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Occupational noise-induced hearing loss among migrant workers in Kuwait

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Abstract

Background–Although the effect of hearing loss on years lived with disability (YLD) is quite substantial, occupational hearing loss among migrant workers is significantly under-studied. In Kuwait, where nearly two-thirds of the population are migrant workers, the burden of occupational noise-induced hearing loss (ONIHL) is unknown.

Objective–To assess the prevalence of ONIHL among migrant workers in Kuwait and explore workplace and individual risk factors that are associated with ONIHL. Subjects and Methods–We obtained data of annual physical exams for the year 2018 conducted by the Shuaiba Industrial Medical Center (SIMC) for all industrial workers in the area. We applied univariate and multivariate logistic regression models to estimate the effects of individual and occupational characteristics on ONIHL.

Results–A total of 3,474 industrial workers visited SIMC for an annual exam. The vast majority were men (99%) and non-Kuwaitis (98%) with a median age of 38 years. A total of 710 workers were diagnosed with ONIHL with a prevalence of 20.4%. Age, years of experience, and self-reported exposure to noise were associated with statistically significant higher odds of ONIHL. When adjusted for age, years of experience and other individual level factors, type of industry was not a statistically significant predictor of ONIHL.

Conclusions–The study uncovers the significant burden of hearing loss among the migrant workers subpopulation in Kuwait, an area of occupational health that is often underestimated or unrecognized. Although laws and regulations are in place to prevent and control noise in the workplace, local authorities must ensure that industrial workers are provided with the necessary training and controls to reduce noise exposure.

Introduction

Noise in the environment ranges from tolerable to hazardous levels. According to the World Health Organization (WHO), noise is linked to adverse health effects, which can lead to sleep disorders and cardiovascular diseases as well as influences on individual's social and work performance (WHO, 2019). At the international scale, hearing loss is increasing with the increase in aging populations. Interestingly, occupational noise-induced hearing loss (ONIHL) is one of the most prevalent work-related diseases (Chen et al. 2020), such that approximately 16% of adult-disabling hearing loss is attributed to occupational noise (Nelson et al., 2005). In the US, an estimated 12% of the American workforce population suffers from hearing loss, out of which 24% is due to work-related exposures (Centers for Disease Control and Prevention [CDC], 2019).

Hearing loss is a significant public health problem that denotes social and economic burdens (Chisolm et al., 2007). Although the notion that people do not die directly from hearing loss is true, the effect of hearing loss on years lived with disability (YLD) is quite substantial. Hearing loss is one of the top five causes of global YLD and is associated with depression, cognitive decline, dementia, risk of falls, and hospitalizations (Li et al., 2014; Lin et al., 2014). Additionally, companies pay approximately $242 million yearly as compensation for the hearing loss disabilities of workers in the US (Friis, 2019).

The prevalence of occupational hearing loss in developing countries at 23% is more problematic compared with developed countries at 16% (Lie et al., 2016). For example, the prevalence and burden of workers in Kuwait with hearing loss due to occupational exposure are unknown. Consequently, prevention and control measures are not being sufficiently considered and implemented. Meanwhile, the majority of Kuwait's workforce are male migrant workers employed in low-skilled sectors (PACI, 2019). In general, migrant workers experience high levels of hazardous job-related exposure and working environment, which results in negative effects on health, such as work-related injuries and disabilities (Moyce & Schenker, 2018). According to Rabinowitz et al. (2005), hearing loss in migrant workers is significantly under-studied. Workplace hazard can be especially amplified among migrant workers due to language and cultural barriers. Typically, migrant workers are marginalized subpopulations frequently employed in least desired professions with high risk of occupational injury (Low et al., 2015).

ONIHL among migrant workers is an overlooked public health problem in Kuwait, which necessitates urgent policy and regulatory implementation. To bridge the research gap, the current study aims to investigate the prevalence of ONIHL among migrant workers in Kuwait and explore workplace and individual risk factors that are associated with ONIHL.

Subjects And Methods

Study population

The cross-sectional study is retrospective in nature and utilizes data from annual medical examinations conducted by the Shuaiba Industrial Medical Center (SIMC) at the Department of Occupational Health of the Ministry of Health. SIMC is located in the Al Shuaiba industrial area and provides services to migrant workers from various industrial factories and corporations located in the Al Ahmadi governorate (Al-Fajjam & Samir, 2018). SIMC collects data from periodical, pre-employment, and medical fitness tests for all industrial workers in the area. The study obtained data for all physical exams for the year 2018 (January to December). The sample consists of workers from various nationalities and aged over 21 years. Data were considered secondary because information was not collected specifically for the study. Ethical approval was obtained from the Ministry of Health and Kuwait University with only the primary researchers granted access to anonymized data.

Audiometry tests

All audiometric tests were conducted by two experienced well-trained nurses in a testing facility fulfilling ISO 8253-1(1989) criteria. All subjects were examined by otoscopy to exclude external and middle ear medical disorders such as ear wax, otitis externa and otitis media followed by Pure-tone audiometric tests (air and bone conduction) that was conducted to determine the hearing thresholds in the conventional frequencies 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz for both ears of each subject, using a Madsen- Orbiter 922: Diagnostic Audiometer, with TDH-50P earphones. The audiometer met ANSIS3.26-1981 standard and was calibrated. Measurements were taken using 5 dB increments. Audiometric tests were only made at least 18 h after the last exposure to noise to allow recovery from any temporary hearing threshold shifts. Noise-induced hearing loss (NIHL) was calculated as the average of a hearing threshold level for the critical noise-sensitive frequencies (i.e., 3000, 4000, and 6000 Hz) (Leensen et al., 2011; Frederiksen et al., 2017). Audiometric tests were classified under the following conditions: 1) scores suggesting NIHL when hearing thresholds exceed 25 dB in frequencies of 500, 1000, 2000, 3000, and 4000 Hz; 2) a notch in frequencies (i.e., 3000, 4000, and 6000 Hz); or 3) presence of a sensorineural curve with a drop in higher frequencies and a descending curve with a notch shape. If NIHL was bilateral, then it was classified as occupational NIHL. Typically, ONIHL is bilateral due to symmetrical exposure to noise, whereas unilateral NIHL can be attributed to many reasons apart from occupation (Mirza et al., 2018). Workers with missing audiometric results and exposure data were excluded from analysis.

Individual characteristics

Most of workers worked on average a 72-h per week (12 h per day, 6 days a week). However, official daily working hours per day were 8, and the extra hours were considered as overtime earning additional income. Moreover, SIMC conducted a survey on self-reported noise exposure (yes/no), which was completed by the participants. The questionnaire also collected data on age, gender, years of experience, noise exposure, nationality, job type, and industry type.

Statistical analysis

Continuous variables were expressed as mean and standard deviations or median and interquartile range. Categorical variables, such as age groups, gender, years of experience (≤15, 16–29, and ≥30 years), noise exposure (yes/no), nationality, job type, and industry type were presented as numbers and percentages. To examine the independent factors associated with ONIHL, the study employed univariate and multivariate logistic regressions and reported odds ratios with confidence intervals for each factor. Univariate analyses were conducted to investigate the relationship between the ONIHL and other predictors, one at a time. Multivariate logistic regression was performed to elucidate the relationship between the outcome and variables after adjusting for other predictors. A significance level of $P < 0.05$ was used for all tests. Statistical procedures were performed using SPSS version 26 (SPSS, 2019).

Results

Table 1 presents the characteristics of 3,474 industrial workers who visited SIMC in 2018 and the prevalence of ONIHL. The vast majority were male (98.8%) with a median age of 38 years (IQR; 15 years). A total of 710 workers were diagnosed with ONIHL with prevalence rates of 20.4% and 20.6% for the entire population and among males, respectively. According to age, the highest prevalence rate was observed among the ≥61-year age group (69.6%). Kuwaitis represented (2%) of the sample with a prevalence rate of 17.1%. When stratified by nationality, high prevalence rates were noted among non-Kuwaiti workers, especially those from Pakistan (36.9%) and the Philippines (28.2%). Based on years of tenure, those who worked for 30 years or more displayed a high rate of ONIHL (63.3%). In terms of self-reported noise exposure, the prevalence rate of ONIHL among those who answered "yes" was 29.0% compared with 15.8% among those who answered "no."

Table 2 presents ONIHL by job and industry type. The highest prevalence rates were observed for services and sales workers (31.8%) followed by crafts and related trade workers (29.0%). According to industry type, workers in transportation and storage displayed the highest prevalence (35.7%).

Regression Analyses

Table 3 reports the unadjusted and adjusted odds ratios of ONIHL.Crude odds ratios suggest that age, years of experience, and self-reported exposure to noise are associated with higher odds of ONIHL. Compared with young workers (21–30 years), workers aged 31–40 year and ≥61 years exhibited nearly twice the odds and approximately 40-fold increase in the crude odds of ONIHL. A work experience of ≥30 years is associated with unadjusted odds ratios of 7.9 (95% CI: 4.4–14.4) compared to those with ≤15 years. Compared to Indians (i.e., the nationality with the greatest number of workers), univariate analysis revealed that other nationalities were significantly associated with higher ONIHL, such as Filipinos (OR 1.5; 95% CI: 1.1–2.2), Pakistanis (OR: 2.4; 95% CI: 1.7–3.4), and Bangladeshis (OR: 1.2; 95% CI: 0.87–1.6). When investigating the relationship between job type and ONIHL, the study found that professionals (OR: 0.79; 95% CI: 0.5–1.3) and clerical support workers (OR: 0.69; 95% CI: 0.4–1.4) displayed statistically significant lower odds of ONIHL compared with elementary occupations. Finally, except for the construction and wholesale and retail trade and repair of vehicles and motorcycles industries, significantly lower odds of ONIHL were noted for all other industries compared with administrative and supportive service activities.

After adjustment, the odds of ONIHL among age groups remain statistically significantly higher than the reference group, although the effect estimates were attenuated after adjustment. Workers aged >61 years were 30.5 times more likely to have ONIHL than young workers. A trend is clearly observed: the odds of ONIHL increase for every 10 years increase in the categories of age. The coefficient for gender is no longer statistically significant in the multivariate regression after adjusting for the other variables. A work experience of >30 years exhibits twice the adjusted odds of ONIHL compared to a work experience of ≤15 years. Similarly, self-reported exposure to noise is associated with adjusted odds ratio of 2.0 (1.7–2.4).

Furthermore, the results for Filipinos (OR: 1.4: 95% CI: 1.0–2.2) and Pakistanis (OR: 2.1; 95% CI:1.4–3.3) remain significant compared with Indians (reference group). Finally, job and industry type became non-significant, except for job type crafts and related trade works (OR: 1.6; 95% CI: 1.2–2.2).

Discussion

To the best of our knowledge, this study is the first in Kuwait and the Gulf Region to assess the prevalence and predictors of ONIHL among migrant workers. We leveraged routinely collected secondary data from SIMC to enable the investigation of ONIHL. The study uncovers the significant burden of hearing loss among the migrant workers subpopulations. This area of occupational health is often underestimated or unrecognized among marginalized subpopulations, which renders it an important public health topic (Rabinowitz et al., 2005).

Unwarranted exposure to noise can result in cochlear trauma which leads to hearing loss and tinnitus. Occupational workers are at most risk of noise-induced hearing loss. Noise-induced hearing loss is a term used to describe the effect of long term and continuous exposure to noise. As an exposure, magnitude of noise can be correlated to cochlear damage. Acoustic trauma is another term used to describe sudden hearing loss typically caused by single or repeated noise exposure. NIHL can be characterized by being either temporary, where the individual can regain their hearing within 48 hours, known as temporary threshold shift (TTS) or it can result in permanent threshold shift (PTS). Some individuals might experience hidden hearing loss, where a pure-tone threshold shift is absent. The pathophysiology of permanent threshold shift is as follows; loss of the outer hair cells with evidence suggesting that it might cause degeneration of the auditory nerve (as demonstrated by histopathology of the temporal bone) (Wang et al., 2002). In a similar way, it can be said that excessive exposure to noise ultimately leads to the damage of the organ of corti. That can be compartmentalised into two main categories; the first being mechanical destruction typically caused by short exposure to noise or metabolic decompensation, a sequel of prolonged exposure to noise by reactive oxygen species, formation of free radicals and glutamate excitotoxicity. All which ultimately lead to cell death. Equally important, noise exposure also surges the level of free calcium existing in the outer hair cells, again, activating apoptosis and necrosis. Audiometric tests are imperative at determining the degree of hearing impairment caused by noise. Firstly, pure tone audiometry, recognizes the hearing threshold of an individual and is mostly used to establish the degree of NIHL. A major downfall of this investigation is the difficulty separating between presbycusis and NIHL (Ali et al., 2014). Secondly, a decrease in speech recognition scores alongside a normal audiogram can be associated with NIHL. Subsequently, otoacoustic emission test is a sensitive and easy mean to diagnose NIHL, where it can be used to detect those in the pre-symptomatic phase (early indicator) and normal audiograms. Though, it can only be used in settings where hearing can decline further. The last tool that can be used for determining the extent of NIHL is objective measures for noise-induced-synaptopathy, which is an electrophysiological measurement lacking both sensitivity and evidence in humans. In terms of tinnitus, it was reported that it affects approximately 24% of those that have been exposed to noise in comparison to the general population where only 14% reported symptoms (Shargorodsky et al., 2010). Finally, concurrent exposure to ototoxic substances, such as solvents and heavy metals, may also contribute to the damaging effect of noise (EU 2003; Johnson 2010). The extent to which these ototoxic substances interact with noise needs to be further explored (Le et al., 2017).

The evidence at hand shows that migrant workers in Kuwait suffer from ONIHL with a prevalence of 20.4%, which is in line with those of Kitcher et al. (2012) and Leensen et al. (2011) at 21.5% in Ghana and 22.1% in Germany, respectively. However, the estimated prevalence in the present study is lower than those of Dement et al. (2018) and Robinson et al. (2015) at 58% among older construction US workers and 44% among woodworkers in Nepal, respectively. Prevalence ratios can vary depending on the study sample and the nature of the workplace, therefore are not readily generalizable nor easily comparable. However, as expected, the current study found that ONIHL is significantly associated with age, nationality, years of experience, noise exposure and job type, in agreement with the previous literature (Dement et al. 2018; Leensen et al. 2011). The odds of ONIHL increased with age and years of work experience, which is in line with Dement et al. (2018) and Eldin et al. (2016). Furthermore, Hong (2005) and House et al. (2010), found that the prevalence of ONIHL was the highest among workers in construction with more years of work experience. Because our sample is largely from manufacturing industry, construction workers were, on average, younger and not fully representative of the entire construction industry which may explain the apparent crude protective effect of working in construction compared to administrative workers who tend to be old. After adjustments to age and years of experience, none of the industry types were significant.

The age pattern observed in the study is similar to those of Carroll et al. (2017) and Masterson et al. (2013). Interventions aimed at reducing exposure to noise at the workplace must consider predictors that are significantly associated with ONIHL. For example, older workers must be carefully targeted for risk reduction. Such interventions include re-designing the workplace, noise training, substituting forms of work, providing community and workplace support, and implementing health promotion and disease prevention programs, as well as support programs for employees (Wegman & McGee, 2004).

Migrant workers worldwide suffer from significant issues that compromise physical health and mental wellbeing. In addition, they are at risk of having occupational diseases and injuries due to many stressors that arise from individual, occupational, environmental, and community domains (Alahmad et al., 2020). Migrant workers experience higher rates of hazardous job-related exposures in their work environments, which significantly results in adverse health effects, work injuries, and work-related fatalities (Moyce & Schenker, 2018). In particular, migrants in Kuwait could be synergistically exposed to occupational injuries and diseases, due to the cultural and language barriers that prevent adequate safety training. Migrant workers are about than two-thirds of the population in Kuwait but are mostly employed in low wage and hazardous jobs that may not provide adequate personal protective equipment and offer little or no training. Cumulatively, migrant workers become susceptible to ONIHL despite their young age.

The Kuwait Environmental Public Authority (KEPA) regulates noise control in industrial settings, namely, Articles (19), (54), and (55) from the Environmental Protection Law 42/2014 Amended by 99/2015 and Decision No. (210/2001). Furthermore, the Ministry of Social Affairs and Manpower have a Ministerial resolution No. (208/2011) regarding the safety levels and standards of noise in workplaces and areas. The legal text of each regulation is mentioned in table 4.

Although laws and regulations are in place to prevent and control noise in Kuwait, the results indicate a possible problem in the implementation of such rules and regulations. An overall prevalence of 20.4% in a slightly younger workforce indicates that industrial institutions and workers in Kuwait have a lot more to do. Thus, it is recommended that each company should provide a periodic report of its noise levels to KEPA, which should establish a robust monitoring system on industrial companies and a disciplinary fine system for violators. Moreover, each industrial company should provide employees with hearing conservation programs, which are intended to serve workers exposed to occupational noise. In general, a hearing conservation program should include noise exposure monitoring, hearing protection, and hearing testing, training, and record-keeping (CDC, 2005). International companies, especially globally recognized ones, widely utilize hearing conservation programs. In several countries, the program is mandatory. In Kuwait, however, hearing conservation programs are not legally mandated. Notably, SIMC recently initiated its hearing conservation program and is expected to yield results in the near future. Moreover, we recommend that companies should follow optimal methods for preventing workplace hazards through the use of primary prevention measures, such as engineering controls, modification of work practices, and administrative controls. As the saying goes, “an ounce of Prevention is worth a pound of cure”, primary prevention turns out to be the best strategy to avoid the effects of acoustic trauma. Hearing conservation programs (HCPs) in grade school children are potentially effective to increase the knowledge about the hazards of noise exposure early in life and this may be associated with behavioral changes towards noise reduction and ear protection (Neufeld et al, 2011). For noise in the workplace, the hierarchy of controls has its place here, from elimination (best line of defense) or reduction of noise through engineering or administrative controls. Laws and legislation on occupational noise exposure (if and when enforced) will be instrumental in regulating noise exposure, which results in noise reduction and/or noise reducing technical improvements to protect employees (Joy and Middendorf, 2007). Hearing protection equipment’s offers a secondary level of protection. However, evidence for effective hearing loss prevention programs (using personal hearing protection) is limited. Indeed, there are challenges in preventing and controlling exposure to occupational noise that need to be recognized in establishing a hearing conservation program. However, there are challenges in preventing and controlling exposure to occupational noise that need to be recognized in establishing a hearing conservation program. Indeed, Tikka et al (2017) concluded that, while earmuffs and earplugs can reduce noise to safe levels, without proper training, they might not provide sufficient protection. On the other hand, engineering solutions might be as effective as PPEs, only if they are implemented carefully (Tikka et al. 2017).

Limitations

The study has its limitations. First, the sample was extracted from data provided by SIMC; thus, the sample may not be representative of all industrial workers in Kuwait. However, the results are comparable to studies utilizing random samples. Second, noise exposure information was self-reported. Such exposure assessment is prone to recall bias and therefore should be interpreted with caution. The current study used one audiogram per employee in estimating a snapshot prevalence. Follow-up studies based on a baseline audiogram and a repeated measures of periodic audiogram per worker will be critical to establish temporality. Moreover, the study was short of data on education level and behavioral aspects, such as the use of headphones for phone calls or listening to music, which may have influenced the results. Future research should focus on a representative sample and collect additional specific data on hearing thresholds and covariates to render the results generalizable. Finally, future studies in Kuwait must also investigate the economic and social burdens of ONIHL, which could be significant to public health.

Conclusion

In conclusion, migrant workers worldwide suffer from significant issues that compromise their physical health and mental wellbeing. The study provided evidence that one-fifth of migrant industrial workers in Kuwait suffer from hearing loss likely from occupational exposure. The prevalence of ONIHL calls for prevention using available measures, such as the existing use of hearing protection devices and hearing conservation programs. The results point to several recommendations. In Kuwait, companies must adhere to the permissible noise levels following the local laws as well as international standards such as the recommendations of the U.S. Occupational Safety and Health Administration (OSHA). In addition, implementation of laws must be more assertive as KEPA continues its monitoring of the industrial sector. Preventing hearing loss can reduce significant social and health burdens on individuals and the population.

References

Alahmad, B., Kurdi, H., Colonna, K., Gasana, J., Agnew, J. and Fox, M. 2020. COVID-19 stressors on migrant workers in Kuwait: cumulative risk considerations. *BMJ Global Health*, 5(7), p. e002995.

Al-Fajjam, S. and Samir, A., 2018. Work-Related Accidents Referred to Industrial Medical Center, Kuwait, From 2015 To 2017. *Egyptian Journal of Occupational Medicine,* 42(2), pp.285-302.

Ali, S., Morgan, M., & Ali, U. (2014). Is it reasonable to use 1 and 8 kHz anchor points in the medico-legal diagnosis and estimation of noise-induced hearing loss?. *Clinical Otolaryngology*, *40*(3), 255-259. doi: 10.1111/coa.12362

Carroll, Y. and Eichwald, J. 2017. CDC research on non-occupational NIHL. *The Hearing Journal*, 70(4), p. 40.

CDC, NOISH. 2005. *A Model Hearing Conservation Program* [eBook]. Available at: https://www.cdc.gov/niosh/mining/userfiles/workshops/hlp1/03-byrneconservationprograms.pdf

Dement, J., Welch, L., Ringen, K., Cranford, K. and Quinn, P. 2018. Hearing loss among older construction workers: Updated analyses. American Journal of Industrial Medicine, 61(4), pp. 326-335.

Eldin, W., Khalil, S., Elhosseiny, D. and Shaarawy, M. 2016. Occupational noise-induced hearing loss and hypertension: A cross-sectional study among dry food factory workers. *The Egyptian Journal of Community Medicine*, 34(3), pp. 79-91.

Frederiksen, T.W., Ramlau-Hansen, C.H., Stokholm, Z.A., Grynderup, M.B., Hansen, Å.M., Kristiansen, J., Vestergaard, J.M., Bonde, J.P. and Kolstad, H.A., 2017. Noise-induced hearing loss–a preventable disease? Results of a 10-year longitudinal study of workers exposed to occupational noise. *Noise & Health*, *19*(87), p.103.

Hong, O. 2005. Hearing loss among operating engineers in American construction industry. *International Archives of Occupational and Environmental Heal*th, 78(7), pp. 565-574.

Euro.who.int. (2019). *Noise*. [online] Available at:http://www.euro.who.int/en/health-topics/environment-and-health/noise/noise [Accessed 21 Apr. 2019].

EU 2003 - EU. Directive 2003/10/EC on the minimum health and safety requirements regarding exposure of workers to the risks arising from physical agents (noise). EU 2003.

House, R., Sauvé, J. and Jiang, D. 2010. Noise-induced hearing loss in construction workers being assessed for hand arm vibration syndrome. *Canadian Journal of Public Health*. Available at: https://www.jstor.org/stable/41995446 [Accessed 24 April 2019].

Johnson AC, Morata TC. Occupational exposure to chemicals and hearing impairment. *Arbete och Halsa* 2010; **44**:1–177. [https://gupea.ub.gu.se/bitstream/2077/23240/ 1/gupea˙2077˙23240˙1.pdf]

Joy GJ, Middendorf PJ. Noise exposure and hearing conservation in U.S. coal mines–a surveillance report 2007. *J Occup Environ Hyg. 4:26–35.*

KEPA, 2001. *Decision No. 210/2001*. Environment Public Authority.

KEPA, 2020. *Decision Number (4) for the Year 2020*. Kuwait: Enviroment Public Authority Kuwait.

Kitcher, E., Ocansey, G. and Tumpi, D. 2012. Early occupational hearing loss of workers in a stone crushing industry: Our experience in a developing country. *Noise and Health,* 14(57), p. 68.

Khoshakhlagh, A., Yazdanirad, S. and Sarsangi, V. 2018. The relationship between individual risk factors and hearing loss in textile workers. *Archives of Occupational Health*, 2(2).

Masterson, E., Tak, S., Themann, C., Wall, D., Groenewold, M., Deddens, J. and Calvert, G. 2013. Prevalence of hearing loss in the United States by industry. *American Journal of Industrial Medicine*, 56(6), pp. 670-681.

Moyce, S. and Schenker, M. 2018. Migrant workers and their occupational health and safety. *Annual Review of Public Health*, 39(1), pp. 351-365.

Neufeld A, Westerberg BD, Nabi S, et al., 2011. Prospective, randomized controlled assessment of the short- and long-term efficacy of a hearing conservation education program in Canadian elementary school children*. Laryngoscope.121:176–81.*

Rabinowitz, P., Sircar, K., Tarabar, S., Galusha, D. and Slade, M. 2005. Hearing loss in migrant agricultural workers. *Journal of Agromedicine*, 10(4), pp. 9-17.

Robinson T., Whittaker J., Acharya A., Singh D. and Smith M. 2015. Prevalence of noise induced hearing loss among woodworkers in Nepal: a pilot study*. International Journal of Occupational and Environmental Health,* 21(1), pp. 14-22.

Wegman, D. and McGee, J. 2004. *Health and Safety Needs of Older Workers*. Washington, DC: National Academies Press.

Centers for Disease Control and Prevention (CDC). 2019. *Loud Noises Damage Hearing*. Available at: https://www.cdc.gov/media/dpk/injury-violence-safety/noise-induced-hearing-loss/hearing-loss.html [Accessed 1 May 2019].

Chen, K., Su, S. and Chen, K. 2020. An overview of occupational noise-induced hearing loss among workers: epidemiology, pathogenesis, and preventive measures. *Environmental Health and Preventive Medicine*, 25(1), pp. 1-10.

Chisolm, T., Johnson, C., Danhauer, J., Portz, L., Abrams, H., Lesner, S., McCarthy, P. and Newman, C. 2007. A systematic review of health-related quality of life and hearing aids: Final report of the American Academy of Audiology Task Force on the health-related quality of life benefits of amplification in adults. *Journal of the American Academy of Audiology*, 18(2), pp. 151-183.

Friis, R. 2019. *Essentials of Environmental Health* (3rd ed.).

Global Burden of Disease Study 2013 Collaborators 2015. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet (London, England)*, 386(9995), pp. 743-800. https://doi.org/10.1016/S0140-6736(15)60692-4

Leensen, M., van Duivenbooden, J., and Dreschler, W. (2011). A retrospective analysis of noise-induced hearing loss in the Dutch construction industry. *International Archives of Occupational and Environmental Health*, 84(5), pp.577-590.

Le, T., Straatman, L., Lea, J., & Westerberg, B. (2017). Current insights in noise-induced hearing loss: a literature review of the underlying mechanism, pathophysiology, asymmetry, and management options. *Journal Of Otolaryngology - Head & Neck Surgery*, *46*(1). doi: 10.1186/s40463-017-0219-x

Li, C. M., Zhang, X., Hoffman, H. J., Cotch, M. F., Themann, C. L. and Wilson, M. R. 2014. Hearing impairment associated with depression in US adults, National Health and Nutrition Examination Survey 2005-2010. *JAMA Otolaryngology--Head & Neck Surgery*, 140(4), pp. 293-302. https://doi.org/10.1001/jamaoto.2014.42

Lie, A., Skogstad, M., S Johnsen, T., Engdahl, B. and Tambs, K. 2016. Noise-induced hearing loss in a longitudinal study of Norwegian railway workers. *BMJ Open*. doi: 10.1136/bmjopen-2016-011923

Lin, F. R. and Albert, M. 2014. Hearing loss and dementia—who is listening? *Aging & Mental Health*, 18(6), pp. 671-673. https://doi.org/10.1080/13607863.2014.915924

Low, W., Tong, W. and Binns, C. 2015. Migrant workers in Asia Pacific and their rights to health. *Asia Pacific Journal of Public Health*, 27(6), pp. 584-587.

Mirza, R., Kirchner, B., Dobie, R. and Crawford, J. 2018. Occupational noise-induced hearing loss. *Journal of Occupational and Environmental Medicine*, 60(9), pp. 498-500.

Moyce, S. and Schenker, M. 2018. Migrant workers and their occupational health and safety. *Annual Review of Public Health*, 39(1), pp. 351-365.

Nelson, D., Nelson, R., Concha-Barrientos, M. and Fingerhut, M. 2005. The global burden of occupational noise-induced hearing loss. *American Journal of Industrial Medicine*, 48(6), pp. 446-458.

PACI. 2019. The Public Authority for Civil Information. Government of Kuwait.

Shargorodsky, J., Curhan, G., & Farwell, W. (2010). Prevalence and Characteristics of Tinnitus among US Adults. *The American Journal Of Medicine*, *123*(8), 711-718. doi: 10.1016/j.amjmed.2010.02.015

Tikka C, Verbeek JH, Kateman E, Morata TC, Dreschler WA, Ferrite S. Interventions to prevent occupational noise-induced hearing loss. *Cochrane Database of Systematic Reviews* 2017, Issue 7. Art. No.: CD006396. DOI: 10.1002/14651858.CD006396.pub4

WHO Programme For Prevention Of Deafness And Hearing Loss: An Outline. [eBook] WHO. Available at: https://www.paho.org/hq/index.php?option=com_docman&view=download&category_slug=publications-pob-eye-care-9511&alias=42722-who-programme-for-prevention-deafness-hearing-loss-an-outline-722&Itemid=270&lang=en [Accessed 10 December 2020].

Wang, Y., Hirose, K., & Liberman, M. C. (2002). Dynamics of noise-induced cellular injury and repair in the mouse cochlea. *Journal of the Association for Research in Otolaryngology : JARO*, *3*(3), 248–268. https://doi.org/10.1007/s101620020028

Ministerial Resolution No. (208) of 2011. [ebook] Kuwait: The Ministry of Social Affairs and Manpower. Available at: <https://www.manpower.gov.kw/docs/LaborLaw/18.pdf> [Accessed 25 February 2021]

Tables

Demographic characteristics	N	All (n = 3476)		Without ONIHL (n = 2764)		With ONIHL (n = 710)		
		n	(%)	n	(%)	N	(%)	P-value
All	3474	3474	(100)	2762	(79.6)	710	(20.4)	
Age (years)	3474							<0.001*
21–30		712	(20.5)	672	(94.4)	40	(5.6)	
31–40		1268	(36.5)	1124	(88.6)	144	(11.4)	
41–50		921	(26.5)	689	(74.8)	232	(25.2)	
51–60		517	(14.9)	262	(50.7)	255	(49.3)	
≥61		56	(1.60)	17	(30.4)	39	(69.6)	
Median Age (years) [IQR]	3474	*38*	*[15]*	*37*	*[13]*	*49*	*[14]*	*<0.001**
Gender	3474							<0.002*
Male		3434	(98.8)	2725	(79.4)	709	(20.6)	
Female		40	(1.2)	39	(97.5)	1	(2.5)	
Nationality	3474							*<0.001**
Indian		1974	(56.8)	1584	(80.2)	390	(19.8)	
Egyptian		483	(13.9)	392	(81.2)	91	(18.8)	
Bangladeshi		271	(7.8)	210	(77.5)	61	(22.5)	
Filipino		181	(5.2)	130	(71.8)	51	(28.2)	
Pakistani		141	(4.1)	89	(63.1)	52	(36.9)	
Kuwaiti		70	(2.0)	58	(82.9)	12	(17.1)	
Others		354	(10.2)	301	(85.0)	53	(15.0)	
Experience (years)	3441							<0.001*
≤15		2974	(85.4)	2448	(82.3)	526	(17.7)	
16–30		418	(12.1)	272	(65.1)	146	(34.9)	
≥30		49	(1.40)	18	(36.7)	31	(63.3)	
Median Experience (years) [IQR]	3474	*3*	*[3]*	*2*	*[4]*	*4*	*[9]*	*<0.001**
Exposure to Noise	3474							<0.001*
No		2262	(65.1)	1904	(84.2)	358	(15.8)	
Yes		1212	(34.9)	860	(71.0)	352	(29.0)	

1 *Baseline characteristics of industrial workers according to occupational noise-induced hearing loss status*

.: occupational noise-induced hearing loss

ficant at the 5% level.

tegorical association is conducted using global chi-square test. The Kruskal–Wallis test was conducted to determine the ation between continuous variables.

Job and industry type	N	All (n = 3476)		Without ONIHL (n = 2764)		With OHNIL (n = 710)		P-value
		n	(%)	n	(%)	n	(%)	P-value
All	3474	3474	(100)	2764	(79.6)	710	(20.4)	
Job Type	3474							*<0.001**
Managers		38	(1.1)	27	(71.1)	11	(28.9)	
Professionals		204	(5.9)	179	(87.7)	25	(12.3)	
Technicians and associate professionals		886	(25.5)	733	(82.7)	153	(17.3)	
Clerical support		110	(3.2)	98	(89.1)	12	(10.9)	
Services and sales		22	(0.6)	15	(68.2)	7	(31.8)	
Elementary occupations		735	(21.2)	624	(84.9)	111	(15.1)	
Crafts and related trade works		669	(19.3)	475	(71.0)	194	(29.0)	
Plant and machine operators and assemblers		810	(23.3)	613	(75.7)	197	(24.3)	
Industry type	3474							<0.001*
Mining and quarrying		786	(22.6)	676	(86.0)	110	(14.0)	
Manufacturing		1858	(53.5)	1400	(75.3)	458	(24.7)	
Water supply, sewerage, waste management, and remediation activities		89	(2.6)	83	(93.3)	6	(6.70)	
Construction		190	(5.5)	153	(80.5)	37	(19.5)	
Wholesale and retail trade and repair of vehicles and motorcycles		9	(0.3)	8	(88.9)	1	(11.1)	
Transportation and storage		42	(1.2)	27	(64.3)	15	(35.7)	
Professional, scientific, and technical activities		84	(2.4)	80	(95.2)	4	(4.8)	
Administrative and supportive service activities		416	(12)	337	(81.0)	79	(19.0)	

Baseline job and industry type of industrial workers according to occupational noise-induced hearing tus

ccupational noise-induced hearing loss.

nt at the 5% level.

orical association is conducted using global chi-square test.

de and adjusted odds ratio of occupational noise-induced hearing loss among 3474 industrial workers

characteristics	Sub-group	Crude odds ratio of ONIHL			Adjusted odds ratio of ONIHL		
	N	OR	[95% C.I.]	P-value	AOR	[95% C.I.]	P-value
	712	1	[Reference]		1	[Reference]	
	1268	2.2	[1.6–3.1]	0.001*	1.8	[1.3–2.7]	0.002*
	921	5.7	[4.0–8.1]	0.001*	4.6	[3.2–6.7]	0.001*
	517	16.4	[11.4–23.5]	0.001*	13.2	[8.8–19.6]	0.001*
	56	38.5	[20.1–74.0]	0.001*	30.5	[15.2–61.5]	0.001*
	3434	1	[Reference]		1	[Reference]	
	40	0.1	[0.013–0.716]	0.022*	0.182	[0.02–1.4]	0.100
	1974	1	[Reference]		1	[Reference]	
	483	0.1	[0.73–1.2]	0.628	1.1	[0.9–1.5]	0.346
	271	1.2	[0.87–1.6]	0.301	0.9	[0.6–1.3]	0.568
	181	1.6	[1.1–2.2]	0.008*	1.5	[1.0–2.2]	0.039*
	142	2.4	[1.7–3.4]	0.000*	2.2	[1.4–3.3]	0.001*
	70	0.8	[0.44–1.6]	0.581	1.0	[0.4–2.7]	0.986
	354	0.7	[0.52–0.97]	0.033*	0.8	[05–1.1]	0.178
teristics							
ears)							
	2974	1	[Reference]		1	[Reference]	
	418	2.5	[2.0–3.1]	0.001*	1.1	[0.9–1.5]	0.380
	49	7.9	[4.4–14.4]	0.001*	2.2	[1.1–4.3]	0.021*
loise							
	2262	1	[Reference]		1	[Reference]	
	1212	2.2	[1.9–2.6]	0.001*	2.0	[1.7–2.4]	0.001*
stry type							
occupations	734	1	[Reference]		1	[Reference]	
	38	2.3	[1.1–4.8]	0.024*	1.2	[0.5–2.8]	0.673
ls	204	0.8	[0.5–1.3]	0.326	0.9	[0.5–1.5]	0.579
and associate professionals	886	1.2	[0.9–1.6]	0.198	0.9	[0.7–1.3]	0.641
pport	110	0.7	[0.4–1.4]	0.259	0.7	[0.4–1.4]	0.350
d sales	22	2.6	[1.1–6.6]	0.038*	1.5	[0.5–4.1]	0.436
related trade works	669	2.3	[1.8–3.0]	0.000*	1.6	[1.2–2.2]	0.002*
achine operators and assemblers	810	1.8	[1.4–2.3]	0.000*	0.9	[0.7–1.3]	0.737
ive and supportive service	416	1	[Reference]		1	[Reference]	
quarrying	786	0.3	[0.2–0.8]	0.024*	0.7	[0.5–1.1]	0.116
ing	1858	0.5	[0.3–1.1]	0.013*	0.8	[0.6–1.2]	0.347
ly, sewerage, waste management ion activities	89	0.3	[0.1–0.8]	0.008*	0.5	[0.2–1.3]	0.161
	190	1.1	[0.4–3.6]	0.888	1.3	[0.8–2.2]	0.297
and retail trade and repair of notorcycles	9	1.0	[0.5–2.1]	0.556	0.2	[0.01–1.5]	0.109
ion and storage	42	0.8	[0.4–1.6]	0.012*	1.6	[0.8–3.8]	0.257
l, scientific, and technical	84	0.4	[0.2–0.9]	0.003*	0.5	[0.2–1.5]	0.237

C Kuwait (2018)

pational noise-induced hearing loss; OR: odds ratio.

at the 5% level.

= Adjusted for Age, gender, nationality, years of experience, noise exposure, job type, and industry type.

Summary of workplace noise regulations in Kuwait

Regulator	Law number	Regulation
KEPA	Environmental Protection Law 42/2014 Amended by 99/2015-Article (19)	*"All establishments, in the exercise of their activities, are obligated to ensure the safety of workers and prevent exposure to damage resulting from the emission or leakage of pollutants in the work environment whether as a result of the nature of the establishment's practice of its activities or defects in equipment. Moreover, the necessary measures include taking precautions and measures to stay within the permissible safe limits for exposure to chemicals, noise and vibration, heat and humidity, lighting and ultrasound, inactive radiation, and other requirements specified by the executive regulations of this law."*
KEPA	Environmental Protection Law 42/2014 Amended by 99/2015-Article (54)	*"All parties and individuals producing or providing services, mostly during the operation of machinery and equipment and the use of alarm machines and amplifiers, are obligated to stay within the permissible limits of noise level and to conduct related activities in places allocated for this purpose. Lincensing authorities should consider the use of appropriate machinery such that the total frequencies of noise emitted from fixed sources in an area stay within permissible limits."*
KEPA	Environmental Protection Law 42/2014 Amended by 99/2015-Article (55)	*"The construction of establishments that emit noise and cause damage to the neighborhood environment is prohibited. The authority shall work to ensure the application of noise reduction regulations in roads, public projects, and around human gatherings and within the controls outlined in the executive regulations of this law. A fine of 500 Kuwaiti Dinars is imposed on any industrial institution found not observing this law"*
KEPA	Environmental Protection Law Decision No. (210/2001)	The permissible noise levels should be less 85 dBA per 8 hours
Ministry of Social Affairs and Manpower	Ministerial Resolution No. (208/2011)	The noise level in the workplace should be less than 85 dB and should not exceed 98 dB with a maximum exposure of 8 h per day