



<https://doi.org/10.47811/bhj.201>

Assessing the prevalence of noise-induced hearing loss and among Buddhist monks and nuns in monastic institutions in Thimphu, Bhutan: a cross-sectional study

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ABSTRACT

Introduction: Noise-induced hearing loss remains underestimated. It is common in factories and in the military due to exposure to loud noise. In Buddhist institutions, various ritual instruments are used daily. Monks and nuns are exposed to different levels of noise in varying frequencies with varying durations, thus predisposing them to noise-induced hearing loss. The existing literature reveals no studies done on noise-induced hearing loss among monks and nuns in Buddhist institutions. Therefore, it is vital to study the prevalence of hearing loss in this group so that appropriate interventions can be implemented. **Methods:** A descriptive cross-sectional study was performed among Buddhist monks and nuns in monastic institutions in Thimphu, Bhutan. **Results:** This study revealed the prevalence of noise-induced hearing loss among monks and nuns in monastic institutions to be at 12.34% and a statistically significant association was noted between noise-induced hearing loss and duration of stay in monastic institutions ($P=0.01$). **Conclusion:** Monks and nuns are at an increased risk of developing noise-induced hearing loss, and the duration of ritual noise exposure was strongly correlated to the prevalence and severity of the exposure, articulating the cruciality of preventive and rehabilitation measures.

Keywords: Bhutan; Monks; Noise-induced hearing loss; Nuns; Pure tone audiometry.

INTRODUCTION

With rapid development, the world is becoming a noisier place to live in, with sound intensities ranging from 30 dB (decibels) from a person whispering to 140 dB from a powerful firecracker¹. The World Health Organization (WHO) estimates that by 2050, one in every ten people worldwide will have disabling hearing loss². The duration of safe listening time decreases as the sound intensity increases³. The Occupational Safety and Health Administration (OSHA) of the United States of America allows 8 hours of exposure to 90 dB but only 2 hours of exposure to 110 dB sound levels. The NIOSH (National Institute for Occupational Safety and Health) would recommend limiting the 8 hour exposure to less than 85 dB. At 100 dB, NIOSH recommends less than 15 minutes of exposure per day⁴. Noise-induced hearing loss (NIHL) affects communication, productivity, safety and is associated with social isolation, depression, increased risk of dementia, cognitive decline, sleep disturbance and adverse cardiovascular outcomes⁵⁻⁷. Despite its widespread repercussions, NIHL remains an under recognized public health concern, particularly in low and middle-income countries where nearly 80% of people with disabling hearing loss reside⁸.

The prevalence of NIHL varies across different occupational sectors. In India, studies have reported an 89% prevalence of NIHL among bus transport workers and 48% among those in the agriculture sector. In Pakistan, the prevalence of NIHL among aviation workers was 66%. A study in Iran reported a prevalence of 42.4 % among professional musicians⁹. Meanwhile, a study in Nepal found NIHL prevalence rates of 31% among carpenters and 44% among sawyers¹⁰.

Although NIHL is well documented among factory workers¹¹, musicians⁹ and military personnel¹², research in Bhutan remains limited^{9,11,12}. The Ministry of Health estimated that 0.33% of the Bhutanese population had hearing impairment in 2019 but the types of hearing loss were not specified¹³. Only one occupational study has explored the prevalence of NIHL in Bhutan¹⁴. This study however, doesn't include monks and nuns, who are routinely exposed to varying frequencies of sounds from ritual instruments, making them more prone to develop NIHL than the general population.

Bhutan is a Buddhist country and has a significant population of monks and nuns in Buddhist institutions across the country. As of 2017, there were 7373 monks, 275 nuns and 461 Gomchens registered with the central monastic body of Bhutan¹⁵. The absence of evidence in this population has significant bearing, as unrecognized hearing loss can increase the risk of injury, decrease the productivity of the individual and diminish overall well-being¹⁶.

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if the monks were excluded from the study, they were provided treatment for other causes of ear, nose and throat pathology. Participants were anonymized by assigning specific code numbers once the information was gathered. Data confidentiality was maintained with all patient related data being stored under lock and key accessible only to the principal investigator.

RESULTS

Demographics

A total of 389 of the 413 monks present at the institutions met the inclusion criteria and participated in the study. Of these, 351 were monks and 38 were nuns. As shown in Table 1, participants’ ages ranged from 7 to 50 years, with the majority (212, 54.40%) in the 21–30 year age group. Nearly half of the participants (51.41%) had been in monastic institutions for more than 10 years, as depicted in Table 1.

Table 1. Demographics characteristics of the monks and nuns in the monastic institutions during the study period (n=389)

Characteristics	n(%)
Age (years)	
<=10	8 (2.06)
11-20	96 (24.68)
21-30	212 (54.49)
31-40	59 (15.17)
41-50	14 (3.59)
Monastic institutions	
Hongtsho	38 (9.77)
Pangrizampa	62 (15.94)
Tango	116 (29.82)
Simtokha	71 (18.25)
Tashichodzong	102 (26.22)
Number of years in the monastic institution	
<=10	189 (48.59)
>10	200 (51.41)

Prevalence and characteristics of noise induced hearing loss

The overall prevalence of NIHL among the monks and nuns was 12.34%. Of the 48 with NIHL, 46 were monks and 2 were nuns. In the majority of participants with NIHL (87.5%), both ears were affected followed by the left and the right ear respectively

(Table 2).

Table 2. Laterality of ear affected by NIHL in the monks and nuns in the monastic institutions during the study period (n=389)

Side of hearing loss	n (%)
Both ears	42 (87.5)
Left ear	4 (8.3)
Right ear	2 (4.2)

Amongst the monks and nuns with NIHL, the majority (32, 66.7%) had mild degree of hearing loss followed by 20.8% with moderate degree of hearing loss. As reflected in Figure 1, 10.4% had severe degree of hearing loss and 2.0% had profound degree of hearing loss.

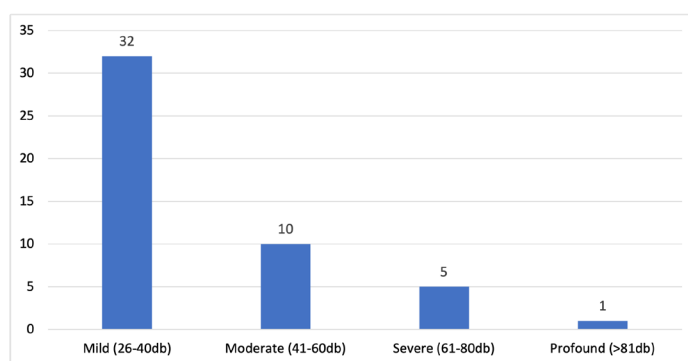


Figure 1. Spectrum of NIHL amongst the monks and nuns in the monastic institutions during the study period (n=48)

Association between prevalence of NIHL and the demographics characteristics

The prevalence of NIHL increased with longer duration of stay in monastic institutions. Among participants who had been in monastic institution for 10 years or less, 7.9% had NIHL. In contrast, among those who had been in monastic institutions for more than 10 years, 16.6% had NIHL. This difference was statistically significant with a p value of 0.014 as shown in Table 3.

Sound produced by instruments used at the monastic institutions

Sound levels produced by instruments used by the monks and nuns were measured using the NIOSH sound level meter application⁵. As shown in Table 4, *Gyaling* (trumpet) produced the highest average sound level at 102 dB followed closely by *Dung Chen* (horn) at 102 dB. The lowest average sound level was produced by drums at 78 dB.

Table 3. Association between NIHL and the demographics characteristics of the monks and nuns in the monastic institutions

Characteristics	Hearing loss present	Normal hearing	p-value
	n(%)	n(%)	
Age (in years)			
<10	0 (0%)	8 (100%)	0.058
11-20	6 (6.25%)	90 (93.75%)	
21-30	28 (13.3%)	184 (86.7%)	
31-40	10 (17%)	49 (83%)	
41-50	4 (28.6%)	10 (71.4%)	
Sex			
Male (monks)	46 (13.1%)	306 (86.9%)	0.278
Female (nuns)	2 (5.5%)	35 (94.5%)	
Monastic institutions			
Hongtsho	2 (5.3%)	36 (94.7%)	0.213
Pangrizampa	5 (8%)	58 (92%)	
Tango	20 (17.6%)	94 (82.4%)	
Simtokha	9 (12.9%)	61 (87.1%)	
Tashichod-zong	12 (11.6%)	92 (88.4%)	
Duration of stay in the monastery			
<10 years	15 (7.9%)	175 (92.1%)	0.014
>10 years	33 (16.6%)	166 (83.4%)	

Table 4. Sound level produced by instruments used by the monks and nuns in the monastic institutions during the study period

Instruments	Average sound level (dB)
<i>Gyaling</i> (Trumpet)	102 dB
<i>Dung Chen</i> (horn)	100 dB
Cymbals	96 dB
Bells	90 dB
Drum	78 dB

DISCUSSION

NIHL emerged as a notable occupational health concern among monks and nuns in monastic institutions in Thimphu, with a prevalence rate of 12.34%. Globally, the prevalence of NIHL is estimated to range between 7% and 21% across different regions, as reported by the US NIOSH¹⁷. In Bhutan, Pelden et.al reported a prevalence of 27.9% among factory workers¹⁴. In comparison, the prevalence of NIHL amongst monks and nuns in this study was 12.34%, which is lower than both the national industrial prevalence and the reported global estimates. However, it is higher than rates reported among administrative industry workers, which was 6.73% in the study by Pelden et al¹⁴. The relatively lower prevalence in the monastic population compared to industrial workers may be attributed to the shorter daily exposure durations (approximately 5 hours a day) and the intermittent nature of ritual instrument use with frequent breaks rather than the continuous noise exposure in industries. Additionally, as the study included participants aged 50 years and below, unlike the study done by Pelden et.al who included participants aged above 50 years, this rate does not represent the true burden of NIHL among the entire monastic population.

Monks are enrolled into monastic institutions as early as four years of age, beginning their education with learning alphabets, spelling and reading, before progressing to memorization of chants and prayers. As they advance in their studies, they specialize in various aspects including the use of ritual instruments¹⁸. During the course of their study, they frequently participate in religious ceremonies, during holy months or while performing annual rituals in households. These events represent the periods of greatest noise exposure as instruments are used extensively for the rituals. In this study, the *Gyaling* (trumpet) was found to produce an average sound level of 102 dB while *Dung chen* (horn) produced 100 dB, suggesting that monks and nuns are exposed to sound levels comparable to those seen in high-risk occupational settings. For comparison, the average decibel ratings of normal conversation ranges from 60-70 dB, sounds in a movie theaters ranges from 74-104 dB, sounds produced by motorcycles and dirt bikes range from 80-110 dB and sounds produced by sirens range from 110-129 dB¹⁹.

A study by Dendup et.al reported that 34.6% of the industries studied in Bhutan had occupational noise levels between 85 and 90 dB, while 38.5% had levels exceeding 91 dB. Carpenters and machine operators were identified as particularly vulnerable to NIHL²⁰. In comparison, this study found that monks and nuns were exposed to cumulative sound levels ranging from 80 to 95 dB during ritual ceremonies, as measured by the NIOSH sound level meter application. This highlights the fact that even religious environments can present noise exposure levels similar to industrial workplaces.

This study found that the majority of monks and nuns with NIHL (66.7%) had mild hearing loss. This pattern is

consistent with findings from other studies where individuals with occupational NIHL had a mild degree of hearing loss. For instance, Pelden et al reported that most about 41.6% of industrial workers with NIHL had mild hearing loss, 37.9% had minimal hearing loss, 15.8% had moderate hearing loss, 2.8% had moderately severe hearing loss and 2% had severe hearing loss¹⁴. These findings suggest that many affected individuals may remain unaware of their hearing impairment, particularly when symptoms are subtle. This issue is further compounded by the fact that hearing assessments are rarely incorporated into routine health care. According to the Regulation on Occupational Health, Safety and Welfare issued by the Ministry of Labour and Human Resources, employees working in environments where noise levels exceed 85 dBA are required to undergo auditory examination by a qualified medical professional at least once in every six months²¹. Failure to detect hearing loss early and initiate timely intervention can allow the condition to progress, resulting in greater impact²². This underscores the importance of routine hearing screening and adopting preventive measures to minimize NIHL.

NIHL occurs due to structural or metabolic damage to the cochlea, either from a single intense exposure to an intense “impulse” sound, such as an explosion, or from repeated exposure to loud sounds over time, similar to the exposure monks and nuns experience when playing ritual instruments²³. This study demonstrated a statistically significant association between duration of stay in monastic institutions and the prevalence of NIHL ($p = 0.010$), with those exposed for more than 10 years showing a higher prevalence than those with 10 years or less of stay. Monks and nuns begin training with ritual instruments early in their careers, and the duration of exposure was categorized into two groups (less than 10 years and those more than 10 years) based on evidence from audiometric studies such as one done by Noah et al., which showed that significant NIHL typically appears after a decade of continuous noise exposure²⁴. Similarly, Mohammed et al reported a high prevalence of NIHL among Jordanian industrial workers with over 10 years of noise exposure¹¹. Consistent with this finding, this study observed that NIHL was more prevalent in those with longer duration of monastic life, with 7.9% affected in those with less than 10 and 6.5% in those with more than 10 years of exposure.

Preventive measures such as the use of ear protection during ritual performances and minimizing direct exposure to ritual instruments could substantially reduce the risk of NIHL. In addition, educating monks and nuns on the safe exposure limits and allowable duration of exposure may help prevent its occurrence. This is important as NIHL, once established, is largely irreversible. Interventions can only aim to prevent further auditory damage.

STRENGTH AND LIMITATIONS

This study is the first community-based research conducted to

determine the prevalence of NIHL amongst monks and nuns. A limitation of this study is that only four ototoxic medicines were considered for excluding participants, which may not account for all possible confounding factors.

CONCLUSION

This study shows the prevalence of NIHL among monks and nuns in Thimphu to be at 12.34% with a statistically significant association noted between duration of monastic stay and NIHL. These results highlight the cumulative effect of prolonged noise exposure in monastic settings and underscore the importance of routine screening and applying early preventive measures to prevent NIHL. This study also stresses the need for future large-scale studies in monastic institutions around Bhutan so that it will help in mitigating this preventable cause of deafness.

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AUTHORS CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

ST: Conceptualization, writing original draft, reviewing, editing, data collection, data analysis, method development, funding acquisition

SJ: Conceptualization, method development, writing original draft, reviewing, editing

TRA: Conceptualization, method development, writing original draft, reviewing, editing

PW: Writing original draft, reviewing, editing, data entry and analysis

Authors agree to be accountable for all respects of the work in ensuring that questions related to the accuracy and integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

None

GRANT SUPPORT AND FINANCIAL DISCLOSURE

Ministry of Health