>

to loud music for long periods). The amount of time levels of noise to which a person is exposed affects the degree of hearing damage caused. Quieter sounds can be listened to safely for long periods of time; however, exposure to higher levels of noise for extended periods can cause permanent damage. Table 2 lists the maximum recommended noise dose exposure levels as recommended by the NIOSH.

Each line by itself represents 100% of the permissible noise dose per 24-hour day. Viz. if a person has already been exposed for 15 minutes to noise levels of 100 dB, they have reached the limit of acceptable exposure to loud noise. The person should exercise caution and avoid exposure to sounds above 85 dB, and should if possible be below 70 dB for the remainder of the day in order to avoid NIHL.

### Noise and Worship

Many religious activities include music or loud sounds which have the potential to harm hearing. For instance, singing of hymns and organ music at churches or recitation of Quran verses and Azaan (call to prayer) at mosques all generate high levels of noise. Noise generation at places of worship is a sensitive issue wherein it is necessary to examine its occurrence and relevance to hearing safety. There have been numerous concerns that the level of noise at mosques is unacceptable and harmful to hearing following which a

study of noise at mosques was executed with the following results.

## CONCLUSION

Hearing safety is related to both sound level and duration of hearing exposure. The limit set by the NIOSH is 85 dB of continuous exposure for 8-hours. It has been noted that if a discontinuation of noise relieves any temporary hearing loss or problems (ringing in the ears, muted everyday sounds, etc.), then such problems are not indicative of any permanent damage or NIHL. Prayers or religious gatherings certainly do not last for 8 continuous hours. Further, neither worshippers nor workers/Imam at the mosque are exposed to high levels of sound for an extended period thus negating any possibility of NIHL. Therefore, the level of noise at mosques is acceptable and in compliance with international norms of hearing safety. Moreover it does not present any risk to hearing in the long run.

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