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# Associations between earplug use and hearing loss in ROK military personnel

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## ABSTRACT

**Introduction** The easiest way to prevent noise-induced hearing loss (NIHL) is to wear earplugs. The Republic of Korea (ROK) Ministry of National Defense (MND) is supplying earplugs to prevent NIHL, but many patients still suffer from this. We speculated that earplugs would have a high NIHL rate, depending on the rate of use of earplugs, regardless of the rate of supply. Therefore, we conducted this study to investigate the relationship between the use of earplugs and hearing loss by ROK military personnel.

**Methods** The study used data from the Military Health Survey conducted in 2014–2015, which included 13 470 questionnaires completed by ROK military personnel. Hearing loss and earplug use were self-reported. Logistic regression analysis was used to assess associations between earplug use and hearing loss.

**Results** The study sample included 13 470 ROK military personnel (response rate of 71.2%) (Army, 8330 (61.8%); Navy/Marines, 2236 (16.6%); and Air Force, 2904 (21.6%)). Overall, 18.8% of Korean military personnel reported that they always wore earplugs, and 2.8% reported hearing loss. In logistic regression analysis, there were significant differences in the rates of hearing loss associated with wearing earplugs sometimes (OR=1.48, 95% CI 1.07 to 2.05) and never wearing earplugs (OR=1.53, 95% CI 1.12 to 2.10). In subgroup analysis, in Air Force, non-combat branch, forward area and long-term military service personnel increased hearing loss was associated with not wearing earplugs.

**Conclusion** Our study confirmed that within the ROK military, there is an association between hearing loss and lack of earplug use. In the ROK MND, Army, Navy/Marines and Air Force headquarters must provide guidelines for the use of earplugs during field training to protect military personnel's hearings and, if necessary, need to be regulated or institutionalised.

## INTRODUCTION

Noise-induced hearing loss (NIHL) is a sensorineural hearing deficit that begins at the higher frequencies (3–6 kHz) and develops gradually as a result of chronic exposure to excessive sound levels.<sup>1</sup> In addition, sudden noise of 70 dB or more can have a critical effect on the body.<sup>2</sup> Although the hearing loss is typically symmetric, noise from such sources as firearms or sirens may produce an asymmetrical loss.

Due to the nature of the profession, the main task is for military personnel to use guns and artilleries. However, it has been reported that the noise level for a single gunshot is 75–90 dB for rifle shot and 75 dB for carbines. In addition, the M-16 rifle fire sounds are 170 dB and the artillery fire sounds are

## Key messages

- ▶ Overall, 2.8% of the Republic of Korea (ROK) military personnel surveyed reported that they had experienced hearing loss.
- ▶ Close to half of the 13 470 ROK military personnel surveyed reported that they did not wear earplugs at all (6090, 45.2%).
- ▶ Not wearing earplugs was significantly associated with hearing loss.
- ▶ The hearing loss and the low rate of earplug use in the ROK military identified in the present study can be used as a basis for strategies designed to increase the use of earplugs in the organisation.

180 dB of noise, which can cause NIHL.<sup>3</sup> Thus, according to data provided by the Republic of Korea (ROK) Armed Forces Medical Command (AFMC), otolaryngologists in the military are estimated to treat more than 110 000 patients each year for blast-related ear injuries and/or hearing loss induced by rifle fire or artillery training.<sup>4</sup>

The easiest way to prevent way to prevent NIHL is to wear earplugs.<sup>5–7</sup> Therefore, the ROK Army, Navy/Marines and Air Force provide military personnel with earplugs as a way of personal hearing protection and provide education to prevent NIHL.<sup>8</sup> However, NIHL continues to arise from ROK military personnel.<sup>9</sup>

ROK military research on NIHL continues. However, unlike the case of another nation's military attempting a multifaceted approach to the NIHL,<sup>10–12</sup> the ROK military focused primarily on the Air Force's hearing loss.<sup>13–15</sup> There has been little research on the hearing of the army and navy. Therefore, we conducted this study to confirm how the use of earplugs in the Army, Navy/Marines and Air Force is related to NIHL.

## METHODS

### Study participants

Data were obtained from the 2014–2015 Military Health Survey (MHS), which is a cross-sectional survey of military personnel that was conducted by the School of Military Medicine to investigate health determinants. The survey was designed to acquire self-reported data via a questionnaire. Raw data were obtained from the Korean Military Medical School with the dean's approval. Because the 2014 MHS was an anonymous self-administered survey, individual responses cannot be linked to specific personnel or medical records.



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**Table 1** General characteristics of study observations (Military Health Survey 2014–2015)

Variable	Hearing loss			P value
	Total n (%)	Yes n (%)	No n (%)	
Earplug use				0.0353
Always	2528 (18.8)	52 (2.1)	2476 (97.9)	
Sometimes	4852 (36.0)	140 (2.9)	4712 (97.1)	
None	6090 (45.2)	186 (3.1)	5904 (97.0)	
Sex				0.3596
Man	13 080 (97.1)	370 (2.8)	12 710 (97.2)	
Woman	390 (2.9)	8 (2.1)	382 (98.0)	
Marital status				<0.0001
Married	1630 (12.1)	88 (5.4)	1542 (94.6)	
Single (divorced, separated or bereaved)	306 (2.3)	22 (7.2)	284 (92.8)	
Never married	11 534 (85.6)	268 (2.3)	11 266 (97.7)	
Educational level				0.5636
High school or less	2484 (18.4)	74 (3.0)	2410 (97.0)	
College or more	10 986 (81.6)	304 (2.8)	10 682 (97.2)	
Military type				0.8874
Army	8330 (61.8)	230 (2.8)	8100 (97.2)	
Navy and Marines	2236 (16.6)	66 (3.0)	2170 (97.1)	
Air Force	2904 (21.6)	82 (2.8)	2822 (97.2)	
Branch				0.3112
Combat	8740 (64.9)	236 (2.7)	8504 (97.3)	
Non-combat	4730 (35.1)	142 (3.0)	4588 (97.0)	
Rank				0.0023
Warrant officer and commissioned officer (W1–O6)	1798 (13.4)	58 (3.2)	1740 (96.8)	
Non-commissioned officer (E5–E9)	3378 (25.1)	118 (3.5)	3260 (96.5)	
Enlisted soldier (E3 and E4)	3958 (29.4)	110 (2.8)	3848 (97.2)	
Enlisted soldier (E1 and E2)	4336 (32.2)	92 (2.1)	4244 (97.9)	
Working area				0.3557
Forward area	8922 (66.2)	242 (2.7)	8680 (97.3)	
Rear area	4548 (33.8)	136 (3.0)	4412 (97.0)	
Service classification				<0.0001
Long-term military service	2922 (21.7)	150 (5.1)	2772 (94.9)	
Short-term military service	10 548 (78.3)	228 (2.2)	10 320 (97.8)	
Working time (hour/week)				0.4297
≤48	6684 (49.6)	180 (2.7)	6504 (97.3)	
≥49	6786 (50.4)	198 (2.9)	6588 (97.1)	
Total	13 470 (100.0)	378 (2.8)	13 092 (97.2)	

The survey was conducted every year for 5000 officers, warrant officers, non-commissioned officers (NCOs) and 5000 enlisted soldiers. The total number of survey participants during the 2 years of the study was 14 244 (response rate of 71.2%) (1914 officers and warrant officers, 3604 NCOs and 8726 enlisted soldiers). Respondents who used medical services pertaining to hearing loss over the past year were tabulated, as were those who answered questions relating to wearing earplugs.

Only respondents who answered questions identifying their sex, marital status, educational level, military type, branch, rank, working area, service classification and working time were included in the current study. The final analysis dataset included 13 470 military personnel, 94.6% of all survey respondents (1798 officers and warrant officers, 3378 NCOs and 3378 enlisted soldiers).

### Variables

Hearing loss was the main dependent variable in the current study. The MHS investigated this via the question ‘Check all

diseases you have experienced over the past year’. The analyses of hearing loss in the current study was based on respondents who checked ‘hearing loss’ in response to that prompt. The interesting variable was earplug use. The relevant question in the survey was ‘Do you wear earplugs?’. Possible answers were ‘always wear earplugs’, ‘sometimes wear earplugs’, ‘often do not wear earplugs’, ‘do not wear earplugs’ and ‘not applicable’. We distinguished between sometimes wear earplugs, often do not wear earplugs and sometimes wear earplugs. Not applicable was excluded from the analysis.

Several covariates were assessed, including sociodemographic, military-related and health-related characteristics. Sociodemographic characteristics included sex (male and female), marital status (married, previously married (divorced, separated or bereaved) or unmarried) and education level (high school or less, college or above). Military-related characteristics included military type (Army, Navy/Marines or Air Force), branch (combat, technique/administration or special), rank (warrant officer or commissioned officer (W1–O6), NCO (E5–E9), or enlisted

**Table 2** Factors associated with hearing loss and whether to use earplugs (Military Health Survey 2014–2015)

Variables	Hearing loss	
	Adjusted OR (95% CI)	P value
<b>Earplug use</b>		
Always	1.00	
Sometimes	1.48 (1.07 to 2.05)	0.0185
None	1.53 (1.12 to 2.10)	0.0081
<b>Sex</b>		
Man	1.00	
Woman	1.54 (0.74 to 3.24)	0.2516
<b>Marital status</b>		
Married	1.00	
Single (divorced, separated or bereaved)	1.38 (0.85 to 2.26)	0.1963
Never married	0.69 (0.47 to 0.99)	0.0462
<b>Educational level</b>		
High school or less	0.92 (0.70 to 1.20)	0.5262
College or more	1.00	
<b>Military type</b>		
Army	1.16 (0.82 to 1.64)	0.409
Navy and Marines	1.06 (0.74 to 1.52)	0.7414
Air Force	1.00	
<b>Branch</b>		
Combat	1.16 (0.90 to 1.48)	0.2489
Non-combat	1.00	
<b>Rank</b>		
Warrant officer and commissioned officer (W1–O6)	1.00	
Non-commissioned officer (E5–E9)	1.14 (0.80 to 1.61)	0.4675
Enlisted soldier (E3 and E4)	2.58 (1.57 to 4.25)	0.0002
Enlisted soldier (E1 and E2)	1.92 (1.15 to 3.18)	0.0123
<b>Working area</b>		
Forward area	1.06 (0.80 to 1.40)	0.6752
Rear area	1.00	
<b>Service classification</b>		
Long-term military service	1.00	
Short-term military service	0.27 (0.17 to 0.44)	<0.0001
<b>Working time (hour/week)</b>		
≤48	1.03 (0.83 to 1.28)	0.7955
≥49	1.00	

soldier (E3 and E4) or enlisted soldier (E1 and E2)), working area (forward area or rear area), service classification (long-term military service or short-term military service) and working time (≤48 or ≥49).

### Statistical analysis

The  $\chi^2$  test and logistic regression analysis were used to analyse associations between earplug use and hearing loss. The  $\chi^2$  test was used to investigate the significance of differences in hearing loss, depending on earplug use. Logistic regression analysis was used to determine ORs and 95% CIs. Subgroup analysis of earplug use was performed based on hearing loss, sex, marital status, educational level, military type, branch, working area and service classification. Statistical analyses were performed using SAS software V.9.4. A p value of <0.05 was deemed to indicate statistical significance.

### RESULTS

The sample included 13 470 military personnel (Army, 8330 (61.8%); Navy/Marines, 2236 (16.6%); and Air Force, 2904

**Table 3** Factors of hearing loss depending on whether to use earplugs (Military Health Survey 2014–2015)

Variables	Hearing loss		
	Always use earplugs	Sometimes use earplugs	Do not use earplugs
	Adjusted OR	Adjusted OR (95% CI)	Adjusted OR (95% CI)
<b>Sex</b>			
Man	1	1.44 (1.04 to 1.99)	1.51 (1.10 to 2.07)
Woman	1	–	–
<b>Marital status</b>			
Married	1	1.01 (0.51 to 2.00)	1.81 (0.98 to 3.32)
Single (divorced, separated or bereaved)	1	2.04 (0.43 to 9.64)	0.83 (0.21 to 3.28)
Never married	1	1.68 (1.14 to 2.48)	1.55 (1.05 to 2.28)
<b>Educational level</b>			
High school or less	1	1.03 (0.47 to 2.26)	2.00 (0.99 to 4.03)
College or more	1	1.58 (1.10 to 2.26)	1.40 (0.98 to 2.00)
<b>Military type</b>			
Army	1	1.33 (0.89 to 1.98)	1.32 (0.89 to 1.95)
Navy and Marines	1	1.43 (0.70 to 2.90)	0.80 (0.38 to 1.65)
Air Force	1	1.77 (0.70 to 4.47)	3.41 (1.44 to 8.06)
<b>Branch</b>			
Combat	1	1.42 (0.96 to 2.09)	1.39 (0.95 to 2.03)
Non-combat	1	1.59 (0.87 to 2.91)	1.80 (1.01 to 3.21)
<b>Working area</b>			
Forward area	1	1.52 (1.01 to 2.30)	1.68 (1.13 to 2.50)
Rear area	1	1.46 (0.86 to 2.48)	1.36 (0.81 to 2.28)
<b>Service classification</b>			
Long-term military service	1	1.43 (0.85 to 2.43)	1.88 (1.15 to 3.08)
Short-term military service	1	1.49 (0.98 to 2.26)	1.31 (0.87 to 1.98)

(21.6%). Overall, 2.8% of military personnel reported that they had experienced hearing loss. Most military personnel either sometimes wore earplugs or never wore earplugs. Of the total 13 470 respondents, 2528 (18.8%) reported that they always wore earplugs; 4852 (36.0%) reported that they sometimes wore them; and 6090 (45.2%) reported that they never wore them (Table 1).

The results of the logistic regression analysis pertaining to hearing loss are shown in Table 2. In the logistic regression analysis, there were significant differences in the rates of hearing loss associated with wearing earplugs sometimes (OR=1.48, 95% CI 1.07 to 2.05) and never wearing earplugs (OR=1.53, 95% CI 1.12 to 2.10). Enlisted soldiers were more likely to experience hearing loss than warrant officers and commissioned officers (enlisted soldiers (E3 and E4), OR=2.58, 95% CI 1.57 to 4.25; enlisted soldiers (E1 and E2), OR=1.92, 95% CI 1.15 to 3.18).

Data reflecting differences between those who reported always wearing earplugs and those who reported sometimes wearing them or never wearing them are shown in Table 3. In the Air Force, personnel who never wore earplugs were more likely to experience hearing loss than those who always wore them (OR=3.41, 95% CI 1.44 to 8.06). With regard to branch, non-combat personnel who never wore earplugs were more likely to experience hearing loss than those who always wore them (OR=1.80, 95% CI 1.01 to 3.21). With regard to working area, forward area personnel who sometimes wore earplugs and those who never wore them were more likely to experience hearing loss than those who always wore them (sometimes wore earplugs group, OR=1.52, 95% CI 1.01 to 2.30; never wore earplugs group, OR=1.68, 95% CI 1.13 to 2.50). With regard to service classification, long-term military service personnel were more

likely to have experienced hearing loss (OR=1.88, 95% CI 1.15 to 3.08).

## DISCUSSION

This study can be used as a basis for demonstrating the effects of wearing earplugs during training. ROK Defense, Army, Navy/Marines and Air Force Command provide earplugs to protect the military personnel's hearing. However, in our analysis, 81.2% of military personnel responded they never use or sometimes use earplugs. Hearing loss was most likely in military personnel who never use earplugs or sometimes use earplugs. This suggests that the continued use of earplugs is important.

We suggest the following points. First, efforts to protect military personnel's hearings must be continued. Ministry of National Defense should continue to provide earplugs to military personnel so that they are not exposed to hearing loss. Second, military personnel should be educated on the importance of continued use of earplugs. Our study found that the group which occasionally wears earplugs was 1.48 times more likely to have a hearing loss than the group which always uses earplugs. The group which never uses earplugs was 1.53 times more likely to have a hearing loss than the group which always uses earplugs. This suggests that if you do not continue to use earplugs, your exposure to hearing loss is similar to the never-use group. Therefore, earplugs should always be worn to protect the military personnel's hearing. Finally, it is necessary to analyse the cause of the poor use of earplugs. Only 18.8% of military personnel in our study said they always used earplugs. It is necessary to examine when the use of earplugs does cause discomfort or dissatisfaction for military personnel, and if evidence is found, efforts will be needed to improve them.

The present study had some limitations. First, MHS asked if military personnel had hearing loss and if they wore earplugs in general. Because the current study utilised self-reported data, recall bias can occur at this point. Second, if there was any dissatisfaction with the earplugs supplied, self-reported data may reflect a tendency to under-report usage. Third, because this study is a cross-sectional study, there was no capacity to thoroughly investigate causal relationships between hearing loss and earplug use in the ROK military. A randomised controlled trial is needed to investigate such relationships, but notably, such trials involving military personnel are very limited in the ROK military. Therefore, it is necessary to accumulate long-term data such as those derived from military defence cohorts, to analyse the phenomena of interest. Fourth, it would have been better if the study analysed the effect of wearing earplugs on the severity of hearing loss. However, due to the limitation of the data, the analysis according to the severity could not be performed. Lastly, the sample population consisted entirely of ROK military personnel so the results of the study may not be readily generalisable to other groups.

Despite the aforementioned limitations, the present study had several strengths. The data used were sourced from the largest survey ever conducted by the ROK AFMC, which was undertaken to investigate health behaviours in military personnel and facilitate the calculation of health-related statistics required for health business planning and evaluation. That survey was administered to more than 13 000 military personnel and incorporated the selection of representative samples with regard to distributions of class, health status and region in the ROK Army, Navy/Marines and Air Force. Therefore, the data were derived from the largest healthcare-related survey conducted in military personnel. Another strength of the study is that as well as ROK

Air Force personnel, it incorporated ROK Army and ROK Navy/Marines personnel. Hitherto, studies investigating hearing loss in the ROK military have mainly focused on the Air Force. To the best of our knowledge, this is the first study to investigate hearing loss and earplug use in the ROK Army, Navy/Marines and Air Force.

## CONCLUSION

Our study confirmed that within the ROK military, there is an association between hearing loss and lack of earplug use. In the ROK Defense, Army, Navy/Marines and Air Force headquarters, consideration of mandatory equipment wearing and modernisation of equipment is necessary for the protection of military personnel's hearing.

**Contributors** HwJK: conceptualisation, study design, data collection, overview, literature review, formal analysis and write-up. SYO: methodology and review. SYW: data collection, analysis and review. HaJK: study design, data collection and review. TKK and BCK: data collection and review. SYW: review and write-up. E-CP: supervision.

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