ORIGINAL ARTICLE

Noise-chemical Exposure Risk and Awareness of Hearing Loss in The Paint Manufacturing Industry: A Malaysian Perspective

Nur Faiza Abdul Razak[1,2], Farrah Azahirah Abdul Halim[2], Mohd Shukri Mohd Aris[2,3], Siti Fatimah Azzahra Zamri[4]

[1] Institute of Medical Science Technology, Universiti Kuala Lumpur, 43000 Kajang, Selangor , Malaysia
[2] Centre of Environmental Health & Safety Studies, Faculty of Health Sciences, Universiti Teknologi MARA, 42300 Puncak Alam, Selangor, Malaysia
[3] Occupational Health and Safety Risk Management (OHSeRM) Research Initiative Group, Universiti Teknologi MARA, 42300 Puncak Alam, Selangor, Malaysia
[4] Kossan Paint (M) Sdn Bhd, Meru Industrial Park, 42200 Kapar, Selangor, Malaysia

ABSTRACT

Introduction: Noise cannot be assumed to be the only ultimate risk factor that causes hearing loss. Nowadays, hearing loss is not solely caused by noise-induced hearing loss (NIHL), chemical-induced hearing loss (CIHL) also significantly contributes to the global prevalence of hearing disorders (WHO, 2018; Kwon, 2021; Hemmativaghef, 2020). Thus, this study focused on group exposure in high-risk industries, like paint manufacturing, to explore how solvent-related noise may contribute to hearing loss while also assessing workers' awareness of NIHL and CIHL. **Method:** This study in a paint factory assessed workers' exposure to noise and toluene using Noise Risk Assessment (NRA), Chemical Health Risk Assessment (CHRA) and the NoiseChem questionnaire, with data analysed via SPSS to explore hearing issues and awareness. **Results:** The study revealed a significant variation in noise levels across different work areas within the paint manufacturing facility, as identified through One-Way ANOVA. However, no significant association was found between the exposure groups and reported hearing problems, based on the results of a Chi-square test ($p > 0.05$), despite a notable number of workers being exposed to both noise and ototoxic chemicals. The study also shed light on the awareness levels among painting workers concerning their potential hearing problems and CIHL resulting from noise and ototoxic chemical exposure. **Conclusion:** The findings highlight insufficient awareness of hearing issues from occupational noise and solvent exposure. Regular audiometric screening and improved control measures for solvent exposure are recommended to better protect workers and reduce the risk of CIHL.

Malaysian Journal of Medicine and Health Sciences (2026) 22(SUPP3): 79-83. doi:10.47836/mjmhs.22.s3.12

Keywords: NIHL, CIHL, solvent, toluene, hearing problems

Corresponding Author:
Mohd Shukri Mohd Aris, PhD
Email: myshukri@uitm.edu.my
Tel: +60-12376 1808

INTRODUCTION

Occupational safety and health remain a critical concern in high-risk industries due to the frequent exposure of workers to hazardous substances and environments. Among the most prevalent occupational health risks is noise-induced hearing loss (NIHL), a widespread concern globally among industrial workers due to its significant and often irreversible impact on health and well-being (1). NIHL not only diminishes workers' quality of life and productivity but also compromises workplace safety by reducing their ability to detect warning signals and alarms during operations (2). With the continued rise of industrialisation, the global incidence of occupational hearing loss is projected to increase from 6.12% in 2018 to 9.6% by 2050, underscoring the growing importance of addressing NIHL (3). In Malaysia, NIHL remains the most frequently reported occupational disease, with the Department of Occupational Safety and Health (DOSH) recording 6,754 NIHL cases out of 8,155 total occupational disease cases in 2023(4). This concerning trend underscores the urgent need for comprehensive research on the multiple occupational hazards contributing to hearing loss, particularly noise and chemical exposure. Chemicals called ototoxic substances can cause hearing loss or increase sensitivity to noise, with effects observed from exposure to organic solvents, metals, and asphyxiants (5). Independent or combined exposures may lead to greater auditory damage. Workers co-exposed to noise and chemicals like solvents or carbon disulfide show a higher risk of hearing loss (6–10). Ototoxic compounds such as organic solvents, metals, and asphyxiants have been shown to

cause damage to the inner ear or auditory pathways, where acute effects involve direct damage to cochlear cells (11,12). One of the most notable ototoxicants is toluene, a widely used volatile organic compound (VOC) in the paint, lacquer, and adhesive industries. Toluene is a component of BTEX (benzene, toluene, ethylbenzene, xylene) formulations and is commonly released during routine processes such as spray painting (13). It is found in various industrial products, including paints, thinners, and degreasers. Toluene is a colourless liquid with a distinctive aromatic odour and can be absorbed through inhalation, ingestion, or skin contact when proper personal protective equipment (PPE) is not used (14). Due to its rapid evaporation, VOCs such as toluene present both environmental and health hazards if not adequately controlled. Simultaneously, many manufacturing processes produce excessive noise, compounding the risk of hearing impairment. Studies have documented the widespread presence of both toluene and other VOCs in industrial settings, reinforcing the need for effective exposure controls (15). The combined or synergistic effects of noise, representing NIHL, and chemical exposure, representing CIHL, pose an even greater risk to auditory health than either factor alone. Considering these concerns, there is a pressing need for structured evaluation approaches in the workplace, particularly those that assess both the level of worker awareness and the potential auditory impact of dual exposure. Authorities have established permissible exposure limits (PEL) to reduce health risks associated with chemical exposure in the workplace. The PEL is set at 50 ppm for styrene and 100 ppm for both toluene and ethylbenzene (16). This study aimed to examine the relationship between occupational exposure to noise and ototoxic chemicals, specifically toluene, and to determine the prevalence of workers who have hearing difficulties, especially concerning their exposure to noise and toluene. In addition, the study aimed to assess the level of workers' awareness regarding the risks of NIHL and CIHL.

MATERIALS AND METHODS

Sample collection

A cross-sectional study was conducted at a selected paint manufacturing company in Kapar, Selangor. The paint manufacturing company was an appropriate representation of high-risk industries where workers were routinely exposed to hazardous chemicals such as toluene, a solvent commonly used in paint mixtures. In addition, the workers are exposed to elevated noise levels resulting from machinery and production processes. As a result, a total of 80 operators participated in this study. The participants were divided into three groups based on their workplace exposure: a noise group (exposed only to noise), a solvent group (exposed to both noise and toluene), and a control group (not exposed to either noise or toluene). The inclusion criteria were that participants were chosen from selected work areas within the paint manufacturing facility where they were exposed to noise and toluene. In addition, workers from the office department were selected as a control group. On the other hand, exclusion criteria include operators with pre-existing hearing impairments, respiratory disorders, or other medical conditions that could affect the outcome of the study.

Review the Noise-Risk Assessment (NRA) and Chemical Health Risk Assessment (CHRA) reports

Current documentation and reports, specifically the NRA and CHRA reports, were reviewed. The NRA report provided a comprehensive evaluation of noise exposure levels in several work zones within the paint manufacturing company. The report included information on noise intensity, noise sources, and potential zones where noise exposure may be particularly high. Following that, the CHRA report on worker exposure to organic solvents at the workplace was reviewed to define the exposure group. The purpose of reviewing the CHRA report was to determine the status of the toluene level in different work areas. Operators from selected work areas that utilised toluene in their work routine were selected as the exposure group to answer the questionnaire.

NoiseChem Questionnaire

This research utilised the NoiseChem questionnaire (17) to gather the required research data from participants who were operators of the production area. The questionnaire consisted of three sections. Section A collected participants' personal information, Section B delved into their medical history, and Section C assessed participants awareness of occupational noise and solvent exposure in the workplace.

Data Integration

The data from the NoiseChem questionnaire obtained from the participants were analysed using the Statistical Package for the Social Sciences (SPSS) Version 27.0. Frequency analysis was performed to examine the distribution of exposure groups, while descriptive statistics were used to analyze demographic information such as gender and age. To address the study objectives, a One-Way ANOVA was used to identify noise level differences across various work areas. The prevalence of hearing problems among workers was assessed using descriptive analysis. A Chi-square test was applied to examine the relationship between exposure to noise and toluene with reported hearing problems. Lastly, descriptive analysis was also employed to assess workers' awareness of noise-induced hearing loss (NIHL) related to chemical exposure.

RESULTS

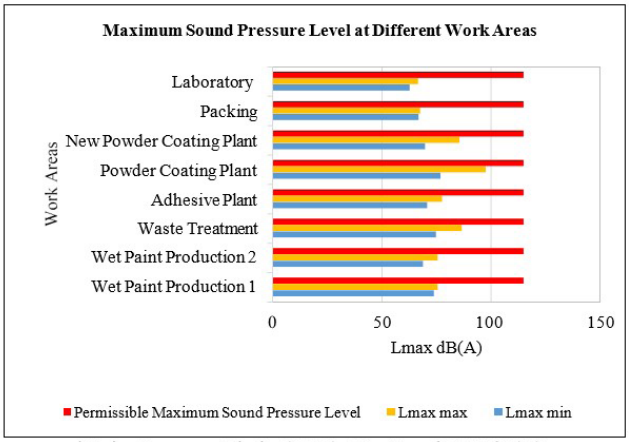
Demographic characteristics of respondents

80 operators in the paint manufacturing company were selected based on the inclusion and exclusion criteria. Many of the respondents fall within the age of 20 to 30

years old.

Noise Level at Different Work Areas

An analysis was conducted on the noise levels in different work areas. The average noise level in Wet Paint Production 1 was found to be 74.8 dB(A). Variations in noise levels were observed in Wet Paint Production 2, waste treatment, adhesive plant, powder coating plant, packing, and laboratory. All noise levels remained below the specified NEL, with many areas recording levels below 80 dB(A). The packing and laboratory areas had the lowest noise level, while the powder coating plant had the highest noise level at 98.0 dB(A). The results of the comparison of noise levels at different work areas are shown in Fig I.



*Noise Exposure Limits (NEL): Max Level: 115 dB(A)

Fig. 1: The maximum sound pressure level at different work areas. An analysis of workplace noise revealed Wet Paint Production 1 averaged 74.8 dB(A), with all areas below NEL. Variations were observed in Wet Paint Production 2, waste treatment, adhesive plant, powder coating plant, packing, and laboratory, with packing and laboratory being the quietest and powder coating reaching 98.0 dB(A).

The NRA report evaluated workers' exposure in different work areas with high maximum sound pressure levels, such as a powder coating plant, a new powder coating plant, waste treatment, and one specific area with the lowest Lmax. Except for the laboratory and waste treatment areas, the majority of work areas adhered to noise exposure regulations. The personal exposure results on paint manufacturing working areas are presented in Table I.

Level of toluene in different work areas

Data on toluene levels in different work areas were obtained from Chemical Exposure Monitoring (CEM) reports. The exposure level to toluene (ppm) in the air at the worksite was below the permissible exposure limit (PEL), as specified in Schedule I of USECHH Regulation 2000. Table II displays the toluene levels in the production area.

Table II: Toluene Levels in Different Work Areas

Parameter	Work Area	Permissible Exposure Limit (PPM)	Results of CEM
Toluene	Raw material preparation Wet paint mill grinding Wet paint drum & filter washing Wet paint R&D Wet paint mixing	50	Below PEL

Hearing Problems Between Different Group Exposure

According to Table III, 30 per cent of workers in the paint industry reported having problems with hearing, which had an impact on their general well-being, safety, and health. Nonetheless, 70 per cent of workers stated they had no problems with hearing.

Table III: Frequency of Hearing Problems Among Workers.

Hearing problems	Frequency	Percentage (%)
Yes	24	30

The study revealed at Table IV that among the participants, 18.4 per cent from 38 workers, were exposed to solvents and noise , and 43.8 per cent from 32 workers, were exposed to noise only reported hearing problems. Additionally, 30.0 per cent from 10 workers of the control group workers also experienced hearing problems. Nevertheless, there was no significant association between group exposure and auditory impairments.

Table IV: Relationship Between Group Exposure and Hearing Problem

	Having Hearing problem	Not Having Hearing Problem n(%)	X^2 statistic (df)	P-value
Solvent	7(18.4)	31(81.6)	5.307(2)	0.070
Noise	14(43.8)	18(56.3)	-	-
Control	3(30.0)	7(70.0)	-	-

Table I: Result of Personal Noise Monitoring.

No	SEG	Working Area	LaeqTe dB(A)	LEX,8h dB(A)	Max Level dB(A)	Peak Level dB(C)	Compliance Status
S1	Operators	Wet Paint Production 1	81.8	81.2	102.6	129.7	Complied
S2		Waste Treatment	85.1	84.5	101.5	127.5	Not complied
S3		Powder Coating Production	82.1	81.5	101.1	128.0	Complied
S4			78.0	77.4	103.4	129.5	Complied
S5		Laboratory	84.6	84.0	99.2	121.0	Not complied

Excessive Noise Level: LeqTe = 82 dB (A) 2. Noise Exposure Limits (NEL): LEX, 8h = 85 dB (A): Max Level = 115 dB (A) and: Peak Level = 140 dB 3.

The study examined workers' awareness of hearing problems due to occupational exposure, specifically NIHL and CIHL. The results showed at Table V that 36.3 per cent of workers perceived hearing problems from ototoxic chemicals as a significant issue. Meanwhile, 28.7 per cent of workers identified it as a concern. The remaining 35.0 per cent of workers regarded hearing problems due to occupational exposure as not a problem at all. 33.8 per cent of workers considered hearing problems caused by noise exposure to be a significant issue, while the highest percentage (43.8%) did not fully acknowledge the extent of its impact. This indicated that most workers possessed a limited level of awareness regarding potential hearing problems of NIHL and CIHL.

Table V: Awareness Regarding Hearing Problems.

Questions	Big problem,N (%)	Not a big problem,N (%)	No problem at all,N (%)
Hearing problems as a result of ototoxic chemical exposure	29(36.3%)	23(28.7%)	28(35%)
Hearing problems as a result of noise exposure	27(33.9%)	18(22.5%)	35(43.8%)

DISCUSSION

According to the NRA report, the noise level was primarily characterised as steady-continuous and fluctuating-continuous. The noise was identified as originating from a range of sources, including heavy machinery and activities in the production area. The machines and activities in this work area also emitted noises that were transmitted to the surroundings and impacted workers in that work area.

In addition, the NRA report highlighted that the main source of excessive noise from the waste treatment facilities came from blowers and air guns. Meanwhile, the excessive noise from the laboratory came from machinery and its activities. As stated in the Occupational Safety and Health (Noise Exposure) Regulation 2019, the permissible noise exposure is 85 dB(A) for 8 hours (18). Therefore, the noise levels in most work areas complied with regulations, except for personal monitoring in waste treatment and laboratory areas. The areas recorded the Laeq values of 85.1 dB(A) and 84.6 dB(A), respectively, which surpassed the allowable noise exposure limits. Upon combining the results of noise level assessments in work areas and personal noise monitoring, it was determined that many workers in the powder coating plant were subjected to high levels of noise.

The analysis, using a Chi-square test, found no significant association between different exposure groups and reported hearing problems. This is contrary to previous studies in which exposure to solvents, heavy metals, and noise appeared to damage hearing due to combined exposures (19). The limitation of the study stemmed from its dependence on the subjective assessments of research participants concerning hearing problems and the absence of accurate audiometry test outcomes to compare the hearing health of workers. This limitation potentially affected the study's validity and reliability. Without comprehensive audiometry assessments, the study's findings may lack depth. Thus, the results may not fully capture the nuances of workers' hearing impairments. Therefore, addressing this limitation is crucial for enhancing the study's credibility and ensuring more robust conclusions regarding occupational hearing issues.

Many workers acknowledged the seriousness of NIHL, but they were not aware of the potential impact of CIHL, which has a comparable impact. As a result, a significant number of workers continued to have poor levels of awareness of CIHL. The finding is aligned with the results of another study that investigated the knowledge, attitude, and practice of noise-induced hearing loss among quarry workers in Malaysia. The study revealed that the workers' scores in the areas of knowledge, attitude, and practice were all below average (20). These findings are useful in developing targeted awareness campaigns or educational interventions to improve the understanding and promote preventive actions for occupational hearing health.

CONCLUSION

In conclusion, this study offers valuable insights into occupational health and safety in the manufacturing sector, particularly concerning exposure to noise and ototoxic chemicals. The findings demonstrate that noise levels varied significantly across different work areas. However, no significant association was found between exposure groups and reported hearing problems, as determined by a Chi-square test. It is important to acknowledge that this study did not include audiometric testing, relying instead on self-reported data from participants. This limitation may affect the accuracy of hearing loss prevalence and should be considered when interpreting the results. Future research is encouraged to incorporate objective audiometric evaluations to obtain more reliable and comprehensive findings. The study also revealed a generally low level of awareness among workers regarding the risks of NIHL and CIHL. This highlights the need for targeted awareness programs, routine audiometry screening, and stricter control of solvent exposure to enhance workplace hearing conservation efforts. Overall, the understanding of occupational hearing loss should extend beyond noise alone to include chemical exposures that may contribute significantly to auditory impairments.

ACKNOWLEDGEMENT

This research was funded by a National grant (Ministry of Higher of Education) - FRGS/1/2021/SKK06/UITM/02/2.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

ETHICAL CLEARANCE

We obtained approval from the UiTM research Committee (Ref No: REC/09/2023 (PG/MR/358).

REFERENCES

1. Chen, K. H., Su, S. B., & Chen, K. T. (2020). An overview of occupational noise-induced hearing loss among workers: Epidemiology, pathogenesis, and preventive measures, 0, 1–10.
2. Razak, A., Aris, M., & Shukri, M. (2024). Overview of the prevalence and contributing factors for occupational noise-induced hearing loss (NIHL) in Malaysia. International Medical Journal Malaysia (IMJM), 23(3).
3. World Health Organization. (2018). Addressing the rising prevalence of hearing loss (pp. 655–658). Geneva, Switzerland. https://apps.who.int/iris/handle/10665/260336
4. Department of Statistics Malaysia. (2023). National occupational injury and disease statistics 2023.
5. Morata, T. C., & Johnson, A. C. (2012). Effects of exposure to chemicals on noise-induced hearing loss. In D. Henderson, R. J. Salvi, A. Quaranta, A. C. Fiorino, & R. Hamernik (Eds.), Noise and Health (pp. 223–254). Springer. https://doi.org/10.1007/978-1-4419-9523-0_11
6. Choi, Y. H., & Kim, K. S. (2014). Noise-induced hearing loss in Korean workers: Co-exposure to organic solvents and heavy metals in nationwide industries. PLoS ONE, 9(5), e97538. https://doi.org/10.1371/journal.pone.0097538
7. Staudt, A. M., Whitworth, K. W., Chien, L. C., Whitehead, L. W., & Gimeno Ruiz de Porras, D. (2019). Association of organic solvents and occupational noise on hearing loss and tinnitus among adults in the U.S., 1999–2004. International Archives of Occupational and Environmental Health, 92(3), 403–413. http://dx.doi.org/10.1007/s00420-019-01419-2
8. Chang, S. J., Chen, C. J., Lien, C. H., & Sung, F. C. (2006). Hearing loss in workers exposed to toluene and noise. Environmental Health Perspectives, 114(8), 1283–1286.
9. Chang, S. J., Shih, T. S., Chou, T. C., Chen, C. J., Chang, H. Y., & Sung, F. C. (2003). Hearing loss in workers exposed to carbon disulfide and noise. Environmental Health Perspectives, 111(13), 1620–1624.
10. Hemmativaghef, E. (2020). Exposure to lead, mercury, styrene, and toluene and hearing impairment: Evaluation of dose-response relationships, regulations, and controls. Journal of Occupational and Environmental Hygiene, 17(11–12), 574–597. https://doi.org/10.1080/15459624.2020.1842428
11. Kwon, J. (2021). Occupational hearing loss. Eye Ear Nose Throat Monthly, 34(2), 105–107.
12. Lewkowski, K., Heyworth, J. S., Li, I. W., Williams, W., McCausland, K., Gray, C., et al. (2019). Exposure to noise and ototoxic chemicals in the Australian workforce. Occupational and Environmental Medicine, 76(5), 341–348.
13. Morata, T. C., Fiorini, A. C., Fischer, F. M., Colacioppo, S., Wallingford, K. M., Krieg, E. F., et al. (1997). Toluene-induced hearing loss among rotogravure printing workers. Scandinavian Journal of Work, Environment & Health, 23(4), 289–298.
14. Agency for Toxic Substances and Disease Registry (ATSDR). (2017). Toxicological profile for toluene. U.S. Department of Health and Human Services.
15. Campo, P., Lataye, R., Cossec, B., & Placidi, V. (1997). Toluene-induced hearing loss: A mid-frequency location of the cochlear lesions. Neurotoxicology and Teratology, 19(2), 129–140.
16. Department of Occupational Safety and Health (DOSH). (2000). Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000. Malaysia.
17. Morata, T. C., & Little, M. B. (2002). Suggested guidelines for studying the combined effects of occupational exposure to noise and chemicals on hearing. Noise & Health, 4(14), 73–87.
18. Department of Occupational Safety and Health (DOSH). (2019). Occupational Safety and Health (Noise Exposure) Regulations 2019. http://www.dosh.gov.my/index.php/en/legislation/regulations-1/osha-1994-act-154/3174-00-occupational-safety-and-health-noise-exposure-2019/file
19. Schaal, N. C. (2017). Chemical induced hearing loss in shipyard workers. Journal of Occupational and Environmental Medicine, 1–25.
20. Filza Ismail, A., Daud, A., Ismail, Z., & Abdullah, B. (2013). Noise-induced hearing loss among quarry workers in a north-eastern state of Malaysia: A study on knowledge, attitude and practice. Oman Medical Journal, 28(5), 331–336.