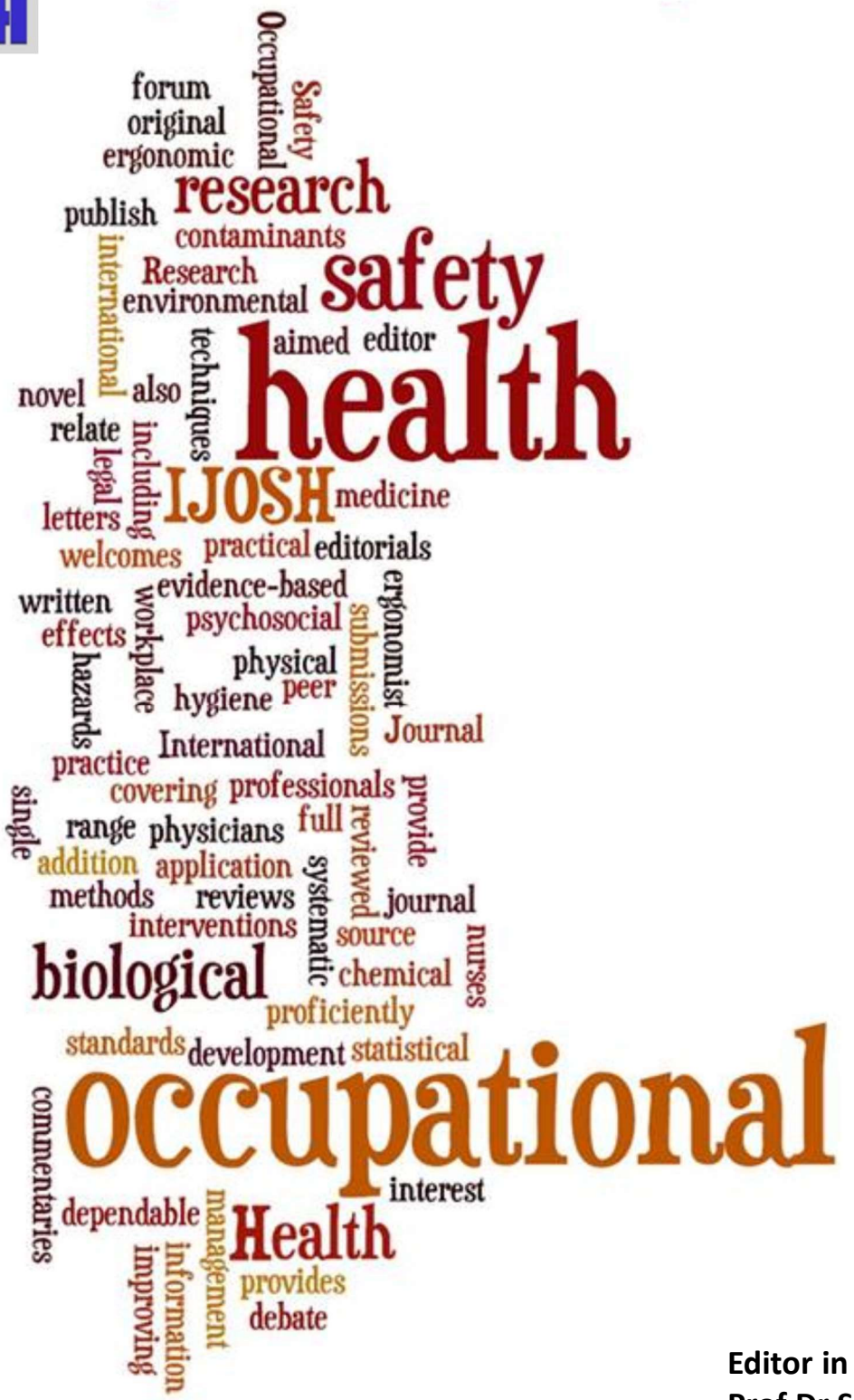
International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Vol 14, No 2 (2024)



Journal website: http://www.nepjol.info/index.php/IJOSH/index
Official journal of the Occupational Health and Safety Society of Nepal

OPEN ACCESS

DOAJ EBSCO Embase Google scholar INDEX COPERNICUS INTERNATIONAL Scopus

International Journal of Occupational Safety and Health

Vol 14, No 1 (2024)

ISSN: 2091-0878 (Online)
ISSN: 2738-9707 (Print)

Table of Contents

Short communications

Original Articles

Journal website: http://www.nepjol.info/index.php/IJOSH/index
Official journal of the Occupational Health and Safety Society of Nepal

International Journal of Occupational Safety and Health

Vol 14, No 1 (2024)

ISSN: 2091-0878 (Online)
ISSN: 2738-9707 (Print)

Table of Contents

Original Articles

Review Articles

Journal website: http://www.nepjol.info/index.php/IJOSH/index
Official journal of the Occupational Health and Safety Society of Nepal

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Short Communication

Ergonomic risk identification and postural analysis in electrical transformers manufacturing company located in Southern India

Biradar Vidyadhar G[1], Hebbal SS[1], Qutubuddin SM[1]

[1]PDA College of Engineering, Kalaburagi, Visvesveraya Technological University, Belagavi – 590018, India

Corresponding author:
Mr. Vidyadhar. G. Biradar ,
Department of Mechanical Engineering,
P.D.A. College of Engineering, Kalaburagi-585102, Karnataka, India.
Tel.: +919880023484
E-mail: vgbiradar@gmail.com
ORCID ID:https://orcid.org/0000-0001-9321-7732

Date of submission: 30.05.2023
Date of acceptance: 26.10.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.53692

ABSTRACT

Introduction: Musculoskeletal disorders are the major factors resulting in discomfort at work in manufacturing industries to workers and these conditions contribute to the poor health of the workforce, subsequently to lower productivity. Therefore, the design of a workstation based on Ergonomic principles is becoming significant to reduce the effects of MSD. This study aimed to identify and assess the ergonomic risks associated with the work tasks in the company through posture analysis and develop recommendations for reducing those risks.

Methods: About 36 manufacturing workers from five sections were randomly selected for the cross-sectional study. The chosen team members were from Core building, Core winding, Assembly, Tanking and Tank fabrication sections with experience of more than two years. The presence of MSDs was assessed using a Nordic musculoskeletal questionnaire. For postural analysis, Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) were utilized. Few selected postures were analysed using CATIAV5 software and improvements reducing the risks of postures were recommended.

Results: All of the 36 workers selected for the study were male with a mean age of 32 years, average experience of 10 years and 75% of workers had normal body mass index. The MSD questionnaire indicated discomfort of 86% mostly on the lower back portion of the body. The combined findings of RULA and REBA showed that about 44% of postures were in the high-risk group.

Conclusion: Well-defined ergonomic interventions such as redesigning the workstation are suggested to reduce awkward postures and manual handling risks, leading to improvement in job performance and productivity.

Keywords: Ergonomics, Musculoskeletal Disorders, Postural Analysis, RULA, REBA

Introduction

The current manufacturing industries are continuously making efforts to improve the productivity of their organization and at the same time focusing on safety aspects of their workforce to ensure their well-being.[1] Ergonomics is a science that can be used for designing and arranging work environments, equipment, and systems to fit the people who use them, and it plays a key role in achieving the expected goals.[2] Ergonomic risk identification is concerned with identifying workplace factors that may cause musculoskeletal disorders (MSDs) or other ergonomic injuries. These factors can include repetitive motions, forceful exertions, awkward postures, and vibrations. On the other hand, posture analysis involves analyzing workers' postures while they

perform their tasks to identify any deviations from the recommended postures. Poor posture can lead to MSDs, fatigue, discomfort, and decreased productivity.[4]

Conducting ergonomic risk identification and posture analysis are crucial to minimize workplace injuries and improve employee overall health and productivity.

Work systems that are designed keeping ergonomics in mind will always help to achieve a balance between worker qualities and job needs.[5] The adoption of ergonomics techniques in the workplace is crucial for the manufacturing sector since this can improve productivity and quality, increase revenue, reduce rejection costs and provide a better safety work environment.[6] The primary cause of workers' discomfort, decreased productivity, and monetary losses is work-related musculoskeletal ailments.[7] Musculoskeletal disorders may be caused because of continuously carrying out repetitive tasks, awkward postures, and anthropometric mismatches performing heavy physical work and using forceful exertion. This may lead to a high level of absenteeism among the workers.[8,9,10]

A transformer manufacturing industry, like any other manufacturing industry is involved in many manufacturing activities that expose workers to ergonomic risk factors.[11] The available literature indicates that there is strong acceptance of ergonomic tools as an effective means of improving productivity in the manufacturing sector.[12] However, the application level of ergonomic tools in industries, especially in small and medium-sized enterprises, needs to be improved, current research work has been undertaken to identify ergonomic deficiencies in the working methods of the workers in the transformer manufacturing industry, study postures, and identify risks using ergonomic assessment tools like RULA and REBA.[13,14,15] Catia v5 software is used to create a digital model of the workspace and automatically calculate the RULA score for a posture.[16,17]

Methods

The present study was carried out in a local electrical transformer manufacturing industry located in Kalaburagi City, Karnataka, India. A total of 36 male workers above 20 years of age, with a minimum of 2 years of work experience in manufacturing and who gave consent were included in the study. The chosen workers were from the following five sections, core building, core winding, assembly, tanking and tank fabrication and their work scope is to core building, winding, and tanking of transformer coils for long durations.

Data collection was carried out by giving consideration to type of data. The primary information was obtained directly from workers and management through interviews and surveys, such as the manufacturing process of transformers, Temperature, and Humidity in the workplace, and Size of the production space. Workers' complaints of physical aches in certain areas were recorded through the Nordic musculoskeletal questionnaire.[18] Work postures were photographed or video recorded using a mobile phone camera directly for further analysis. Anthropometric measurements of workers were carried out using a flexible measuring tape and weighing scale.

Meanwhile, secondary information is obtained indirectly from the subject of research. Secondary information in this study includes general information about the transformer manufacturing industry such as organizational structure, hours of operation, manufacturing procedures, and other information pertinent to the research issues.

Two posture evaluation methods were used in the present study to assess ergonomic disorders among employees. The first technique is called RULA (Rapid Upper Limb Assessment), and it is often used in research to measure upper extremity postural.[19,20] The second technique, called REBA (Rapid Entire Body Assessment), assesses the participant's posture to decide if it is appropriate or inappropriate.[21,22]

The work postures of the body had also been examined manually using the RULA evaluation worksheet and through the use of the Catia-v5

application software to offer a more precise RULA score, body postures alignment and the load's weight had all been set up and entered into the software. The weight of the load is used to calculate the forces and moments that will be generated on the workers' body. Then, to lessen the problem of musculoskeletal disorders, body postures were suggested to be modified as a result of the analysis performed in the study.

Results

All the participants in the study were men, ranging in age from 20 to 46 years. According to the body mass index (BMI), 75% of employees have normal weight, while only eight percent were overweight. The study was carried out during the day shift. Table 1 shows the details of the demographic figures of workers.

Table 1: Demographic figure of workers (n=36)

Sl.No.	Particulars	Minimum	Maximum	Mean (SD)
1	Age (Years)	20	46	31.41(8.17)
2	Height (Meters)	1.52	1.77	1.67(0.05)
3	Weight (Kg)	46	85	61(9.93)
4	Experience (years)	2	20	9.26(5.71)
5	BMI (Kg/M^2)	16.49	26.77	21.8(3.16)

Table 2: Nordic musculoskeletal Questionnaire Findings

Body Parts	Number of workers (n=36)	Percentage %
Neck	9	25
Shoulder	21	58
Upper Back	20	55
Lower Back	31	86
Wrist	22	61
Elbow	6	16
Thighs	20	56
Knees	25	69
Ankles/Feet	18	50

In ordert to determine the occurrence of MSDs, the Nordic musculoskeletal questionnaire was used. The prevalence of work-related MSDs in different body parts of workers is presented in Table 2. The MSD questionnaire reveals that more than four-fifths (86%) of the workers were suffering from lower back discomfort.

As stated, the risks associated with the working postures were determined using the RULA and REBA evaluation methods. Thirty-six postures were taken from five sections. Photographs taken using a good-quality phone camera were examined. The risk score was determined using the RULA assessment and scoring sheet. Table 3 displays the results of the analysis.

Table 3: Distribution of RULA score among workers

RULA Level	RULA Score	Action	Number of Postures(N=36)	Percentage %
0	1-2	Acceptable posture	7	19.4
1	3-4	Further Investigation and change may be needed	10	27.7
2	5-6	Further Investigation, change soon	05	13.8
3	7	Investigation and Implement change	14	38.8

Table 4: Distribution of REBA score among workers (n=36)

REBA Level	REBA Score	Action	No. of Postures	Percentage %
0	1	Negligible risk	01	2.7
1	2 to 3	Low risk, change may be needed	08	22.2
2	4 to 7	Medium risk, further investigation change soon	10	27
3	8 to 10	High risk, investigate and implement change	17	47.2
4	11+	Very high risk, implement change	0	00
		Total	36	100%

Similarly, the REBA assessment and scoring sheet were used to determine the risk score and consequently, the appropriate action. Table 4 summarizes the analysis findings.

The analysis of the worker's body postures while performing three different tasks was conducted by using images of the worker's actual postures. Figure 1 shows the workers involved in three different activities.

The worker in Figure 1, image A, was lifting 16 kg of mild steel sheets. Awkward working body posture and repetitive heavy lifting are major workplace postures, with two lifts performed every minute.

The worker in Figure 1, image B, was spraying the transformer tank on the floor. The critical working posture requires frequent bending which is prone to injury. The worker in Figure 1, image C, was operating a coil-winding machine. The upper body parts are at risk of MSD due to the vibration of the winding machine as it is done for a longer duration, under the noise of the machine.

Figure 1: Postures of workers involved in different work activities (Image A, B, and C respectively)

Catiav5software includes human modeling and ergonomics analysis capabilities. The software has four modules: Human Builder, Human Activity Analysis, Human Posture Analysis, and Human Measurement Editor. These modules allow users to create and customize human models, analyze their postures and movements, and identify potential ergonomic risks. RULA is one of the tool which is supported by this module.[23] The work postures prior and after rectification are shown in Figure 2.

The postures shown in Figure 2 (a) correspond to a worker lifting a 16 kg to 30 kg load depending on the size of the transformer plates. Due to the worker's requirement to bend their backs and the excessive use of back muscles, an awkward body posture might be observed. A ligament sprain or muscle strain may be caused by improper lifting

or overstressing of weak back muscles.[24] A high RULA score was obtained for the left side of the body from this working position. The weight that must be physically lifted shouldn't be more than 50 pounds (22.67 kilogram).[24] Otherwise physical heavy lifting might cause ergonomic problems, such as back sprains. Even though there is improvement in the work method, the improved work posture still has a substantial RULA score of 7 for both sides of the body as shown in figure 2(a). The most exposed body areas when lifting are the neck, arms, wrists, and muscles.

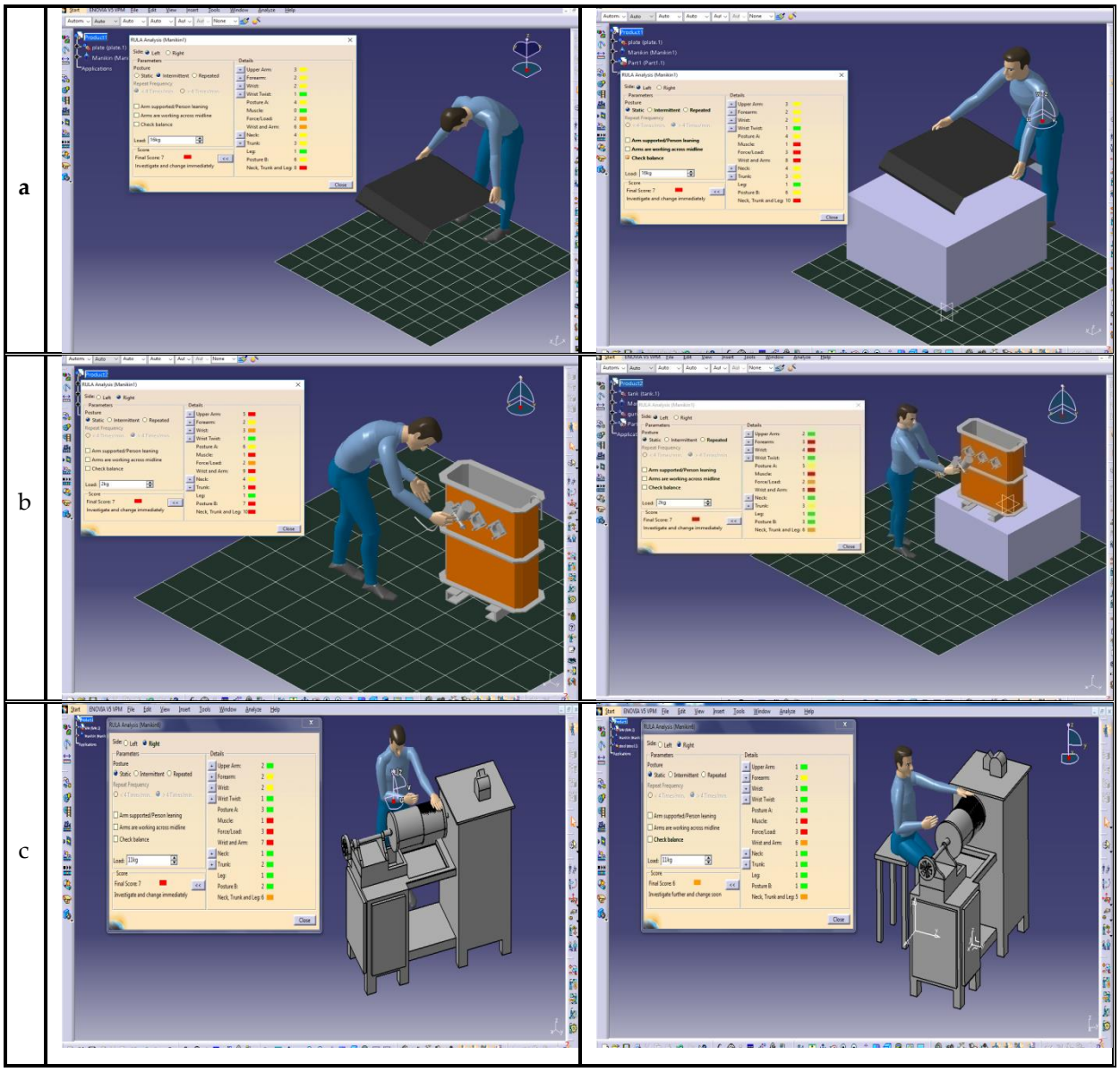


Figure 2: Work Postures A, B, and C before and after the Rectification

The postures shown in Figure 2(b) correspond to workers spraying a transformer tank on the floor. This work posture involves awkward working body postures. The upper body parts that are neck, and trunk are continuously bent forward and sideward for spraying operation. This can put too much strain on the body's lower back. Pressure is also seen in the wrist and arm due to carrying of spray gun for a longer duration of time. The RULA score remains high on both sides of the body despite the changes in working posture during the painting process as seen in Figure 2(b). This is due to the repeated working pattern necessary to complete the painting process. The task of painting requires workers to exert force on their forearm, and wrist muscles repeatedly, which is one of the reasons that contribute to injuries that must be avoided.

The postures shown in Figure 2(c) correspond to the worker operating a coil winding machine. It involves the continuous use of the shoulder, arms, and wrist of the worker. Due to the winding machine, the arms and shoulders are constantly vibrating, and the machine also makes a lot of noise. The changes made in the working methods resulted in a decrease of the RULA score slightly as shown in Figure 2(c) but ear plugs and gloves are still needed to protect the worker.

Discussion

This study is an attempt to identify the ergonomic risks associated with workers in manufacturing areas and develop recommendations. Transformer manufacturing companies are highly labor intensive and most of the tasks are performed manually, which leads to high risks of MSDs. The prevalence of MSD symptoms and their risk factor was very high among selected workers (Table 2). The most common symptoms seen in the lower part of the body were lower back, knees, thighs, and wrist. From the analysis of results and scores(Table 3& 4) obtained by RULA & REBA postural assessment techniques, it can be observed that workers adopt awkward postures involving frequent twisting, bending, and stretching due to a lack of awareness and knowledge about ergonomic practices in work methods in the transformer manufacturing company. This is the result of poorly designed workstations and improper working postures.[2,8]

These findings support that MSDs are a serious problem in the manufacturing industry.[3,4,10] Findings are consistent with musculoskeletal pain among similarly related occupation study.[11]

The images generated in Catiav5 software can be used to identify potential issues with the workplace layout, evaluate the anthropometric fit of the workplace and the tools and equipment used, and identify work postures that might pose risks to workers. Subsequently, these identified postures can then be improved by redesigning the workplace or the tools and equipment used. To establish a work environment that is safer, more efficient, and more comfortable for all the employees.

Employer's initiative to provide a safe workplace for their employees by ensuring that the workplace is free of ergonomic hazards can save themselves from legal liabilities, fines, and damage to the company's reputation.[25] The employers should provide pre-employment training, health education on ergonomics and MSDs to the employees on knowledge and skills that are needed to perform their tasks safely and efficiently from the recruitment and it should be an ongoing process that covers the causes, symptoms, and prevention of MSDs.[26,27]

Conclusions

The results of the analysis carried out in the present study reveal that the working postures exhibited by the workers while executing their tasks are found to be unsafe. The primary cause for this was found to be some specific features of current methods, which involve repetitive jobs for longer durations and repeated handling of heavy exertion loads. Further, the findings of RULA/REBA methods which are used for posture analysis and assessment of each worker's exposure to occupational risk factors have changed the working postures to prevent WRMSD in the future. The recommendations will eventually improve workers' health and work efficiency and in turn, improve job performance and productivity.

Acknowledgments

The authors would like to express their gratitude to the workers who participated in the study and also to the management authorities for their support.

References

1. Zare M, Croq M, Hossein-Arabi F, Brunet R, Roquelaure Y. Does ergonomics improve product quality and reduce costs? A review article. Human Factors and Ergonomics in Manufacturing & Service Industries. 2016 Mar;26(2):205-23. Available from: https://doi.org/10.1002/hfm.20623

2. Kushwaha DK, Kane PV. Ergonomic assessment and workstation design of shipping crane cabin in steel industry. International journal of industrial ergonomics. 2016 Mar 1;52:29-39. Available from:https://doi.org/10.1016/j.ergon. 2015.08.003

3. Punnett L. Musculoskeletal disorders and occupational exposures: How should we judge the evidence concerning the causal association?. Scandinavian journal of public health. 2014 Mar;42(1):49-58. Available from:https://doi.org/10.1177/1403494813517324

4. Nur NM, Dawal SZ, Dahari M. The prevalence of work-related musculoskeletal disorders among workers performing industrial repetitive tasks in the automotive manufacturing companies. In Proceedings of the 2014 international conference on industrial engineering and operations management Bali, Indonesia. 2014 Jan [Cited 2023 Jul 20]:1-8.Available from: URL; https://ieomsociety .org/ieom2014/pdfs/303.pdf

5. Mali S, Vyavahare R. RULA analysis of work-related disorders of foundry industry worker using digital human modeling (DHM). Int Res J Engin Technol. 2015;2(5):1373-8. Available from: https://www.irjet.net/archives/V2/i5/IRJET-V2I5221.pdf

6. Yeow PH, Sen RN. Productivity and quality improvements, revenue increment, and rejection cost reduction in the manual component insertion lines through the application of ergonomics. International journal of industrial ergonomics. 2006 Apr 1;36(4):367-77. Available from: https://doi.org/10.1016/j.ergon.2005.12.008

7. Shavarani SM, Korhan O. Expert system assessment of work-related musculoskeletal disorders for video display terminal users. Applied Research in Quality of Life. 2015 Jun;10:205-16. Available from: http://dx.doi.org/10.1007/s11482-014-9307-5

8. Deros BM, Khamis NK, IsmailAR, Jamaluddin H, Adam AM. An ergonomics study on assembly line workstation design. American Journal of Applied Sciences. 2011;8(11):1195. Available from: https://www.thescipub.com/pdf/ajassp.2011.1195.1201.pdf

9. Karki P, Joshi YP, Khanal SP, Gautam S, Paudel S, Karki R, et al. Prevalence and Factors Associated with Occupational _ Musculoskeletal Disorders among the Nurses of a Tertiary Care Center in Nepal. International Journal of Occupational Safety and Health. 2023 Jul 4; 13(3):375-85. Available from: https://doi.org/10.3126/ijosh.v13i3.51792

10. Aziz FA, Ghazalli Z, Mohamed NM, Isfar A. Investigation on musculoskeletal discomfort and ergonomics risk factors among production team members at an automotive component assembly plant. In IOP conference series: materials science and engineering.2017 Oct;257(1):012040.Available from: http://dx.doi.org/10.1088/1757-899X/257/1/012040

11. Bhadke MK,Wanave SB, Jibhakate MS. Study and Validation of workers posture in transformer manufacturing industry through RULA. International Journal of Analytical, Experimental and Finite Element Analysis (IJAEFEA).2014 July;1(3). Available from: https://www.academia.edu/10872379/Study_and_Validation_of_workers_posture_in_transformer_manufacturing_industry_through_RULA

12. Sain MK, Meena ML. Occupational healthand ergonomic intervention in Indian small-scale industries: a review. Int J Recent Adv Mechanical Engin. 2016;5(1):13-24. Available from: https://doi.org/10.14810/ijmech.2016.5102

13. Budiyanto T, Adiputra N, Sutjana ID, Tirtayasa K. Application of RULA Analysis on Work Posture Improvement to Reduce Workers' Fatigue and Musculoskeletal Complaints and to Accelerate Processing TIME of Wok Molding. International Research Journal of Engineering, IT and Scientific Research. 2019;5(4):8-15. Available from: https://doi.org/10.21744/irjeis.v5n4.648

14. Rivero LC, Rodríguez RG, Pérez MD, Mar C, Juárez Z. Fuzzy logic and RULA method for assessing the risk of working. Procedia Manufacturing. 2015 Jan 1;3:4816-22. Available from: https://doi.org/10.1016/j.promfg.2015.07.591

15. Sukapto P, Cynthia F, Standiklaus S. Application of the REBA method to osh systems to increase work productivity. International Journal of civil

Engineering and technology.2019;10(4):1922-1932.Available from: https://repository.unpar.ac.id/handle/123456789/9090

16. Hussain MM, Qutubuddin SM, Kumar KP, Reddy CK. Digital human modeling in ergonomic risk assessment of working postures using RULA. In Proceedings of the international conference on industrial engineering and operations management Bangkok, Thailand.2019 March [Cited 2023 Jul 20]:5-7. Available from: http://ieomsociety.org/ieom2019/papers/582.pdf

17. Kamat SR, Zula NM, Rayme NS, Shamsuddin S, Husain K. The ergonomics body posture on repetitive and heavy lifting activities of workers in aerospace manufacturing warehouse. In IOP Conference Series: Materials Science and Engineering. 2017 Jun;210(1):012079.Available from: doi: 10.1088/1757-899X/210/1/012079

18. I Kuorinka, B Jonsson, A Kilbom,Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied ergonomics. 1987 Sept;18(3):233-7. Available from: https://doi.org/10.1016/0003-6870(87)90010-X

19. McAtamney L, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. Applied ergonomics. 1993 Apr 1;24(2):91-9. Available from: https://www.sciencedirect.com/science/article/pii/000368709390080S

20. Sahu S, Moitra S, Maity S, Pandit AK, Roy B. A comparative ergonomics postural assessment of potters and sculptors in the unorganized sector in West Bengal, India. International Journal of Occupational Safety and Ergonomics. 2013 Jan 1;19(3):455-62. Available from: https://doi.org/10.1080/10803548.2013.11077001

21. Hignett S, McAtamney L. Rapid entire body assessment (REBA). Applied ergonomics. 2000 Apr 3;31(2):201-5.Available from: https://www.sciencedirect.com/science/article/pii/S0003687099000393

22. Urrejola-ContrerasGP, Pérez-Casanova DC, Pérez-Lizama MA, Gary-Zambra B. Postural stress and risk conditions in manual load handling of Chilean industrial workers. International Journal of Occupational Safety and Health. 2023 Jan 1;13(1):38-46. Available from: https://doi.org/10.3126/ijosh.v13i1.41264

23. Yogasara T. The Use of Computer Aided Design (CATIA V5 R8) For Ergonomics Analysis. In Prosiding Seminar Nasional Ergonomi.2004 Oct;(2): 356-64.Available from: https://ti.unpar.ac.id/wp-content/uploads/sites/10/2016/09/Thedy04_Seminar-Nasional-Ergonomi-2_2004.pdf

24. Thomas R, Colombini D, Occhipinti E, Alvarez E. Manual Lifting: A Guide to the Study of Simple and Complex Lifting Tasks.London: Taylor and Francis Group,2013, pp. 24-30. Available from https://www.researchgate.net/publication/258561731_Manual_lifting_A_guide_to_the_study_of_simple_and_complex_tasks

25. Chu C, Dwyer S. Employer role in integrative workplace health management: A new model in progress. Disease Management and Health Outcomes. 2002 Mar;10:175-86. Available from:https://doi.org/10.2165/00115677-200210030-00005

26. Korunka C, Dudak E, Molnar M, Hoonakker P. Predictors of a successful implementation of an ergonomic training program. Applied ergonomics. 2010 Dec 1;42(1):98-105. Available from: https://doi.org/10.1016/j.apergo.2010.05.006

27. Bohr PC. Efficacy of office ergonomics education. Journal of Occupational Rehabilitation. 2000 Dec;10:243-55. Available from: https://www.researchgate.net/publication/263695682_Efficacy_of_Office_Ergonomics_Education/citation/download

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Application of machine learning modeling for the upstream oil and gas industry injury rate prediction

Desalegn Y[1], Daniel K[1], Mesfin B[2]

[1] School of Mechanical and Industrial Engineering, Addis Ababa Institute of Technology, Addis Ababa University, Addis Ababa, Ethiopia.

[2] University of Stavanger, Department of Energy and Petroleum Engineering, Stavanger, Norway.

ABSTRACT

Introduction: Yearly, the International Labor Organization report indicates many workplace accident occurrences. The degree of the happenings depends on the workplace environment setting and the incident regulatory measures implemented. By the nature of its work environment, the oil and gas upstream sector is susceptible to high incident rates. In the current fierce business competition and practices, improving productivity, quality, and other processes, such as Safety, is vital. Implementing well-designed safety procedures is the key to managing and reducing the risk level of workplace incidents.

Methods: Recently, the application of Machine learning (ML) modeling for accident/injury prediction has been reported in the construction, mining, transport, and health sectors. Likewise, the objective of this paper was to implement three machine-learning-based models to predict injury rates in a drilling operation. The Petroleum Safety Authority of Norway provided the datasets. First, the dataset was pre-processed, and then the selected features and target dataset were used for the modeling. Finally, the model prediction and performance accuracy analysis were performed.

Results: Results showed that multivariable regression (MVR), Random Forest (RF), and Artificial Neural Network (ANN) machine learning algorithms-based models predict the test data with R^2 values of 0.9576, 0.793, and 0.97036, respectively.

Conclusion: As the common saying goes, 'prevention is better than cure.' For this, implementing methods such as improved work processes and Health, Safety, and Environment (HSE) mitigation procedures, workplace injuries, and accidents allow for reducing the risk level of workplace injuries. The application of integrated machine learning tools, along with carefully built-in workplace accident database implementation, will provide early detection and possible remedial precautions that can be taken to prevent workplace injuries/accidents/fatalities. However, extensive research and development are required to deploy the method in real life. Combining Machine Learning modeling and carefully designed safety measures is vital for successful and robust predictive tools.

Keywords: ANN, HSE, Multivariate Regression, Occupational injury, Random Forest, Safety Management

Corresponding authors:

Desalegn Yeshitila, &
Professor Daniel Kitaw (PhD)
School of Mechanical and Industrial Engineering,
Addis Ababa Institute of Technology, Addis Ababa University, Addis Ababa, Ethiopia
Tel.: +251932768383
E-mail: desuselam@yahoo.co.uk
E-mail: danielkitaw@yahoo.com
ORCID ID: https://orcid.org/0000-0002-2696-3548

Date of submission: 21.02.2023
Date of acceptance: 11.09.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.52668

Introduction

Occupational accidents and occupational injuries can happen anytime and in any field. Occupational injury includes personal injury or fatality from work accidents. The consequences can affect the employees' performance and personal life outside of work. A report from the International Labor Organization estimated that every year, a considerable number of work-related accidents and diseases cause death, fatal accidents, and fatal work-related diseases.[1] Hämäläinen et al. stated that the degree of injuries and their causes are associated with the working environments and the safety procedure implemented.[2] Safety management at workplaces is becoming the paramount consideration, and it is being implemented in several industries as a routine management activity.[3] This endeavor's main objective is to reduce workplace accident risk levels. The upstream oil and gas sector is susceptible to high incident rates in the petroleum industry due to its work environment, remote location, and confined spaces. For instance, Morken et al. analyzed the 12 years (1992–2003) of offshore work-related incidents, which is 6725 cases obtained from the Petroleum Safety Authority of Norway.[4] The dataset includes information such as worker's diagnosis, age, occupational category and occupation, and types of exposure. Four main categories (Maintenance, Catering, Drilling, and Administration) were considered. The analysis showed that the dominant occupational categories were maintenance work (40%) and catering (21%). The authors have also indicated the higher occupational incident rate associated with maintenance work and catering in Denmark and the U.K. offshore sector. It is also noted that the rate of injuries varies from region to region. The workplace injuries problem can be avoided, by implementing properly designed HSE guidelines, and the risk level can be minimized.[5] Dyreborg et al. presented case studies of the impact of safety interventions on injury prevention.[6] The result, among others, has shown strong evidence that the safety intervention approach has shown more effectiveness in preventing injuries. In line with this, it is of great importance to develop an accident-identifying tool that allows us to take appropriate preventive measures to minimize or avoid the risk of incidents.

Recently the application of machine learning (ML) for modeling and predicting future event HSE-associated risks has been tested in engineering, management, healthcare, and medicine. Examples of research papers that used machine learning-based modeling for workplace injury analysis, among others, are in the construction industry, the shipping industry, transportation, high-risk flight environments, the tourism sector, the public sector, and the petroleum industry. The following highlights some of the reviewed papers.

Ciarapica et al. assessed the risk of occupational injury, considering the probability and consequences of injuries. The authors have used five years (2002–2006) of occupational injury data in an Italian region. They developed ML modeling and reported that Neuro-fuzzy networks are found to be a powerful tool for prediction.[3]

In industrial, mining, construction, and services sectors, Matías et al. have presented ML methods for analyzing workplace accidents; specifically, floor-level falls. In this paper, they implemented different ML algorithms, such as Bayesian networks, classification trees, and support vector machines.[7] The dataset (2003 -2006) was based on accidents recorded in the industrial, mining, construction, and services sectors in Vigo, Spain. The analysis results show the prediction of the Bayesian network is relatively better and allows for the provision of recommendations for an accident prevention policy. Sánchez et al. have successfully applied the ML model, that is, the Support vector machines (SVMs) learning method, to forecast occupational accidents. They performed a nationwide Survey on work conditions to access HSE and risk prevention, among others. The Authors have performed SVM modeling based on the interview result dataset as input. According to the authors, the results indicated that the SVM performance was good in terms of prediction and the possible overfitting of the data.[8]

In the shipbuilding industry, Fragiadakis, et al. presented the machine learning predictive and occupational risk assessment model developed with an adaptive neuro-fuzzy inference system.[9] Tsoukalas & Fragiadakis also presented multivariable linear regression and genetic algorithm analysis. Results comparing the predicted values with the recorded data, the work has shown that the proposed model indicates the risk of occupational injury.[10]

In the mining industry, van den Hon et al. have used Artificial Neural Networks (ANN) to model, validate and predict the continuous risk of accidents. Moreover, the authors identified patterns between the input attributes. Results based on the case study data showed that ANN produced a correlation between the predicted continuous risk and actual accidents.[11]

In the transportation sector, Mahdi et al. have presented Machine Learning (Artificial Neural Network (ANN)) and Adaptive-Neuro Fuzzy Inference System (ANFIS) modeling to classify the severity of road accidents.[12] They investigated the application of the combined clustering classification system for categorizing severity in road accidents. Bedard et al. have also used several transportation-related accident datasets that affect the fatality risk of drivers in crashes. They used multivariate logistic regression techniques that reveal the fatal injury associated with factors such as age, sex, and speed. They also indicated that the risk of fatal injuries is associated with not using a seatbelt and practicing over-speed.[13]

In the petroleum industry, Zaranezhad et al. have applied ML algorithms to the workplace accidents dataset related to repair and maintenance at oil refineries. The ML models used are artificial neural networks, fuzzy systems, genetic algorithm (G.A.), and ant-colony optimization algorithm. Based on the considered features, results showed that the perceptron neural network was found to have the highest prediction accuracy of 90.9%.[14] They also evaluated the prediction of hybrid models, and the neural-GA network obtained the highest prediction accuracy of 95.9%. The authors proposed the neural-GA hybrid model to predict early accident predictions caused by repair and maintenance.

In the public sector, Sukumar et al. have implemented different ML algorithms such as random forest, k-nearest neighbor, and decision trees for predicting workplace injury/ workplace incidents. They used the dataset (2015 to 2017) obtained from the Occupational Safety and Health Administration (OSHA) database, which comprises about 61% fatal and 39% non-fatal injuries. The target feature of the research was to predict the nature of the injury, i.e., fatal or non-fatal. The authors' results showed that the statistical performance of the decision tree model was higher than the other two algorithms employed in the case.[15] However, referring to the work of Wang et al, Sukumar et al. recommended a Random forest algorithm for high dimensional data.[15,16] The recommendation is in line with the work of Capitaine et al.[17]

In the construction industry, Tetik et al. have modeled occupational injuries and fatalities. They used datasets (2010 and 2012) that are the main factors for the occurrence of construction accidents. In this study, they employed a decision tree algorithm for the modeling. The results show the relationship between the injury status of workers and the attributes, and the accuracy rate of the model was 70.26%. They also proposed applying the model to the prevention and mitigation strategies for construction accidents.[18] Zhu et al. used machine learning techniques to predict the consequences of construction accidents based on 16 incident factors. The authors have implemented eight algorithms: Logistic regression, Decision tree, Support vector machine, Naive Bayes, K-nearest neighbor, Random forest, Multi-Layer Perceptron, and AutoML. According to the authors, results show that Naive Bayes and Logistics regression achieve the best F1-Score of 78.3 % on a raw data set. They also reported that the "Type of accident" and "Accident reporting and handling" are the most critical factors, and "Emergency management" and "Safety training" are critical subsystems that have a significant impact on the severity of the accident.[19]

In the flight sector, Maynard et al. have used neural networks and Machine learning modeling to predict high-risk flight environments from accident and incident data. Results indicated the potential application of the ANN model to identify the most significant flight risks.[20]

In the tourism sector, Chadyiwa et al. have investigated the application of Machine Learning Applications in the Prediction of Occupational Injuries in South African National Park. The authors compare the performance of the SVM, k-nearest neighbors (KNN), X.G. boost classifier, and deep learning neural networks (DNN) machine learning models concerning the prediction of occupational injuries. Based on the considered datasets, the author's results show that the SVMs had the best performance in prediction.[21]

In a recent public sector study, Khairuddin et al. presented a Machine Learning Approach and Feature Optimization for Smart Workplace Surveillance. For the analysis, the authors have used 66,405 data from the public occupational injury records from OSHA. The idea is to develop a possible occupational Injury Risk Mitigation method. They employed five machine learning algorithms: Support Vector Machine, K-Nearest Neighbors, Naïve Bayes, Decision Tree, and Random Forest. The comparison result reveals that the Random Forest outperformed other models with higher accuracy and F1-score. The authors have also proposed a feature optimization technique, and from the study, they highlight the promising potential for smart workplace surveillance for future injury corrective and preventive strategies.[22]

In a recent injury analysis in the transportation sector, Augustine et al. applied a machine learning modeling approach to predict a road accident. For this, they compared the accident prediction of machine learning models such as Logistic Regression, Random Forest, Decision Tree, K-Nearest Neighbor, XGBoost, and Support Vector. They used the government record accident datasets in a district in India. The comparison result reveals that the Random Forest algorithm gave the highest accuracy of 80.78%.[23] Pandaa et al. also analyzed the statewide accident dataset in India for the period 2008–2019 with four different machine learning methods, including support vector machine (SVM), random forest (RF), Gradient Boosting Machine (GBM), and extreme gradient boosting (XGB). The authors have considered features such as commercial vehicles, excess speed, national highways, and pedestrian faults which are the factors for accidental road killings. The authors' findings suggest that the Machine learning model predicts the accident severity. Among the considered ML models, the gradient boosting machine achieved the best test accuracy.[24]

Research motivation and objectives: From the reviewed research works, we can observe that the application of ML for predicting workplace injuries/accidents in various sectors has shown promising results. However, up to the authors' knowledge, the application of ML for occupational injuries in the petroleum industry is limited. Therefore, this paper aims to present the application of machine learning modeling to predict the possible occupational injury rate based on the available relevant dataset obtained from drilling activities.

Methods

A total of three ML algorithms were used to compare which one best suits and ensure the data used can be used for modeling and predicting workplace injury rates. Figure 1 shows the methodology implemented in this paperwork, which comprises three main parts. These are data pre-processing, machine learning modeling, and model performance accuracy analysis. The data pre-processing was performed to evaluate the data correlation among the features as well as with the target injury rate.

Once the features were identified, the second phase was splitting the dataset into training and testing to be used for the machine learning modeling and model predictions. In this paper, three learning algorithms were selected, namely, Multivariable regression, Random forest regression, and Artificial Neural network. The

model prediction was analyzed with the test - and training dataset. The statistical model's performance accuracy evaluation methods used in this paper were coefficient of determination (R^2), Mean Square Error, and Root Mean Square Error. The details of how they work are presented in the following sections.

The authors of this paper used multivariable regression for multiple independent variables/features (x_1, x_2, x_3… x_n) to predict the target variable, y [25]

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n + \varepsilon \quad (1)$$

Where

y = the predicted value, which is the dependent variable or target variable

β_0 = the y-intercept (i.e., the value of y when all other independent variables are set to 0)

β_1 = the regression coefficient of the first independent variable x_1

β_n = the regression coefficient of the last independent variable x_n

ε = model error (how much variation there is in the estimate of y)

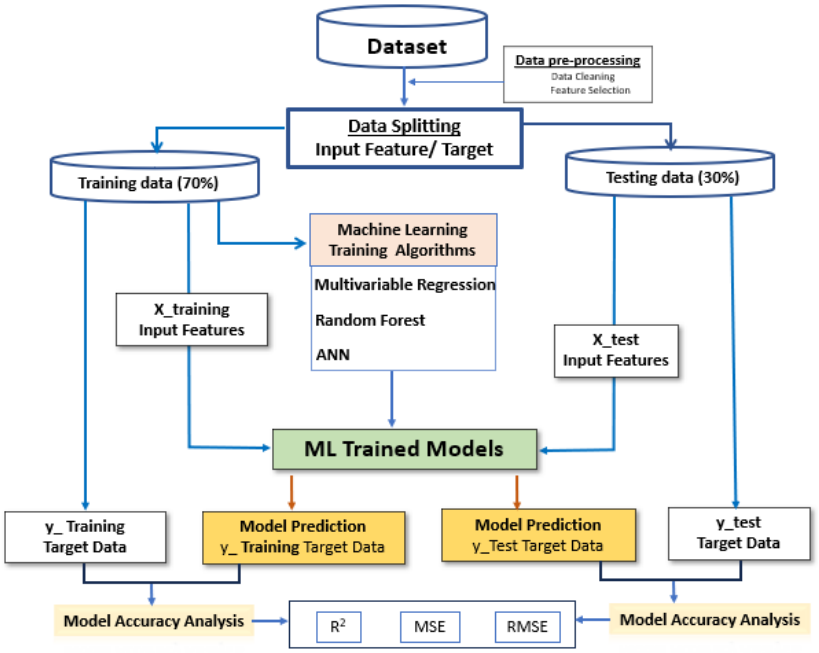


Figure 1: The workflow implemented in this study.

Tsoukalas et al. used a multivariable linear regression method for workplace injury analysis. In this paper, for the multivariable regression modeling, input features used were working hours and injuries within the year range, and the target output is injury rate by splitting the data into 70% for training and 30% for testing.[10]

Random forest is a Supervised Machine Learning Algorithm. It is used in Classification and Regression problems. The concept behind the Random forest algorithms is that they build decision trees based on different inputs and take their majority vote for classifying and averages in case of regression.[26] A random forest algorithm is constructed with a collection of decision trees. The random forest algorithm is a two-step process. First, building n decision trees regressor. Each decision tree regression predicts an output for a given input. The final output is then obtained from the Random forest regression by taking the average of those predictions. Random forest reduces overfitting since it averages over the independent trees.[27] Random forest machine learning algorithm has been employed in several injury studies.[7,15 19,22, 23, 28-30]

In this paper, Random Forest regression is performed, splitting the dataset by 70% for training, and the rest of the dataset (30%) is used for testing the model prediction. The splitting was done to yield a statistically meaningful result.

An artificial neural network (ANN), also known as a neuron network is the mathematical model of

a system that simulates similarly as biological neural networks operate in the human brain capable of learning, prediction, and recognition.[31] Several authors have used ANN learning algorithms for the analysis of workplace injuries.[11,12,14,19,20,32.] ANN uses nodes, similar to neurons building the same sorts of complex interconnections between them (synapses). The neural network comprises three parts, namely the input layer, the hidden layer, and the output layer. The artificial neurons have weighted inputs, transfer functions, and target output. The activation of the neuron uses the weighted sum of the inputs. The single output of the neuron is generated after passing the activation signal through the transfer function. The ANN model is built by using a feed-forward backpropagation network. The training algorithm used in this study was the Levenberg–Marquardt algorithm (TRAINLM). The network training function updates weight and bias values. In addition, the LEARNGDM adaptation learning function is used to calculate the changing weight and update returns the weight change and a new learning state. The network was built with three layers, an input layer, a hidden layer, and an output layer. The input layer consists of three neurons the hidden layers are five neurons and a tangent sigmoid transfer function (TANSIG) transfer function and the output layer has one neuron and the sigmoid TANSIG transfer function. ANN model was developed using inputs and divided into ratios of 70 % for training and 15% for testing, and 15% for validation.

Once the model is built and tested for prediction, the final stage is to evaluate the model's performance accuracy. For this, we used the commonly used statistical parameters such as mean square error (MSE), root mean square error (RMSE), and regression coefficient (R^2), Montgomery.[33]

Mean Square Error (MSE):

MSE provides a measure of how close a regression model is to a measured data point. The closer the MSE value to 0, the more accurate the regression model is.

$$\mathrm{MSE} = \frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{N}}\left(\mathrm{y}_{\mathrm{i}}^{\mathrm{predicted}} - \mathrm{y}_{\mathrm{i}}^{\mathrm{Actual}}\right)^2 \qquad (2)$$

Root Mean Square Error (RMSE):

RMSE is also another regression model performance indicator. It is the measure of the mean difference between the actual and the values predicted by a model. It also estimates the accuracy of the model to predict the true, target value.

$$\mathrm{RMSE} = \sqrt{\frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{N}}\left(\mathrm{y}_{\mathrm{i}}^{\mathrm{predicted}} - \mathrm{y}_{\mathrm{i}}^{\mathrm{Actual}}\right)^2} \qquad (3)$$

Regression Coefficient (R^2):

R-square(R^2) measures the goodness of the best-fit regression line. It defines the degree of variance in the target value that can be explained by the input Features. The R^2 value varies from 0 to 1. A score of 1 is ideal where 100% variation can be explained by the input feature variable.

$$\mathrm{R}^2 = 1 - \frac{\sum_{\mathrm{i}=1}^{\mathrm{N}}\left(\mathrm{y}_{\mathrm{i}}^{\mathrm{predicted}} - \mathrm{y}_{\mathrm{i}}^{\mathrm{Actual}}\right)^2}{\sum_{\mathrm{i}=1}^{\mathrm{N}}\left(\mathrm{y}_{\mathrm{Actual}}^{\mathrm{Mean}} - \mathrm{y}_{\mathrm{i}}^{\mathrm{Actual}}\right)^2} \qquad (4)$$

The secondary workplace injury dataset obtained from Norway's Petroleum Safety Authority[34] was used for ML modeling and analysis. Except for the dataset, the details of the causes, categories, kinds of activities, operators, and other relevant information associated with the injury dataset were not reported in the database. Table 1 shows the dataset, which was recorded from 2009 to 2018, and consists of four variables (Year, Work-hour, Number of injuries, and injury rate). The number of injuries and the associated working hours are not consistently occurring. The injury rate is calculated from the dataset as:

([Number of injuries in the reporting period] x 1,000,000) / (Total hours worked)

The data pre-processing was performed with Pandas/Python library to clean and select features to be used as input for the machine learning algorithms.

Table 1: Workplace injury datasets used in this study.[34]

Year	Work-Hours	Injuries	Injury-rate	Year	Work-Hours	Injuries	Injury-rate
2009	8920468	39	4.4	2014	10084881	25	2.5
2009	6363025	48	7.5	2014	5166295	28	5.4
2009	2221184	28	12.6	2014	2347674	12	5.1
2009	11079666	133	12	2014	15125636	178	11.8
2010	8975538	28	3.1	2015	8869938	26	2.9
2010	5893739	47	8	2015	4856239	32	6.6
2010	2321410	23	9.9	2015	2154055	23	10.7
2010	11834044	122	10.3	2015	10636021	113	10.6
2011	8715265	22	2.5	2016	7744388	18	2.3
2011	5594466	43	7.7	2016	4499170	29	6.4
2011	2402714	24	10	2016	2090811	15	7.2
2011	14951055	154	10.3	2016	9779982	82	8.4
2012	8997539	40	4.4	2017	8329241	33	4
2012	5149376	40	7.8	2017	4503183	27	6
2012	2466948	14	5.7	2017	1988017	19	9.6
2012	15408376	157	10.2	2017	9309383	92	9.9
2013	9386604	38	4	2018	10699902	17	1.6
2013	5553985	41	7.4	2018	4598378	21	4.6
2013	2426849	26	10.7	2018	2101929	9	4.3
2013	15721547	137	8.7	2018	10661638	103	9.7

Results

This section presents the training and test results obtained from the three Machine Learning modeling methods. Here, the training and testing datasets were compared with the respective model predictions. Moreover, the degree of the model accuracy evaluations will be discussed.

Using the whole dataset, the multivariable regression model for the injury rate is obtained as:

$$\text{Injury rate} = \beta_0 + \beta_1 * \text{Year} + \beta_3 * \text{Workhours} + \beta_3 * \text{Injury} \quad (5)$$

Where the coefficients are:

$\beta_o = 304.119737$, $\beta_1 = -0.14682652$, $\beta_2 = -9.6909E\text{-}07$, and $\beta_3 = 0.10734475$

The multivariable regression model was built using the scikit-learn/Python library. Figures 2-3 show the comparison between the training and the testing datasets with model-predicted values, respectively. From the model performance accuracy analysis results presented in Table 2, it is shown that the training dataset and the test datasets correlated with the model predictions with R^2 values of 92.6% and 95.7%, respectively.

Table 2: Multivariable model performance accuracy analysis summary.

Performance	RMSE	MSE	R^2
Training	1.19875	1.4370	0.9264
Testing	0.94129	0.8860	0.9576

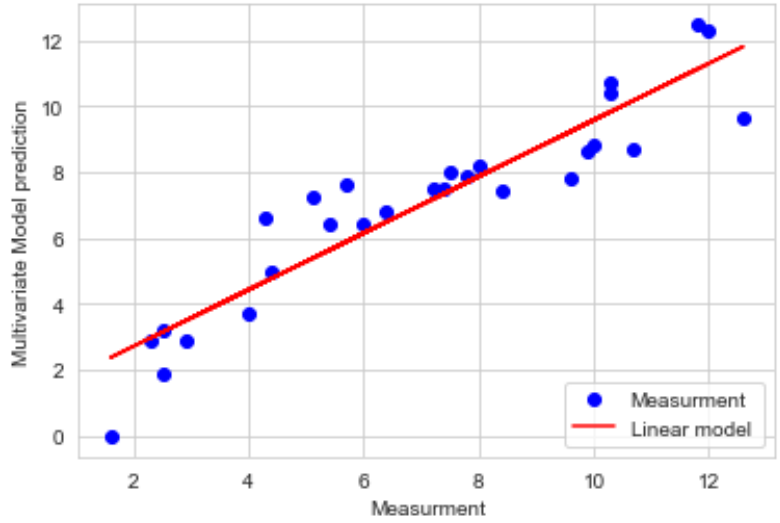


Figure 2: Scatter plot of 70% training injury rate data vs. multivariable regression model prediction.

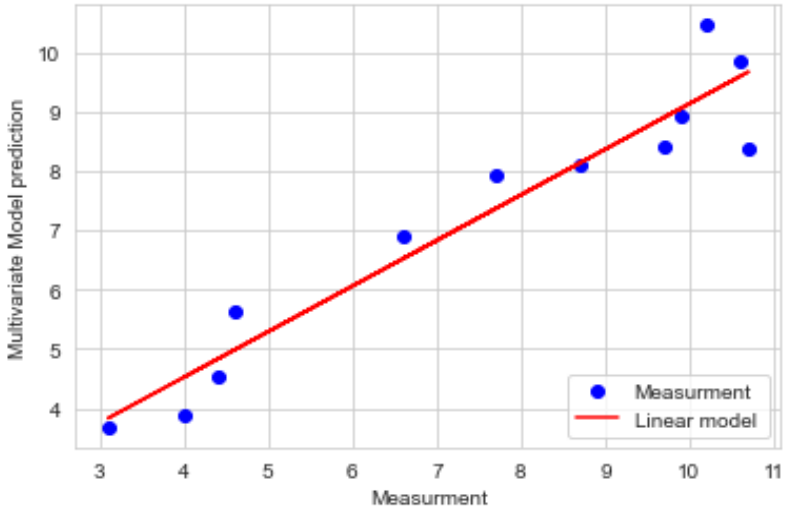


Figure 3: Scatter plot of 30% testing injury rate data vs. multivariable regression model prediction.

The random forest regression was implemented in Python. The basic concept of random forest regression modeling is presented in the methods section, above. Figure 4 displays the comparison of the random forest model prediction, which is based on the 70% dataset and the true training dataset. As provided in Table 3, the model performance accuracy analysis result shows that the random forest model predicts the training dataset with an R^2 value of 0.9875. Further, to evaluate the model prediction performance, 30% of the test datasets were used. Figure 5 shows that the random forest model predicts the test dataset with an R^2 of 79.3%.

Table 3: Random Forest model performance accuracy analysis summary.

Performance	RMSE	MSE	R^2
Training	0.56487	0.3190	0.9875
Testing	1.6946	2.8719	0.793

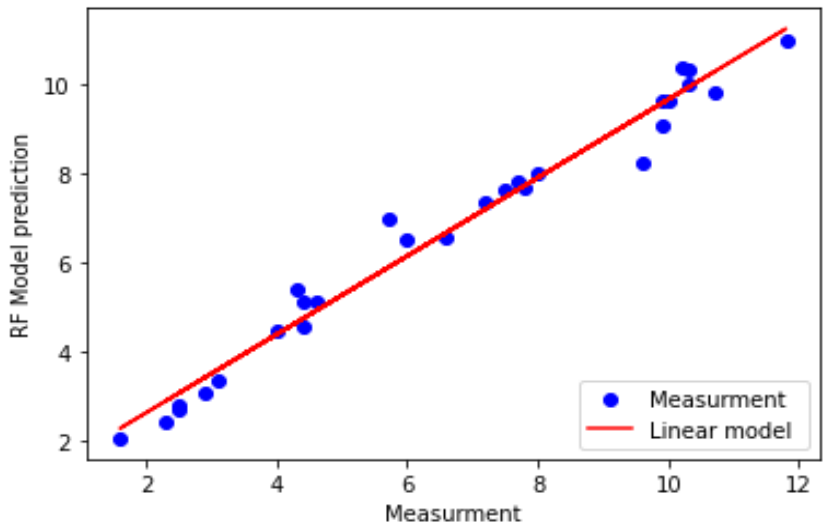


Figure 4: Scatter plot of 70% training injury rate data vs. Random forest regression model prediction.

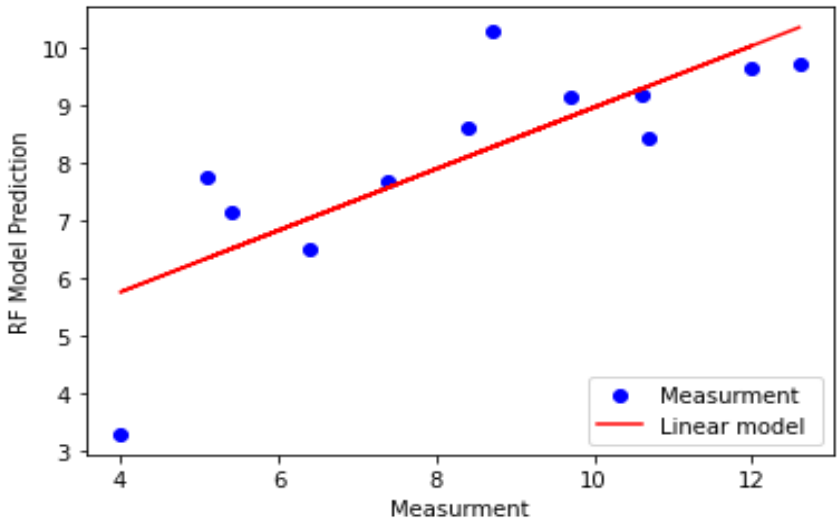


Figure 5: Scatter plot of 30% testing injury rate data vs. Random forest regression model prediction.

A three-layer ANN was also built. To avoid the possible overfitting issue, there are different rule-of-thumb methods for the selection of the appropriate number of neurons for the hidden layers.

The number of hidden layers should be:

- Between the number of the input- and the output layer.
- 2/3 of the number of the input layer plus the size of the output layer.
- Less than twice the size of the input layer.

To satisfy these three conditions, we selected the number of the hidden layer to be five. ANN model is built- in MATLAB/nftool library.[35] Figure 6 displays the results obtained from the measurement (dataset) and ANN model prediction. Table 4 shows the summary of the model performance accuracy analysis obtained from the ANN training, validation, and testing datasets. As provided in the table, the ANN-based model's R^2 values of the training dataset, validation, testing, and all datasets showed a strong correlation with 0.99975, 0.9979, 0.97036, and 0.99283, respectively.

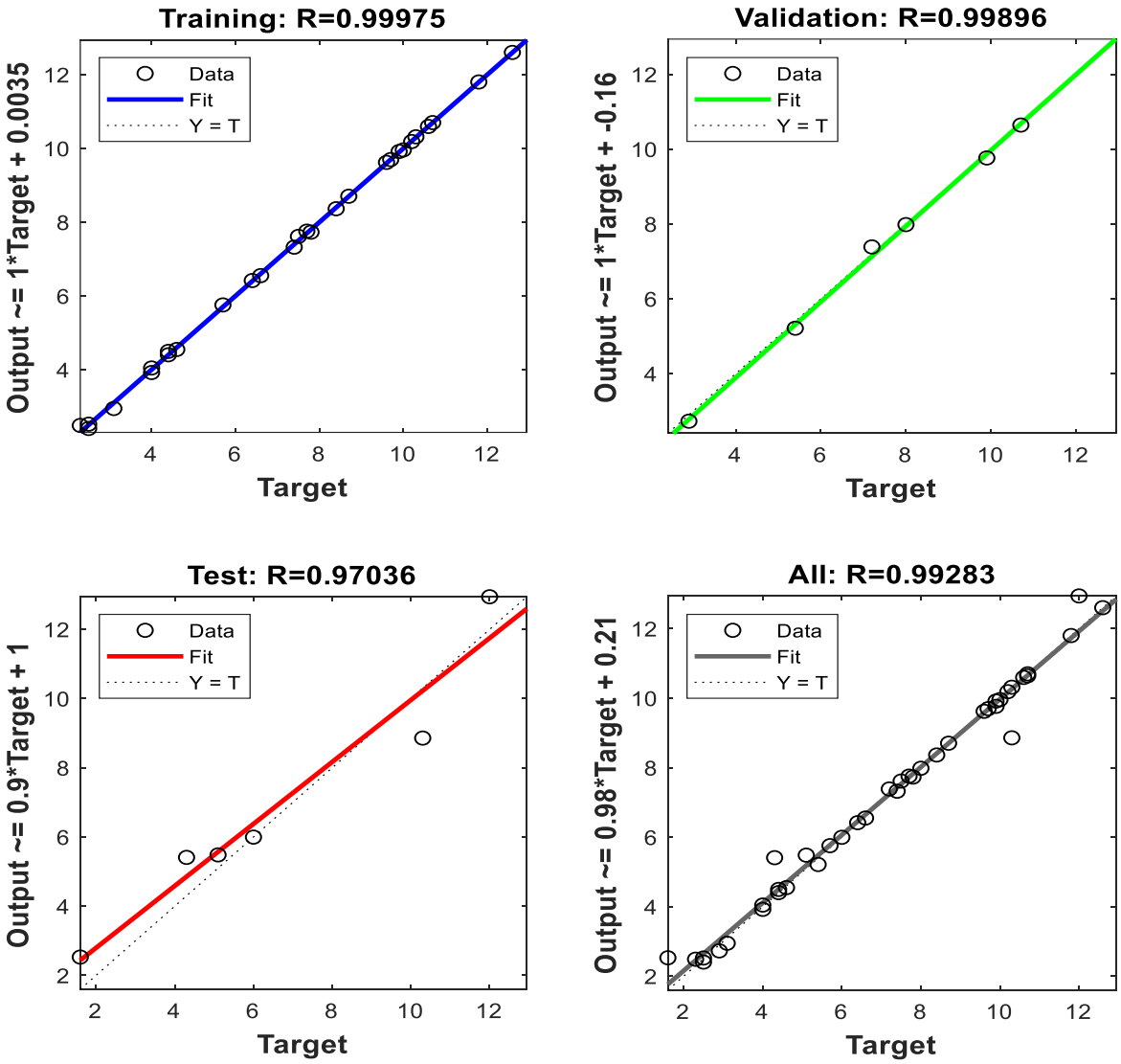


Figure 6: Comparison of ANN model prediction and target dataset.

Table 4: ANN model performance accuracy analysis summary

Performance	Samples	MSE	RMSE	R^2
Training	28	0.00447	0.06686	0.99995
Validation	6	0.02012	0.14184	0.99896
Testing	6	0.86798	0.93165	0.97036

Discussion

Workplace injuries are ordinary happenings in every work environment setting. The severity and the number of occurrences of the injuries may vary due to several factors and sometimes could be deadly. By the nature of its work environment, remote location, confined spaces, and long working hours the oil and gas upstream sector is susceptible to high incident rates. This is in line with the findings of Palathoti S. et al.[36] In the current business competition and practices, it is customary to make every effort to continuously improve; among others, productivity, quality, and Safety are no different. The current trend in safety practices is Safety is left alone for the safety officer and safety department. However, Safety should also be every employee's responsibility.

Despite technological development, improved work processes, and Health, Safety, and Environment (HSE) mitigation procedures,

workplace injuries, and accidents are continuously reported worldwide.[1] The degree of workplace injuries and accidents varies depending on the environmental conditions and safety measures.

The use of contemporary tools plays a vital role in analyzing and accident rate forecasting. As reviewed in the introduction, many studies have applied Artificial intelligence techniques (both regression and classification models) in predicting injury outcomes in various fields, including medical, mining, tourism, transport, and construction sectors. Model analysis results showed that ML is a promising tool for forecasting and injury analysis. The application of the models for injury prediction allows for learning from previous injuries and positive developments related to risk controls and mitigation measures. In addition to modeling, continuous improvement approaches are vital in updating safety measures and precautions to minimize the risk and improve the workplace with the involvement of every employee.

ML application in Safety would help top management in making knowledgeable decision making. It can help them in making general rules from substantial amounts of cases belonging to highly dimensional spaces and is, therefore, a way to ground safety-related decisions under uncertainty on empirical knowledge. ML application could lead to improved decision-making and reduce the accident rate.

The application of artificial intelligence for injury assessment study is limited in the petroleum up - and downstream. Since the ML model performance analysis has shown promising results in various sectors, this paper also aimed to seek the potential application of Machine Learning modeling and prediction of injuries based on the considered dataset in the petroleum industry. For the evaluation, multivariable, Random forest, and ANN machine-learning regression models were selected. Their modeling and optimization procedures are different.

The multivariable regression model is a linear combination of weighted input features related to the target variable. The best regression model is obtained first by writing the error square function, which is the sum of the square of the difference between the multivariable model and the measured, target variable. Applying partial differentiation on the error function concerning the curve fitting coefficients results in optimized coefficients and hence the best-fit model is obtained.

On the other hand, the ANN modeling applies feed-forward-backward propagation training algorithms to achieve the best weight and bias parameters resulting in minimized error.

Unlike the Multivariable and ANN modeling, the Random forest regression is based on building n decision trees regressor (estimator). Then, the final output is then obtained from the average of those predictions. Random forest reduces overfitting since it averages over the independent trees.

Implementing the above three ML training algorithms on available injury data obtained from the North Sea offshore drilling sector, the model's assessment results have shown that the model's predictions are pretty good. However, since the results obtained were from limited datasets, it is difficult to make conclusions for model deployment unless more research is conducted. Regardless of the predictions, the work presented in this paper was to demonstrate the application of machine learning models to predict injuries in the petroleum industry, as also shown in the review of several other public and industrial sectors.

In addition to the selected ML regression models, in the future,

- develop a classification-based model that could predict accident or injury occurrences.
- implement the regression algorithms that were not used in this paper
- include more features that affect workplace accidents or injuries.

Morken et al. presented injuries during drilling operations under five categories, each having

different sub-factors. The database to be used would include Administration, Catering, Drilling and operation, Construction, maintenance, and other injury-related operations. Moreover, the details of the accident, fatal, injury on which part of the body, work department, gender, age, etc. The detailed information on the input features allows for accurate and reliable prediction.[4]

Conclusion

In recent years, the application of ML modeling for injury and safety studies has been increasingly used. Several types of ML algorithms are utilized to model accident/injury data obtained in different sectors, such as mining, transportation, and construction. The performance of the model predictions is also reported to be a potential tool for injury detection and forecasting, which would be necessary for safety practitioners and policymakers.

Due to the limited ML-based injury studies in the oil and gas industry, this paper presents a preliminary ML modeling on drilling-related injury datasets. Model performance accuracy analysis results obtained from the three ML models show that:

- The model accuracy of Multivariable regression, Random Forest, and Artificial Network machine learning algorithms-based models predict the test data with R^2 values of 0.9576, 0.793, and 0.97036, respectively.
- The ANN model has shown a better R^2 value, which is due to the backpropagation-feed forward iteration computations allowing for reducing the error. However, it is important to note that all ML modeling algorithms have pros and cons.

To sum up, the authors believe that implementing integrated machine learning tools along with a carefully built-in workplace accident database will provide early detection and possible remedial precautions that can be taken to prevent workplace injuries /accidents /fatalities. However, extensive research and development are required for deploying the machine learning methods to be utilized in real life. Combining Machine Learning with carefully designed safety measures is the key to successful and robust predictive tools. Moreover, along with new and improved technologies, the application of artificial intelligence on big data could contribute to innovating Safety management systems.

Acknowledgments

The authors acknowledge the Addis Ababa School of Engineering's administrative and technical support.

References

1. International Labour Organization (ILO). Promoting safe and healthy jobs: The ILO Global Programme on Safety, Health and the Environment (Safework): [Internet] 2006. Available from: https://www.ilo.org/global/publications/world-of-work-magazine/articles/WCMS_099050/lang--en/index.htm
2. Hämäläinen P, Saarela KL, Takala J. Global trend according to estimated number of occupational accidents and fatal work-related diseases at region and country level. Journal of Safety Research 2009;40(2):125-39 Available from: https://doi.org/10.1016/j.jsr.2008.12.010
3. Ciarapica FE, Giacchetta G. Classification and prediction of occupational injury risk using soft computing techniques: An Italian study. Safety Science. 2009 Jan; 47(1):36-49. Available from: https://doi.org/10.1016/j.ssci.2008.01.006
4. Morken T, Mehlum IS, and Moen BE. Work-related musculoskeletal disorders in Norway's offshore petroleum industry. Occupational Medicine. 2007; 57(2):112–7 Available from: https://doi.org/10.2118/111622-MS
5. Haugan T, Størseth F, Lootz E, Weggeberg H, Zachariassen S. Work-Related Disorders and Personal Injuries in the Norwegian Petroleum Industry: Achieving a Broader Picture by Combining Data Sources. SPE 111622. Health, Safety, and Environment in Oil and Gas Exploration and Production held in Nice, France, 15–17 April 2008. Available from https://doi.org/10.2118/111622-MS
6. Dyreborg J, Lipscomb HJ, Nielsen K, Törner M, Rasmussen K, Frydendall KB, et. Al.. Safety interventions for the prevention of accidents at work: A systematic review. Campbell Systematic

Reviews: 2022 Jun;18(2). Available from: https://doi.org/10.1002/cl2.1234

7. Matías JM, Rivas T, Martín JE, Taboada J. A machine learning methodology for the analysis of workplace accidents. International Journal of Computer Mathematics. 2008; 85(3):559-78. Available from: https://doi.org/10.1080/00207160701297346

8. Sánchez S, Fernández PR, Lasheras FS, de Cos Juez FJ, García Nieto PJ. Prediction of work-related accidents according to working conditions using support vector machines. Applied Mathematics and Computation. 2011 Dec; 218(7):3539-52. Available from: https://doi.org/10.1016/j.amc.2011.08.100

9. Fragiadakis NG, Tsoukalas VD, Papazoglou VJ. An adaptive neuro-fuzzy inference system (anfis) model for assessing occupational risk in the shipbuilding industry. Safety Science. 2014; 63: 226-35. Available from: https://doi.org/10.1016/j.ssci.2013.11.013

10. Tsoukalas VD, Fragiadakis NG. Prediction of occupational risk in the shipbuilding industry using multivariable linear regression and genetic algorithm analysis. Safety Science. 2016 Mar;83:12-22. Available from: https://doi.org/10.1016/j.ssci.2015.11.010

11. Van den Honert AF, Vlok PJ. Estimating The Continuous Risk Of Accidents Occurring In The Mining Industry In South Africa. S. Afr. J. Ind. Eng. 2015; 26(3):71–85. Available from: http://dx.doi.org/10.7166/26-3-1121

12. Alikhania M, Nedaiea A, Ahmadvand A. Presentation of clustering-classification heuristic method for improvement accuracy in classification of severity of road accidents in Iran.Safety Science. 2013 Dec; 60:. 142-50. Available from: https://doi.org/10.1016/j.ssci.2013.06.008

13. Bedard M, Guyatt GH, Stones MJ, Hirdes JP. The independent contribution of driver, crash, and vehicle characteristics to driver fatalities. Accident Analysis and Prevention. 2002 Nov; 34(6): 717–27 Available from: https://doi.org/10.1016/S0001-4575(01)00072-0

14. Zaranezhad A, Mahabadi HA, Dehghani MR. Development of prediction models for repair and maintenance-related accidents at oil refineries using artificial neural network, fuzzy system, genetic algorithm, and ant colony optimization algorithm. Process Safety and Environmental Protection. 2019 Nov;131: 331-48. Available from: https://doi.org/10.1016/j.psep.2019.08.031

15. Sukumar D, Zhang J, Tao X, Wang X, Zhang W. Predicting Workplace Injuries Using Machine Learning Algorithms. In Proceedings of the 2020 IEEE 7th International Conference on Data Science and Advanced Analytics (DSAA), Sydney, Australia, 2020. 763-64 Available from: http://dx.doi.org/10.1109/DSAA49011.2020.00104

16. Wang Q, Nguyen TT, Huang JZ, Nguyen TT. An efficient random forests algorithm for high dimensional data classification. Advances in Data Analysis and Classification. 2018;12: 953-72. Available from:http://doi.org/10.1007/s11634-018-0318-1

17. Capitaine L, Genuer R, Thiébaut R. Random forests for high-dimensional longitudinal data. Statistical methods in medical research. 2020; 30(1):166-84. Available from: https://doi.org/10.1177/0962280220946080

18. Tetik YO, Kale OA, Bayram I., Baradan S. Applying decision tree algorithm to explore occupational injuries in the Turkish construction industry. Journal of Engg. Research. 2022;10(3B). Available from: https://doi.org/10.36909/jer.12209

19. Zhu R, Hu X, Hou J, Li X. Application of machine learning techniques for predicting the consequences of construction accidents in China. Process Safety and Environment. Protection. 2021; 145: 293–302. Available from:https://doi.org/10.1016/j.psep.2020.08.006

20. Maynard E, Harris D. Using neural networks to predict high-risk flight environments from accident and incident data. International Journal of Occupational Safety and Ergonomics. 2021;28(2):1204-12. Available from: https://doi.org/10.1080/10803548.2021.1877455

21. Chadyiwa M, Kagura J, Stewart A. Investigating Machine Learning Applications in the Prediction of Occupational Injuries in South African National Parks. Mach. Learn. Knowl. Extr. 2022; 4(3): 768–78. Available from: https://doi.org/10.3390/make4030037

22. Khairuddin MZF, Hui PL, Hasikin K, Abd Razak NA, Lai KW, Mohd Saudi AS, et. al. Occupational Injury Risk Mitigation: Machine Learning Approach and Feature Optimization for Smart Workplace Surveillance. Int. J. Environ. Res. Public Health. 2022; 19(21):. Available from: https://doi.org/10.3390/ijerph192113962

23. Augustine T, Shukla S. Road Accident Prediction using Machine Learning Approaches. 2022 2nd

International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE) Greater Noida, India, 2022. 808-11. Available from: https://doi.org/10.1109/ICACITE53722.2022.9823499

24. Pandaa C, Mishrab AK, Dashc AK, Nawabd H. Predicting and explaining severity of road accident using artificial intelligence techniques, SHAP, and feature analysis. International Journal of Crashworthiness. 2022; 28(2):186-201. Available from: https://doi.org/10.1080/13588265.2022.2074643

25. Anderson TW. An Introduction to Multivariate Statistical Analysis. 3rd Edition. Wiley; 2003 752.Available from: https://www.wiley.com/en-us/An+Introduction+to+Multivariate+Statistical+Analysis%2C+3rd+Edition-p-9780471360919

26. Breiman L. Random forests. Machine learning. 2001;45:5-32. Available from: https://link.springer.com/article/10.1023/A:1010933404324

27. Han J, Kamber M, Jian PJ. Data Mining: Concepts and Techniques. 3rd Edition. USA: Elsevier; 2011. 694p. Available from: https://myweb.sabanciuniv.edu/rdehkharghani/files/2016/02/The-Morgan-Kaufmann-Series-in-Data-Management-Systems-Jiawei-Han-Micheline-Kamber-Jian-Pei-Data-Mining.-Concepts-and-Techniques-3rd-Edition-Morgan-Kaufmann-2011.pdf

28. Chang L, Wang H. Analysis of traffic injury severity: An application of non-parametric classification tree techniques. Accident Analysis & Prevention. 2006; 38(5):1019–27. Available from: https://doi.org/10.1016/j.aap.2006.04.009

29. Cheng C, Leu S, Cheng Y, Wu T, Lin C. Applying data mining techniques to explore factors contributing to occupational injuries in Taiwan's construction industry. Accident Analysis & Prevention. 2012; 48:214–22. Available from: https://doi.org/10.1016/j.aap.2011.04.014

30. Choi J, Gu B, Chin S, Lee JS. Machine learning predictive model based on national data for fatal accidents of construction workers. Automation in Construction. 2020;110. Available from: https://doi.org/10.1016/j.autcon.2019.102974

31. Agatonovic-Kustrin S, Beresford R. Basic concepts of artificial neural network (ANN) modeling and its application in pharmaceutical research. Journal of pharmaceutical and biomedical analysis. 2000; 22(5): 717-27. Available from: https://doi.org/10.1016/S0731-7085(99)00272-1

32. Ivaz J, Nikolić RR, Petrović D, Djoković JM, Hadzima B. Prediction Of The Work-Related Injuries Based On Neural Networks. System Safety: Human - Technical Facility - Environment. 2021;3(1):19-37. Available from: https://doi.org/10.2478/czoto-2021-0003

33. Douglas CM. Introduction to Statistical Quality Control. 8th Edition; Wiley; 2019. 768. Available from: https://www.wiley.com/en-us/Introduction+to+Statistical+Quality+Control%2C+8th+Edition-p-9781119399308

34. Petroleum Safety Authority Data. Available from: https://www.ptil.no/contentassets/525fcd91f1f24aa49147857927989c23/eng-faste-innretn-2018.htm

35. Abiodun OI, Jantan A, Omolara AE, Dada KV, Mohamed NA, Arshad H. State-of-the-art in artificial neural network applications: A survey. Heliyon. 2018; 4(11). Available from: https://doi.org/10.1016/j.heliyon.2018.e00938

36. Palathoti S, Al Aghbari AHM, Otitolaiye VO. Effect of Long Extended Working Hours on the Occupational Health and Safety of Oil and Gas Workers in the Sultanate of Oman. International Journal of Occupational Safety and Health. 2023; 13(4): 419–28. Available from: https://doi.org/10.3126/ijosh.v13i4.48968

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

COVID - 19 pandemic and perceived stress in Information Technology professionals

Bano S[1], Raina N[1], Joshi AR[1]

[1]Department of Physiology, Bharati Vidyapeeth (DTU) Medical College, Pune, Maharashtra, India- 411043

Corresponding author:

Saira Bano,
Assistant Professor,
Department of Physiology,
Bharati Vidyapeeth (DTU)
Medical College, Pune,
Maharashtra,
India- 411043,
Tel.: 9372577077
E-mail: saira27raja@gmail.com
ORCID ID:
https://orcid.org/0000-0002-6200-3405

Date of submission: 11.10.2022
Date of acceptance: 20.10.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.47140

ABSTRACT

Introduction: Novel coronavirus disease (COVID-19), a pandemic was declared by WHO on 11 March 2020. The lockdown had an evident impact on various sectors including the Information Technology sector. Few studies have been conducted to find out the levels of stress in Information Technology professionals. During the COVID-19 pandemic, all employees of Information Technology companies were informed to work remotely at their homes without any prior information, training and mental acceptance i.e. 'work from home'. Information technology professionals have occupational stress &working from home during COVID-19 had added mental stress. The present study was planned to assess the impact of the COVID-19 pandemic on perceived stress in Information Technology professionals.

Methods: Present study was a cross-sectional observational study. Volunteers of the Information Technology sector (n=200) of either sex in the age group of 25 to 55 years participated in the study. PSS was administered through Google Forms and scores were analyzed.

Results: Association of various stressors with PSS was done which showed a significantly positive association. The mean PSS score of subjects was 23.53 ± 7.39. Twelve (6%) employees had mild, one hundred twenty (60%) had moderate and sixty-eight (34%) had high stress levels. This study explored that IT professionals experienced an additional level of stress during the COVID-19 pandemic.

Conclusion: The present study concluded statistically significant moderate levels of stress in IT professionals of either sex with the outbreak of (COVID-19) pandemic.

Keywords: COVID-19, Information technology, Perceived Stress Scale, Stress.

Introduction

Novel coronavirus disease (COVID-19), a pandemic was declared by WHO on 11 March 2020.[1] Pandemic is an epidemic occurring worldwide, crossing international boundaries, and usually affecting a large number of the population.[2]

The Government had enforced lockdown, quarantine, and social distancing measures to prevent and slow down the spread of the virus from person to person.[3] The lockdown had an evident impact on various sectors including the Information Technology sector which collectively employs approximately 4 million people. All employees of Information Technology companies were informed to start 'work from home' meaning working remotely at their homes without any

prior information, training, and mental acceptance.[4,5]

Stress refers to a perceived or actual threat to physical and or psychological homeostasis of the human body causing activation of the hypothalamus – Pituitary - Adrenal axis.[6] Studies have shown that epidemics like SARS have created stress among the general population and patients.[7] The worldwide COVID-19 Pandemic was also posing a drastic effect on individual mental as well as physical health. The increasing number of cases & high mortality led to anxiety and depression globally.[4]

There are various methods to estimate levels of stress. Perceived Stress Scale, is a prevalidated questionnaire that measures the degree to which situations in one's life are perceived as stressful in the last one month.[6]

Studies have also shown that Information technology professionals have occupational stress like lack of advancement of career, high workload, risk involved in decision making and expectation from job, etc.[7,8]

During the COVID-19 pandemic, many employees of the Information technology sector started work from home, on short notice and without pre-preparation and proper setup. They also faced difficulties coping with their work timing, looking after kids and their online classes.[4]

Female information technology employees had faced added difficulties in dealing with household chores without domestic help, while others faced difficulty in accessing the internet. Adding more to these challenges, the employees had difficulties in attending online meetings and concentrating on work due to small houses thus lacking privacy and fear of losing their job.[4]

Few studies have been conducted to find out the Perceived stress level in Information Technology professionals during the COVID-19 pandemic.[8,9,10]

So the present study was planned to assess the impact of the COVID-19 pandemic on perceived stress in Information Technology professionals.

Methods

The present study was a cross-sectional study which is a type of observational study design. In this study outcome & exposure were measured at the same time by observation without any intervention. Volunteers of the Information Technology sector (n=200) of either sex in the age group of 25 to 55 years participated in the study. Purposive sampling was used to select information technology professionals of Pune city. The sample size estimation was done using the results of a study done by Sherrill W. Hayes et al.[5] Standard deviation of the perceived stress scale was 5.49 considering the allowable error equal to 0.8 and 5% level of significance, sample size was calculated to be 200.

The study was approved by the Institutional ethical committee. Online informed consent was obtained from subjects. The study was conducted online in July 2020 in Pune. A Google form including multiple choice questions of perceived stress score & other questions like working hours, disturbed sleep, household work affected due to working from home, fear of losing the job, impact of social media, kids online classes, sedentary lifestyle due to less time for exercise, food craving, mood swings & poor internet connectivity was designed. The Google form was shared in June 2020 and 3 days were given to fill in the answers and submit the form.

Subjects suffering from adrenal disease, anxiety disorder and those having a history of taking medication e.g antidepressants, hormonal therapy and steroids were excluded from the study.

The Perceived Stress Scale (PSS) is a classic stress assessment instrument and the most widely used psychological instrument for measuring the perception of stress.[11] It is a measure of the degree to which situations in one's life are appraised as stressful. Items were designed to tap into how unpredictable, uncontrollable, and overloaded respondents find their lives. The scale also includes a number of direct queries about current levels of experienced stress. The PSS was designed for use in community samples with at least a junior high school education. The items are easy to

understand, and the response alternatives are simple to grasp.

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way. Moreover, the questions are of a general nature and hence are relatively free of content specific to any subpopulation group.

PSS scores are obtained by reversing responses (e.g., 0 = 4, 1 = 3, 2 = 2, 3 = 1 & 4 = 0) to the four positively stated items (items 4, 5, 7, & 8) and then summing across all scale items. A short 4-item scale can be made from questions 2, 4, 5 and 10 of the PSS 10-item scale.

0 = Never

1 = Almost Never

2 = Sometimes

3 = Fairly Often

4 = Very Often

Individual scores on the PSS can range from 0 to 40 with higher scores indicating higher perceived stress.[11] Scores ranging from 0 to 13 - Low stress, 14 to 26 - moderate stress, and from 27 to 40 - high perceived stress.

Data analysis was done by SPSS (Statistical Package for Social Sciences) version 28.0. The data was expressed as mean ± standard deviation. Data was analyzed in percentage (%) for multiple-choice questions and the PSS questionnaire. The association of various stressors with PSS score was analyzed and p-value <0.05 means that the value was statistically significant.

Results

200 subjects of either sex in the age group of 25-55 years participated in the study. Out of 200 subjects, 115 (57.5%) subjects were male and 85 (42.5%) subjects were female. The mean PSS score of subjects was 23.53 ± 7.39. The mean PSS score of male was 23.13 ± 7.41 and female was 24.07 ± 7.33.

Out of 200 subjects, 12 (6%) had mild stress, 120 (60%) had moderate levels of stress and 68 (34%) had high stress levels (Figure 1).

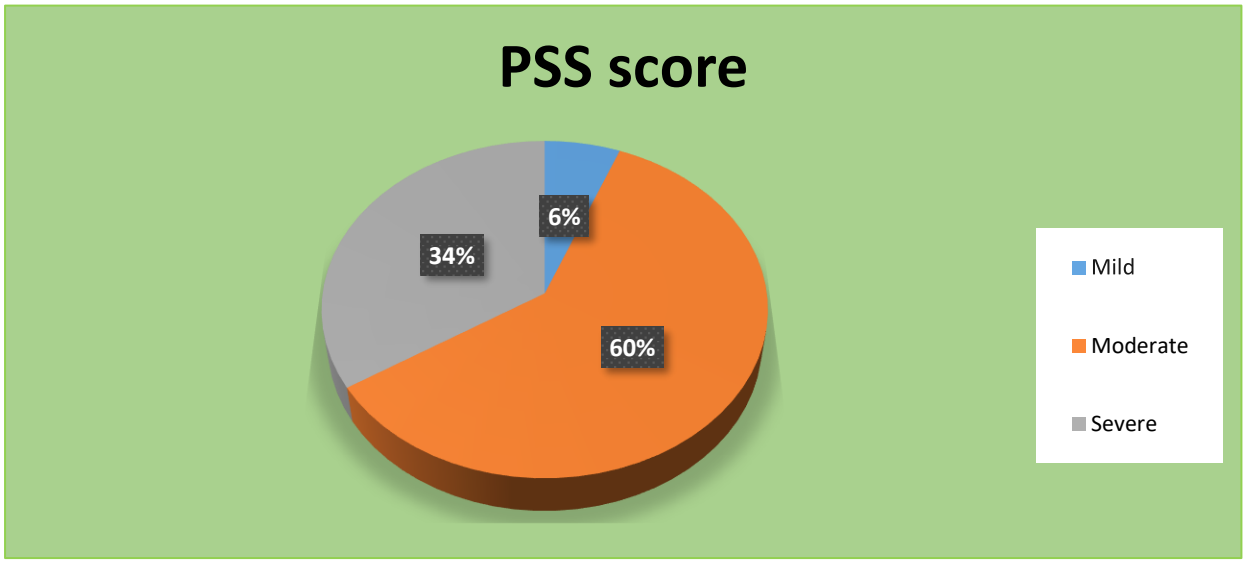


Figure 1: The stress levels in the subjects as assessed by Perceived stress scale

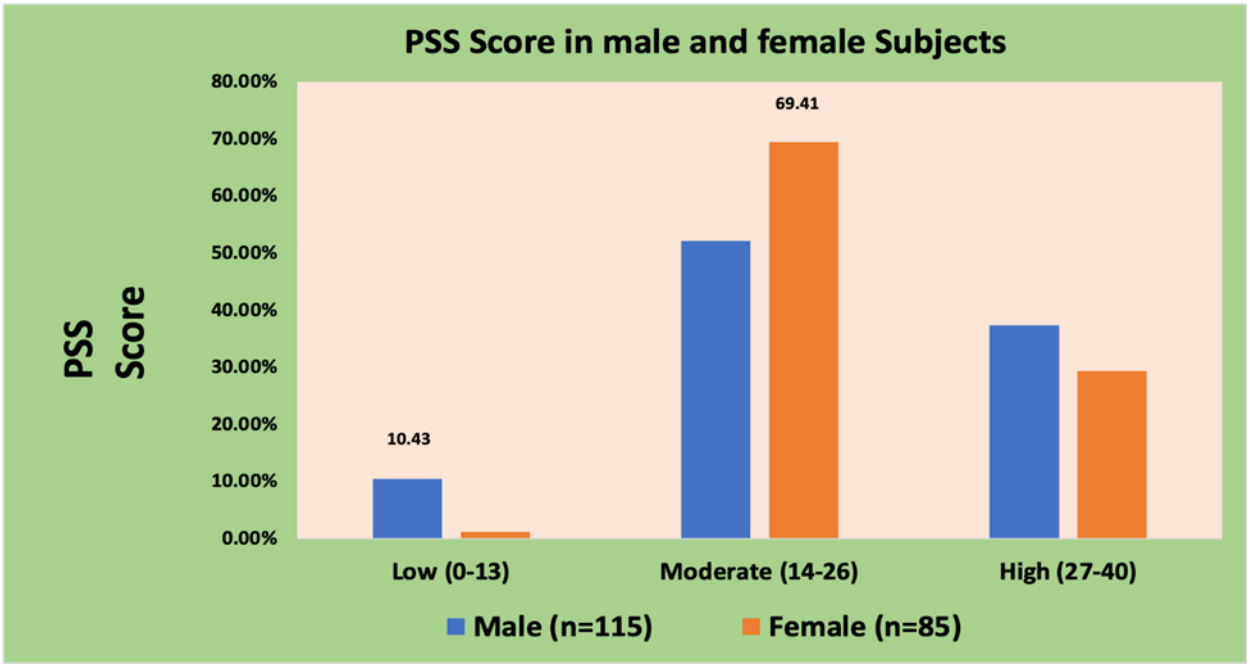


Figure 2:, PSS score in male and female subjects

The important stressors found in our study were prolonged working hours, disturbed sleep, difficulties dealing with the household chores without domestic help, fear of losing the job, kid's online classes, negative news propagated on news channels & social media, poor internet connectivity, food craving, mood swings, excess workload, sedentary lifestyle due to less time for exercise, job pressure and COVID-19 phobia (Table 1).

Out of 200 subjects, 53.5% were stressed due to prolonged working hours of more than 10 hours daily and 78% of subjects reported that they are having disturbed sleep. In 73.5% of subjects, household work was affected and 67.5% of subjects were having fear of losing job. In 80% of subjects, the impact of social media was the main stressor and in 59.5% of subjects, managing kid's online classes along with working from home was causing stress. 56.5% of subjects reported that the pandemic had a negative impact on their lives.

The results also showed that most of the subjects experienced moderate levels of stress during the last one month (Table 2).

Table 1: Association of various stressors amongst IT professionals with the level of stress (PSS score).

Stressors amongst IT Professionals		**PSS score**			**Total**	**Chi-square value**	**p-value**
Items causing stress		**Low**	**Moderate**	**High**			
Working hour	6-8 hours	9	20	0	29	52.08	<0.001*
	8-10 hours	2	43	19	64		
	>10 hours	1	57	49	107		
Disturbed sleep	Yes	26	76	54	156	49.94	<0.001*
	No	30	14	0	44		
Household work affected due to work from home	Yes	34	78	35	147	30.59	<0.001*
	No	33	19	1	53		
Fear of losing a job	Yes	10	62	63	135	59.3	<0.001*
	No	27	38	0	65		

Impact of social media	Yes	40	56	64	160	23.7	<0.001*
	No	18	22	0	40		
Kids online classes	Yes	1	87	32	120	54.71	<0.001*
	No	26	53	1	80		
Sedentary lifestyle due to less time for exercise	Yes	33	53	5	91	6.77	0.034
	No	48	61	0	109		
Food craving	Yes	32	44	0	76	0.62	0.74
	No	52	71	1	124		
Mood swings	Yes	29	36	2	67	0.42	0.81
	No	61	72	4	133		
Poor internet connectivity	Yes	20	40	1	61	3.99	0.14

P < 0.001 – Highly significant

P >0.05 – Not significant

Table 2: Responses to PSS questionnaire:

S. N	Questions	Never n=200 (%)	Almost Never N=200 (%)	Sometimes N=200 (%)	Fairly often N=200 (%)	Very often N=200 (%)
1	upset because of something that happened unexpectedly	15 (7.5%)	12 (6%)	116 (58%)	51 (25.5%)	6 (3%)
2	unable to control the important things in your life	11 (5.5%)	27 (13.5%)	99 (49.5%)	42 (21%)	21 (10.5%)
3	felt nervous and "stressed"	8 (4%)	13(6.5%)	122(61%)	43(21.5%)	14 (7%)
4	felt confident about ability to handle personal problems	34(17%)	81(41%)	70(35.5%)	9(4.5%)	6(3%)
5	things were going on way	28 (14%)	63 (31.5%)	97 (48.5%)	7 (3.5%)	5 (2.5%)
6	could not cope with all the things	5 (2.5%)	12 (6%)	127 (63.5%)	36 (18%)	20 (10%)
7	able to control irritations in the life	23(11.5%)	58 (29%)	108 (54%)	5 (2.5%)	6 (3%)
8	were on top of things	24 (12%)	33 (16.5%)	126 (63%)	10 (5%)	7 (3.5%)
9	angered because of things that were outside of control	3 (1.5%)	18 (9%)	109 (54.5%)	47 (23.5%)	23 (11.5%)
10	difficulties were piling up so high that could not overcome	9 (4.5%)	33 (16.5%)	95 (47.5%)	54 (27%)	9 (4.5%)

Discussion

This study highlighted the level of stress and various stressors faced by IT professionals of either sex on day-to-day basis with the outbreak of (COVID-19) pandemic.

The present study showed statistically significant moderate levels of stress in IT professionals of either sex as shown in figure no. 1, however, the result showed that the level of stress in females (figure no. 2) was more than in males. Similar results were found in a study conducted by Riba Maria et al.[9] A sudden change in the mode of work, from office setups to working from home led to difficulty in coping with office work and household chores.[5] Adding to their difficulties, fear of losing job, and managing kids' online classes may be a factor causing anxiousness in these professionals. Staying indoors led to an increase in the usage of social & digital media platforms, propagating fear of the COVID-19 pandemic amongst the population. Many studies have also documented the same results.[4,9,10]

Our study showed a significant positive association between various stressors with perceived stress. In our study, 80% of subjects reported a negative impact of social media on their mental health status. Similar results were shown in various studies which highlighted the mental health issues among male & female employees who were experiencing feelings of distress.[12,13] The Present study showed a significant positive association of prolonged working hours with perceived stress. 53.5% of professionals who were working for more than 10 hours daily showed moderate to high levels stress. Similar results were shown in a study conducted by S. Karthikeyan Arasu et al who documented that 56% of IT professionals who were working for more than 8 hours suffered from a moderate level of stress.[8]

In our study, 67.5% of subjects had a fear of losing job. A study done by Khudaykulov A et al. also reported that the pandemic led to job insecurity in subjects.[14] In this study, 54.5% of volunteers got angry sometimes and 35% of volunteers got angry often. A study done by Smith et al, documented that anger was associated with younger age and an increased likelihood of facing significant financial difficulties.[15]

Our study found that 73.5% of subjects felt stressed due to household work getting affected by "work from home". Similar results were found in a study conducted by Jelena Lonska et al.[16] 59.5% of subjects showed a positive association of perceived stress with kids' online classes. The result is similar to a study conducted by Priyanka Harjule et al.[17] Present study documented that 52.5% of subjects felt stressed due to an inactive lifestyle as also highlighted in a study done by Ruberti OM et al.[18]

In our study few subjects also experienced that food cravings, mood swings and internet connectivity problems resulted in creating a lot of mental stress but there was no significant association of these stressors with perceived stress.

The work pattern was unstructured unlike the pre-Covid times affecting the mental health of many subjects.[16] Study done by S. Karthikeyan Arasu et al highlighted that IT professionals face stress, anxiety and depression due to exposure to many stressors in the workplace.[8] Studies have shown similar results emphasizing overall decreased work capability, productivity and performance in IT professionals.[18]

The probable mechanism that explains the cause of mental stress in volunteers is a complex relationship between mental stress & Hypothalamo Pituitary Adrenal (HPA) system. The stressors initiate the stress response of the sympathetic nervous system. Psychological stressors increase glucocorticoid levels through increased adrenal activity by activating the HPA axis which inhibits the functions of lymphocytes, macrophages, and monocytes, leading to decreased immunity and thereby increasing the susceptibility to infection leading to poor work performance, decreased concentration and overall work efficiency.[6]

Conclusions

The present study concluded statistically significant moderate levels of stress in IT

professionals of either sex with the outbreak of (COVID-19) pandemic.

Our findings have key implications for organizations and their leaders who need to revisit work-from-home policies for the future workforce. India is one of the leading hubs of Information technology, employing lakhs of people. Thus there is a need to work on minimizing the stressors at the workplace as well as the work-from-home setup & work policies for better physical & mental health of their professionals. Providing a conducive environment for work can help in better work performance & productivity. We highlight our theoretical contributions and outline the scope for future research.

Acknowledgment

The authors of this research express their gratitude to all the IT professionals who wholeheartedly participated in this research and shared their experiences in making this research possible.

References

1. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Biomed. 2020;91(1):157-60. Available from:https://doi.org/10.23750/abm.v91i1.9397
2. Fasano MV, Padula M, Azrak MÁ, Avico AJ, Sala M, Andreoli MF. Consequences of Lockdown During COVID-19 Pandemic in Lifestyle and Emotional State of Children in Argentina. Front Pediatr. 2021; 9. Available from: https://doi.org/10.3389/fped.2021.660033
3. Prasad KDV, Vaidya RW, Mruthyanjaya RM. Effect of occupational stress and remote working on psychological well-being of employees: an empirical analysis during covid-19 pandemic concerning information technology industry in Hyderabad. Indian Journal of Commerce & Management Studies. 2020; 11(2): 1-13. Available from: http://dx.doi.org/10.18843/ijcms/v11i2/01
4. Chippagiri S, Arasu S, Ramesh N, Goud R, Joseph B. Morbidity profile of migrant workers attending health camps in Bangalore urban during the Covid-19 pandemic. Int J Occup Saf Health. 2023; 13(1):78-86. Available from: http://dx.doi.org/10.3126/ijosh.v13i1.43081
5. Hayes SW, Priestley JL, Moore BA, Ray HE. Perceived Stress, Work-Related Burnout, and Working From Home Before and During COVID-19: An Examination of Workers in the United States. SAGE Open. 2021;11(4):1-12. Available from: https://doi.org/10.1177/21582440211058193
6. Anuradha RJ, Mitsha N. Perceived Stress in Postgraduate Students during Training Programme. Journal of Clinical and Diagnostic Research. 2018;12(6):1-4. Available from: http://dx.doi.org/10.7860/JCDR/2018/28300.11634
7. Konstantinos T, Emmanouil R, Athanasios JM, Sofia C, Kympouropoulos S, Spartalis E, et al. Covid-19 pandemic and its impact on mental health of healthcare professionals. Experimental and therapeutic medicine. 2020; 19(6): 3451-3. Available from: https://doi.org/10.3892/etm.2020.8646
8. Arasu SK, Dhivakar R, Chakravarthi JC, Kausik M, Kumar MA. Evaluation of professional stress in IT professionals. International Journal of Community Medicine and Public Health. 2019; 6(3): 1079-82. Available from: https://doi.org/10.18203/2394-6040.ijcmph20190589
9. Kurian RM, Thomas S. Perceived stress among information technology professionals in India during the COVID-19 pandemic. Theoretical Issues in Ergonomics Science. 2021; 23(2): 182-98. Available from: https://doi.org/10.1080/1463922X.2021.1901321
10. Sivaprakash P, Kanchana S, Venkataramanan P, Michael PA. An Efficacy of Covid – 19 Pandemic: Recovery of Workplace Environment and Ecosystem. Int J Occup Saf Health. 2022; 12(3): 141-3. Available from:https://doi.org/10.3126/ijosh.v12i3.42235
11. Cohen S, Kamarck T, Mermelstein R. Global measure of perceived stress. Journal of Health and Social Behavior. 1983; 24(4): 386-96. Available from:

https://doi.org/10.2307/2136404

12. Rasmussen EE, Punyanunt CN, LaFreniere JR, Norman MS, Kimball TG. The serially mediated relationship between emerging adults' social media use and mental well-being. Computers in Human Behavior. 2020; 102: 206-13. Available from: https://doi.org/10.1016/j.chb.2019.08.019

13. Karim F, Oyewande AA, Abdalla LF, Chaudhry Ehsanullah R, Khan S. Social Media Use and Its Connection to Mental Health: A Systematic Review. Cureus. 2020 Jun; 12(6). Available from: https://doi.org/10.7759/cureus.8627

14. Khudaykulov A, Changjun Z, Obrenovic B, Godinic D, Alsharif HZH, Jakhongirov I. The fear of COVID-19 and job insecurity impact on depression and anxiety: An empirical study in China in the COVID-19 pandemic aftermath. Curr Psychol. 2022; 1-14. Available from: https://doi.org/10.1007/s12144-022-02883-

15. Smith LE, Duffy B, MoxhamHall V, Strang L, Wessely S, Rubin GJ. Anger and confrontation during the COVID-19 pandemic: a national cross-sectional survey in the UK. J R Soc Med. 2021;114(2): 77–90. Available from: https://doi.org/10.1177/0141076820962068

16. Lonska J, Mietule I, Litavniece L, Arbidane I, Vanadzins I, Matisane L, et al. Work–Life Balance of the Employed Population During the Emergency Situation of COVID-19 in Latvia. Frontiers in Psychology. 2021; 12: 1-15. Available from: https://doi.org/10.3389/fpsyg.2021.682459

17. Harjule P, Rahman A, Agarwal B. A cross-sectional study of anxiety, stress, perception and mental health towards online learning of school children in India during COVID-19. Journal of Interdisciplinary Mathematics. 2021; 24(2): 411-24. Available from: https://doi.org/10.1080/09720502.2021.1889780

18. Ruberti OM, Telles GD, Rodrigues B. Stress and Physical Inactivity: Two Explosive Ingredients for the Heart in COVID-19 Pandemic Times. Curr Cardiol Rev. 2021;17(6) Available from: https://doi.org/10.2174/1573403x17666210126103204

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Estimation of Atraumatic Hip Microinstability Among Long-distance Truck Drivers in Western Maharashtra: A Cross-Sectional Study

Shinde SB[1], Kadam SS[1], Dalvi SK[1]

[1]Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences Deemed to be University, Karad, Maharashtra, India. Pin. 415110

Corresponding author:
Dr Sandeep B. Shinde,
Professor and Head, Department of Musculoskeletal Sciences, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Krishna Institute of Medical Sciences (Deemed to be University)
Karad, Maharashtra, India.
Tel.: 9975866776--
E-mail: drsandeepshinde24@gmail.com
ORCID ID: https://orcid.org/0000-0002-6466-3888

Date of submission: 23.02.2023
Date of acceptance: 17.12.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: KVV, KIMSDU, Karad.
DOI:https://doi.org/10.3126/ijosh.v14i2.51635

ABSTRACT

Introduction: Hip micro-instability is a growing concern in adults, contributing to hip joint dysfunction and early osteoarthritis. Around 20-25% of people aged 50 and older suffer from hip and knee pain due to chronic wear and tear of joint cartilage. Hip instability is often characterized by painful extra-physiologic hip movements. Long-distance truck drivers often travel long routes with their hips in an ergonomically compromised position, causing pain due to vibrational forces and postural stress.

Methods: A six-month cross-sectional study was conducted in a rural tertiary care hospital in Karad, involving 103 long-distance truck drivers aged 35-45, working over 12 hours a day and 5 days a week without trauma history. The drivers were assessed using the Anterior Apprehension Test, Prone Apprehension Test, and AB-HEER test. The data was analyzed using statistical procedures, providing valuable insights into the drivers' experiences and potential health issues.

Result: The study found that over 12% of participants experienced hip micro-instability, with a significant positive correlation between driving years and pain. The assessment revealed anterior hip micro-instability in flexion (P value = 0.0121), adduction, and internal rotation ranges, while posterior instability was observed in extension, abduction, and external rotation ranges.

Conclusion: The study revealed that over 12% of participants had hip micro-instability. Among truck drivers, anterior hip micro-instability was more common due to capsular laxity caused by prolonged exposure to vibrational forces acting axially over the hip and spine. The study also discovered the existence of hip micro-instability related to ligamentous laxity.

Keywords: Hip joint dysfunction, Hip micro-instability, Hip osteoarthritis, Joint laxity

Introduction

In India, there are an estimated 5–6 million truck drivers, of whom 3.5–4 million are categorized as long-distance drivers.[1] Previously, the Hip joint was particularly considered as a constrained joint that has a powerful suction seal; which helps the joint to achieve its full functional ability.[2,3] So, hip

joint instability was rarely considered or it was thought to be some pathological occurrence like trauma or any kind of developmental bony abnormality like acetabular dysplasia; but the recent evidence of anatomic and finite elemental analysis studies suggests that the relationship between the femoral head and the acetabulum is not perfectly congruent/spherical.[4-7] It is considered to be quasi-hemispherical, as the acetabulum covers only 170° of the femoral head. The posterior coverage is greater than the anterior coverage, which is due to the acetabular tilt of 48° degrees in the coronal plane and 21° in the sagittal plane. The femoral neck is noted to be inclined superiorly by 130° relative to the femoral shaft and anteverted by 10° relative to the femoral trans-condylar axis. Under the influence of physiologic loads there is flattening and widening of the weight-bearing surfaces; and also a translation measuring up to 2-5mm which is observed at the joint.[8, 9]

Micro-instability of the hip is one such new pathology which is generally defined as a painful supra-physiological mobility of the hip that is associated with architectural and functional abnormalities that impair the hip stability.[10-12]

Several risk factors have been noted and described which are responsible for the supra-physiologic motion of the femur relative to the acetabulum, which is classified into 6 categories.[13]

(1) *Bony abnormalities*
(2) Connective tissue disorders
(3) Post-traumatic
(4) *Micro-traumatic*
(5) Iatrogenic
(6) Idiopathic.

The symptoms of hip micro-instability include pain, apprehension, or sensation of instability which can be seen acting only upon the activities demanding major hip involvement. The pain is majorly observed in the inguinal fold which has been progressive over a period of time.[13]

The patho-mechanics for hip micro-instability usually begins with some abnormalities present anatomically in and around the joint; which are subtle or significant in the presence of repetitive forces across the joint. These repetitive forces consist of joint rotation and axial loading which cause damage to the soft tissue stabilizers of the hip, including the labrum and the capsule-ligamentous complex, which then ultimately results in increased translation of femoral head over the acetabulum, stressing the surrounding soft tissues, increasing the labral tension and causing micro-trauma to the joint capsule which leads to labral breakdown and capsular ligament stretching resulting in symptomatic hip micro-instability. Micro-instability once setin, can further cause damage to the bony as well as the chondral surfaces leading to early degenerative changes. Such individuals may or may not have underlying joint laxity.[14,15]A wide range of inflammatory and degenerative conditions affecting soft tissues and skeletal structures that are brought on by or made worse by work or environments associated with it are collectively referred to as work-related musculoskeletal disorders (WMSDs). If treatment for MSDs is delayed, they may worsen and become more serious injuries.[16] One of the largest populations that account for work-related musculoskeletal disorders in the spine and hip is considered to be high mileage truck drivers.[17,18]According to the 2006 statistics, analysis by the Bureau of LabourUS, the drivers of heavy vehicles like trucks and tractors are associated with the second highest number of occupational illnesses and injuries.[19]Similarly some studies show a great prevalence of Work-related musculoskeletal problems (WMSDs) in drivers in the Iranian population.[20]This population has been often linked with the presence of musculoskeletal pain arising due to poor posture, where the drivers are exposed to prolonged periods of vibrational forces acting axially over the spine and hip. This contributes as a major factor in inducing musculoskeletal pain.[21-24]

Loading and unloading heavy goods, decoupling the trailers, tarpaulins to be strapped down, and jumping up and down from the vehicle seat are

the other factors that are linked to the occupation or collectively termed occupational stressors which are also responsible for musculoskeletal pain.[25]Such mechanically demanding activities are carried out by the following large periods of inactivity, lack of preparedness and usually an undernourished body considering the unhealthy eating habits and rest periods during the travel. Such a negative lifestyle is also an important factor leading to musculoskeletal pain amongthem.[26]

There have been limited studies investigating the occurrence of hip pain and hip micro-instability in truck drivers. Therefore, it is critical to assess if hip micro-instability is present as an alternative cause for hip pain in truck drivers.

Methods

This study was conducted in a rural tertiary care hospital in Karad and according to the previous study, prevalence of a total of 103 individuals were randomly selected based on the following selection criteria. They are as follows 1. Long-distance truck drivers by occupation 2. Within the age group of 35-45yrs 3. Working for more than 12 hours in a day 4. Working for 5 days/week 6. No history of trauma.[17] They were assessed by using the Anterior Apprehension Test, Prone Apprehension Test, and AB-HEER test. The recruited subjects were the ones who complained of pain in the hip during their visit to the occupational health screening camp organized at a tertiary care hospital, in Karad, Maharashtra.

Sample size (n) $=(Z_{1-}\propto/2)^2(p)(q)/d^2$

$= 1.96\times1.96\times0.7\times0.3/(0.05)^2$

$= 80$

Where; Z=1.96 at 95% confidence level

p = prevalence=78%=0.7

q=1-p

d=5%=0.05

But in this study, 103 individuals were included.

All the patients were explained the aims, objectives, procedure, and benefits of the current research work along with written consent and verbal informed consent that was taken from all the patients before including them in this study.

The screening was divided into two parts: Interview and Physical Assessment. Interviewing consisted of the collection of Demographic information of the patients including name, age, number of years of driving, presence of any other pathology and/or medications, and presence of ligamentous laxity if yes the score was noted as per Beighton's criteria and a precise subjective pain assessment encompassing Visual Analogue Scale at rest and on movement was documented before physical assessment of the patients was started by first assessing for tenderness which was recorded after palpation at the site of pain and graded according to the grades of tenderness; a range of motion was assessed with the help of goniometer for all the hip ranges; strength of hip musculature was assessed with manual muscle testing of all the muscle groups and graded according to the grades of MMT; provocative maneuvers such as Abduction-Extension-External Rotation test, Anterior Apprehension Test, Posterior apprehension test wasperformed.

The Anterior Apprehension Test/HEER (Hyperextension-External Rotation) is performed with the patient in a supine lying position over the examination plinth at the foot end of the plinth and the legs lying freely off the plinth. The examiner stands over the examination side and applies an anteriorly directed force at the hip, while the contra-lateral hip is flexed by the patient himself holding the extremity. Now the examiner passively hyperextends and externally rotates the ipsilateral hip. If anterior hip pain is provoked in this maneuver, then it indicates positive test results.[27,28]

The Prone Apprehension Test is performed with the patient in a supine position. The examiner stands on the examination side, and the subject's affected hip is placed in 90° flexion, abduction, and internal rotation. The examiner then exerts a force anteroposteriorly downwards on the knee. If any pain sensation is induced it indicates that the test is positive for posterior labral lesion/posterior instability.[27,28]

The AB-HEER test is performed with the patient

in a side-lying position with the affected hip placed upwards. The examiner then abducts the hip to 30°- 45°, extends, and rotates externally. An anteriorly directed force is applied to the posterior aspect of the greater trochanter. A positive test result yields pain in the anterior hip region.[27,28]

Results

The results of the present study revealed that there was the presence of hip micro-instability with hip pain amongst the subjects which caused discomfort. It revealed that over 12% of participants showed positive results for hip micro-instability. A significant positive correlation was observed between the number of years of driving to pain *(p-value < 0.0001)*.On assessment, there was an increase in flexion, adduction, and internal rotation ranges which hence revealed anterior hip micro-instability (P value = 0.0121) as compared to extension, abduction, and external rotation ranges which revealed posterior instability. However, the severity of pain was observed to be related to the years of driving by the subjects. The presence of ligament laxity is a major factor in ruling out hip micro-instability from any other pathology. Depending upon the type of instability i.e. anterior instability or posterior instability the range of motion which was affected was determined.

A total of 103 participants were evaluated for the study. The participants were between 35-45 years and had complaints of pain in their hips (Table 1).

Table 1: Demographic Variables

Demographic variables	No of participants	Percentage of participants(%)
Age		
35-38	29	28.15 %
39-42	38	36.89%
43-45	30	29.12%
More than 45	6	5.82%
Pain region (severity on VAS)		
Gluteal region	19	18.42%
Inguinal region	47	45.63%
The proximalaspect of lateral thigh	24	23.30%
Pain in all 3 regions	13	12.6%
Years of driving		
10-15	49	47.57%
16-20	48	46.60%
More than 20	6	5.82%
Exercising/Non-exercising		
Exercising	0	0%
Non-exercising	103	103%
Laxity		
Present	14	13.59%
Absent	89	86.41%

Among the 103 individuals complaining of hip pain, 12% of them were positive for hip micro-instability and 4% of individuals showed femoral-acetabular impingement and the remaining 84% of individuals need further investigation to rule out the significant root cause for their hip pain.

(Figure 1)

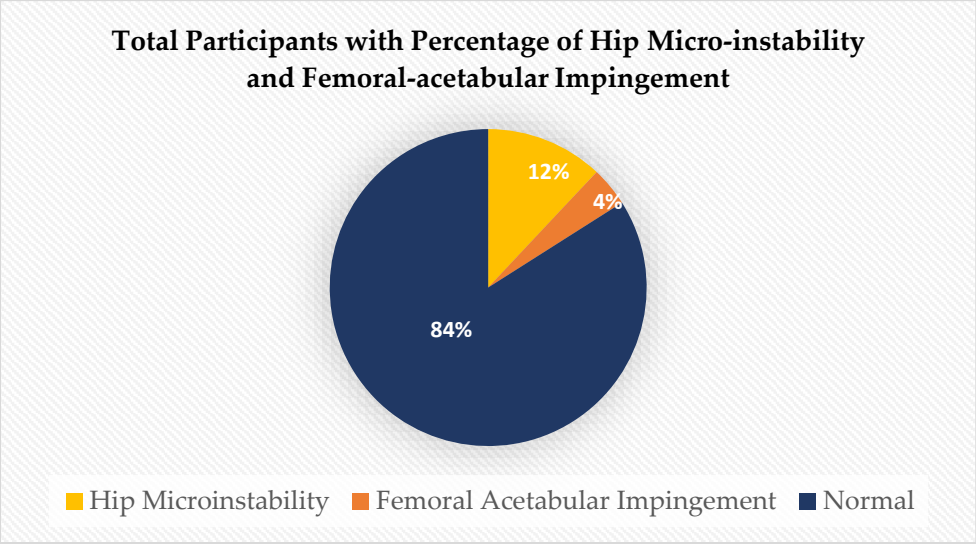


Figure 1: Total participants with the percentage of hip micro-instability and femoro-acetabular impingement

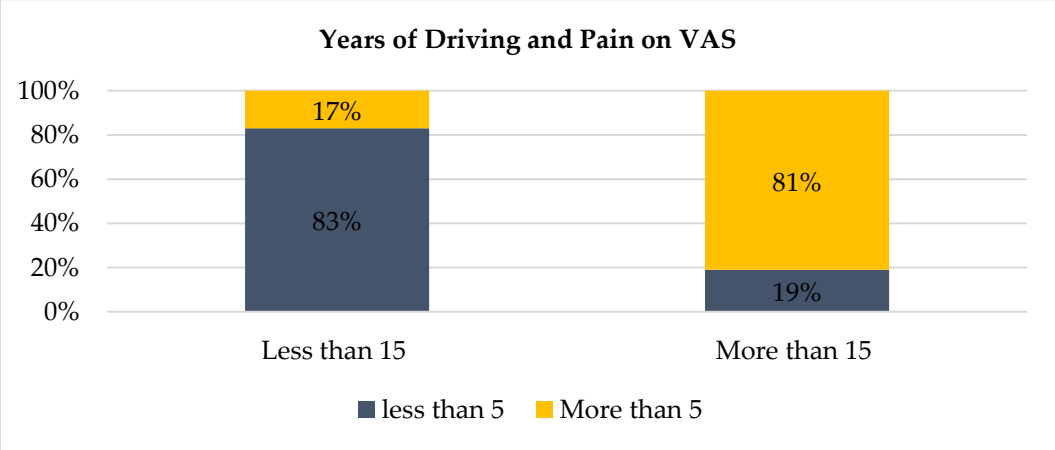


Figure 2: Years of Driving and Pain on VAS

Figure 2 demonstrates a correlation between the number of years of driving and the intensity of pain experienced by the truck drivers, regardless of the presence/absence of hip micro-instability. It was observed that 83% of participants who have less than 15 years of driving experience; showed an average VAS of less than 5 and the remaining 17% more than 5. And similarly, for the subjects who were driving for over more than 15 years; 19% of them showed an average VAS falling below 5 and over 81% of them above 5.

As per previous studies, it is estimated that ligamentous laxity may or may not be present in individuals who have hip micro-instability. The above graphs depict that among the individuals who do not have ligamentous laxity only 5% of them are those who have been diagnosed with hip micro-instability whereas the individuals who have laxity present 79% of them have been diagnosed with hip micro-instability. This thus infers that laxity might be present or absent in individuals with hip micro-instability. (Figure 3)

Figure 4 reveals that the individuals who showed positive results for anterior micro-instability showed significantly increased flexion, internal rotation, and adduction ranges than normal ranges as compared to extension, external rotation, and abduction ranges.

Figure 5 demonstrates that the individuals who

showed positive results for posterior micro-instability showed significantly increased extension, external rotation, and abduction ranges than normal ranges as compared to flexion, internal rotation, and adduction ranges.

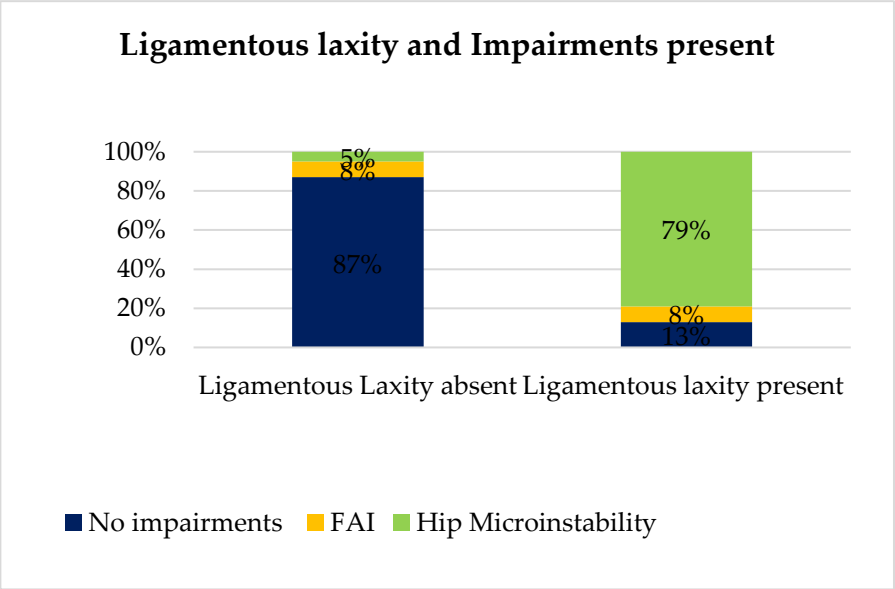


Figure3: Ligamentous laxity and Impairments present

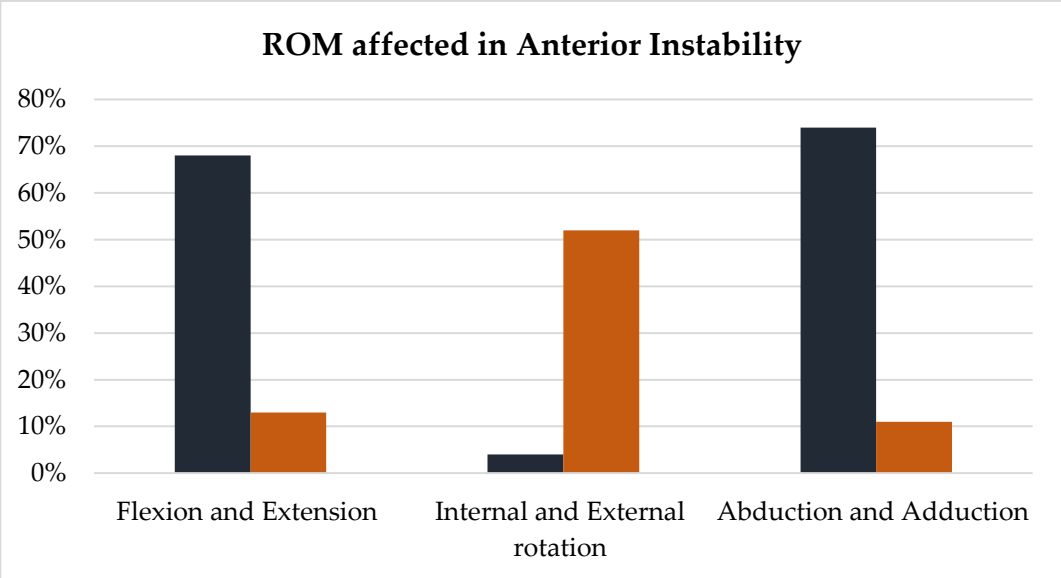


Figure 4: ROM affected in Anterior Instability

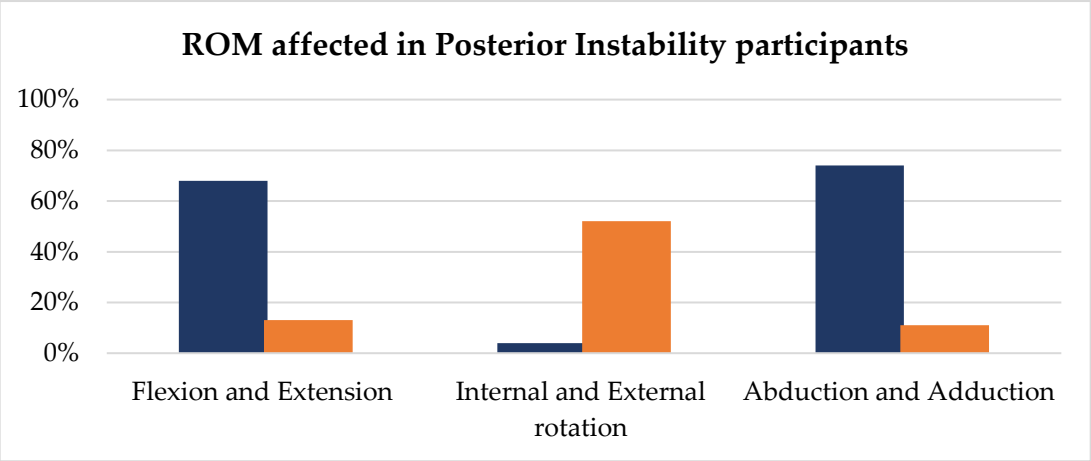


Figure 5: ROM affected in Posterior Instability participants

Discussion

The hip is regarded as an anatomically stable joint because it has passive, active, and neurological elements that work together to promote stability. Truck drivers have been often linked with the presence of musculoskeletal pain arising due to poor posture, wherein the drivers are exposed to prolonged periods of vibrational forces acting axially over the spine and hip. This contributes as a major factor in inducing musculoskeletal pain. Investigations suggest that hip musculoskeletal pain as a whole is one of the main causes of hip micro-instability. Hence, it is important to evaluate the presence of hip micro-instability among long-distance truck drivers.

A review by A.Dangin *et. al* included studies using interviews, clinical examination and imaging as an assessment tool for the evaluation of hip micro-instability as hip instability cannot be diagnosed alone with imaging.[29] Whereas, in our study, we used clinical examination as the standard assessment method along with interview assessment. Another study by D'Hemecourt P and Rodriguez M *et al* used physical assessment as a key investigation method rather than relying on the static imaging modalities for the understanding of micro-instability.[30,31] Whereas this study's results showed that a significant population reflected the presence of hip micro-instability as an underlying cause of pain and discomfort. The results were confirmed with statistical analysis using the "chi-square test". After this, 12% of subjects reflected the presence of hip micro-instability, which thus helps us to bring this pathology into the limelight.

Additionally, Philippon M *et al* depicted that 35% of people presented with hip micro-instability, post previous hip surgery who needed to undergo a revision surgery.[32] Similarly, a study done by McCormick F *et al* depicted that 78% of patients presented radiographic evidence of capsular and iliofemoral defects on the imaging studies done by magnetic resonance arthrography (MRA) who reflected on the symptoms of hip micro-instability after previous surgery.[33] Comparing the study results with Philippon M *et al* and McCormick F *et al*, their findings for the evidence of hip micro-instability were among the post-operative population. Whereas, in our study, we included subjects who don't have a history of surgery or trauma to the hip.[3]

As per studies done by Riboh JC et al and Grahme R, most of the patients who were hyper-laxative showed the presence of microinstability.[34,35] Whereas, Luis Cerezal *et* al stated that hip laxity and micro-instability are not co-related. The subjects who presented with symptoms directed toward laxity; were categorized as positive for micro-instability. Whereas, asymptomatic subjects who were able to subluxate a joint, definitely had laxity but not micro-instability. Clinically, it concluded that a patient with micro-instability will have laxity in both hips, but only the

symptomatic subjects were classified as having micro-instability.[36]Similar results were inferred from our study where 79% of hyper-laxative individuals were diagnosed with the presence of hip micro-instability. While 5% of the population who were diagnosed with hip micro-instability did not report the presence of underlying joint laxity. This opens a new door for further research on whether the presence of joint laxity should or should not be considered as the diagnostic criteria while ruling out hip micro-instability cases.

A study by Dangin*et* al brings into focus the co-relation of capsule relaxation/laxity which focuses on the increase in the range of motion in the joint capsule. The study suggested that the anterior capsule relaxation/anterior laxity led to an increase in the flexion range of motion.[37] While our study was focused on two aspects i.e. anterior or posterior micro-instability; the subjects that showed positive results for anterior micro-instability had anterior capsule relaxation leading to increased flexion, internal rotation, and adduction. Whereas, the subjects' that showed positive results for posterior micro-instability had posterior capsule relaxation leading to increased extension, external rotation, and abduction ranges.

As per the study done by Domb *et* al ; standard assessmentsfor the diagnosis of micro-instability are the three physical examination tests, AB-HEER test, Anterior apprehension test, and Posterior apprehension test. While performing the AB-HEER and anterior apprehension test the hip is externally rotated, which has been shown to result in anterior translation of the femoral head thus depicting anterior capsule relaxation/instability was used.[38] Thus, with this reference anterior and posterior micro-instability was assessed in our study. Also, another study by Shu Safran *et* al performed the posterior apprehension test, wherein the hip is internally rotated and thus, posterior translation of the femoral head has been noted.[14] Also as per Daniel J. Hoppe *et* al the AB-HEER test is the most accurate predictor of hip instability because of its combination of high sensitivity and specificity. However, all 3 tests showed specificities and positive predictive values above85%which makes our reference standards stronger.[27,28]

A cross-sectional study conducted in the community aimed to ascertain the prevalence of low back discomfort among drivers of three wheels. According to the study's findings, three-wheel drivers had moderate to severe emotional and functional interferences as well as moderate to severe low back pain. Within one working day, over half of the subjects described their most severe pain episode.[39]A case study in the year 2022 focused on the employees who worked in the construction industries which was regarding the return to the job of a construction worker following an injury. This study only focused on the rotator cuff injuries of the shoulder but lacked in discussing other underlying problems like changes in the back, in overall posture as well as the impact of their on their hips.[40]

Another study conducted by Sandeep Shinde et al; in the year 2021 consisted of individuals who had pes planus deformity. The study results revealed that individuals with pes planus deformity showed proximal to distal muscular imbalance and a structured strengthening exercise protocol was given to these individuals. This exercise regime further helped in reducing the muscular imbalance.[41] Similarly, further research regarding the truck drivers can be carried out which can focus on providing strengthening protocol for them to improve their hip micro-instability. One more research in the form of a case study was done in January 2023, which was about a female kitchen worker with Kienbock's disease which spoke only about the hand and the consequences faced because of the disease. Herein, early physiotherapy was given to reduce pain, improve the strength of the wrist and finger flexor extensors, improve the range of motion, and vocational rehabilitation to resume her work. But again, being a kitchenworker it is not necessary that problems can be only seen in hands but they can also be seen in other joints specifically the lumbar spine, hips, and knee which were left

unnoticed.[42] Further research can be carried out to see if there is any possible micro-instability seen in these workers as a result of long-standing postures.

Considering the occupational problems of truck drivers and the possible mechanism of injury of hip micro-instability, which are seen to be prevalent in this population hence our study focused on these subjects. Any other study addressing hip pain in truck drivers has not been reflected anywhere. Thus, the further possibility for the extent of degeneration can be ruled out using radiologic evidence standards to enhance the importance of the prevalence of this pathology.

Conclusion

The study revealed that 12% of truck drivers exhibited hip micro-instability. Notably, anterior hip micro-instability was more prevalent than posterior hip micro-instability among this group. The capsular laxity, influenced by prolonged exposure to vibrational forces acting axially over the hip and spine, contributed to these findings. Additionally, the study highlighted the presence of hip micro-instability due to ligamentous laxity.

Acknowledgment

We would like to express our gratitude to the management of KIMSDU for allowing us to perform this research by supplying us with the necessary materials. We appreciate Dean Dr. Varadharajulu's help and advice. We would like to take this time to thank everyone who helped make this study run smoothly, whether directly or indirectly.

In my research, there were no conflicts of interest.

Source of Funding

Krishna Institute of Medical Sciences, "Deemed to be" University provided funding.

References

1. Pandey A, Benara SK, Roy N, Sahu D, Thomas M, Joshi DK, et al. Risk behaviour, sexually transmitted infections and HIV among long-distance truck drivers: a cross-sectional survey along national highways in India. AidsAIDS. 2008 Dec 1;22:S81-90. Available from: https://doi.org/10.1097/01.aids.0000343766.00573.15.
2. Nepple JJ, Philippon MJ, Campbell KJ, Dornan GJ, Jansson KS, LaPrade RF, et al. The hip fluid seal—Part II: The effect of an acetabular labral tear, repair, resection, and reconstruction on hip stability to distraction. Knee Surgery, Sports Traumatology, Arthroscopy. 2014 Apr;22:730-6.Available from: https://doi.org/10.1007/s00167-014-2875-y.
3. Philippon MJ, Nepple JJ, Campbell KJ, Dornan GJ, Jansson KS, LaPrade RF, et al. The hip fluid seal--Part I: the effect of an acetabular labral tear, repair, resection, and reconstruction on hip fluid pressurization. Knee Surg Sports Traumatol Arthrosc. 2014 Apr;22(4):722-9. Available from: https://doi.org/10.1007/s00167-014-2874-z.
4. Afoke NY, Byers PD, Hutton WC. The incongruous hip joint. A casting study. The Journal of Bone & Joint Surgery British Volume. 1980 Nov 1;62(4):511-4.Available from: https://doi.org/10.1302/0301-620X.62B4.7430237.
5. Dy CJ, Thompson MT, Crawford MJ, Alexander JW, McCarthy JC, Noble PC. Tensile strain in the anterior part of the acetabular labrum during provocative maneuvering of the normal hip. JBJS. 2008 Jul 1;90(7):1464-72.Available from: https://doi.org/10.2106/JBJS.G.00467.
6. Safran MR, Lopomo N, Zaffagnini S, Signorelli C, Vaughn ZD, Lindsey DP, et al.In vitro analysis of peri-articular soft tissues passive constraining effect on hip kinematics and joint stability. Knee Surgery, Sports Traumatology, Arthroscopy. 2013 Jul;21:1655-63. Available from: https://doi.org/10.1007/s00167-012-2091-6.
7. Song Y, Ito H, Giori N. Goal of bony resection in femoroacetabularimpingement: a 3-D CT anatomic study. In: PosterPresentation at 55th Annual Meeting of the Orthopaedic Research Society. Las Vegas, NV; 2009. p. 22–5. Available from: https://doi.org/10.1002/jor.20852
8. Gilles B, Christophe FK, Magnenat-Thalmann N, Becker CD, Duc SR, Menetrey J, et al . MRI-based

assessment of hip joint translations. Journal of biomechanics. 2009 Jun 19;42(9):1201-5.Available from: https://doi.org/10.1016/j.jbiomech.2009.03.033.

9. Charbonnier C, Kolo FC, Duthon VB, Magnenat-Thalmann N, Becker CD, Hoffmeyer P, et al . Assessment of congruence and impingement of the hip joint in professional ballet dancers: a motion capture study. The American journal of sports medicine. 2011 Mar;39(3):557-66.Available from: https://doi.org/10.1177/0363546510386002.

10. Jackson TJ, Peterson AB, Akeda M, Estess A, McGarry MH, Adamson GJ, et al. Biomechanical effects of capsular shift in the treatment of hip microinstability: creation and testing of a novel hip instability model. The American Journal of Sports Medicine. 2016 Mar;44(3):689-95.Available from: https://doi.org/10.1177/0363546515620391.

11. Kalisvaart MM, Safran MR. Microinstability of the hip—it does exist: etiology, diagnosis and treatment. Journal of hip preservation surgery. 2015 Jul 1;2(2):123-35.Available from: https://doi.org/10.1093/jhps/hnv017.

12. Domb BG, Philippon MJ, Giordano BD. Arthroscopic capsulotomy, capsular repair, and capsular plication of the hip: relation to atraumatic instability. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2013 Jan 1;29(1):162-73.Available from: https://doi.org/10.1016/j.arthro.2012.04.057.

13. Safran MR. Microinstability of the hip—gaining acceptance. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2019 Jan 1;27(1):12-22. Available from: https://doi.org/10.5435//JAAOS-D-17-00664

14. Shu B, Safran MR. Hip instability: anatomic and clinical considerations of traumatic and atraumatic instability. Clinics in sports medicine. 2011 Apr 1;30(2):349-67.Available from: https://doi:.org/10.1016/j.csm.2010.12.008

15. Boykin RE, Anz AW, Bushnell BD, Kocher MS, Stubbs AJ, Philippon MJ. Hip instability. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2011 Jun 1;19(6):340-9.Available from: https://doi.org/10.5435/00124635-201106000-00004

16. Roli D, Ali I, Neekhra V. Work related musculoskeletal disorders in electrical, telecommunication and instrument mechanics of armed forces. International Journal of Occupational Safety and Health. 2020 Jul 5;10(1):18-27.Available from: https://doi.org/10.3126/ijosh.v10i1.29878.

17. Porter JM, Gyi DE. The prevalence of musculoskeletal troubles among car drivers. Occupational medicine. 2002 Feb 1;52(1):4-12.Available from: https://doi.org/10.1093/occmed/52.1.4.

18. Porter JM, Porter CS, Lee VJA. A A survey of driver discomfort. In Lovesey, E.J. (ed). Contemporary Ergonomics. 1992;262-7. London: Taylor & Francis. Available from: https://doi.org/10.1016/j.trf.2019.04.017.

19. Morales K. UK government to appoint occupational health "tsar" to reduce work related illness. BMJ. 2005 Oct 27;331(7523):986. Available from: https://doi.org/10.1136/bmj.331.7523.986-f.

20. Sadri GH. Risk factors of Musculoskeletal Disorders in Bus Drives. Arch Iranian Med 2003;6(3):214-5. Available from: https://doi.org/10.1002/hfm.20387.

21. Seidel H, and Heide R. Long term effects of whole-body vibration: a critical survey of the literature. International Archives of Environmental Health, 1986;58, 1-26.Available from: https://doi.org/10.1007/BF00378536.

22. Hulshof C, Veldhuijzen van Zanten B. Whole-body vibration and low-back pain: a review of epidemiologic studies. International archives of occupational and environmental health. 1987 Mar;59:205-20.Available from: https://doi.org/10.1007/BF00377733.

23. Bovenzi M, Hulshof CTJ. An updated review of the epidemiologic studies on the relationship between exposure to whole-body vibration and low back pain . International Archives of Occupational Environmental Health. 1999; 72(6): 351-65.Available from: https://doi.org/10.1007/s004200050387.

24. Mansfield, NJ. Human Response to Vibration, 1st Ed. 2005 (London: CRCPress). https://doi.org/10.1121/1.4836496.

25. Phillips DL. Truck drivers and lower back pain. Chiropractic Health Care. 2003. Available from: https://www.drphillipschiro.com/lower-back-pain

26. Jack FR, Piacentini MG, Schröder MJ. Perception and role of fruit in the workday diets of Scottish lorry drivers. Appetite. 1998 Apr 1;30(2):139-49.Available from: https://doi.org/10.1006/appe.1997.0115.

27. Hoppe DJ, Truntzer JN, Shapiro LM, Abrams GD, Safran MR. Diagnostic accuracy of 3 physical examination tests in the assessment of hip microinstability. Orthopaedic Journal of Sports Medicine. 2017 Nov 23;5(11).Available from: https://doi.org/10.1177/2325967117740121

28. Magee DJ. Orthopedic Physical Assessment.Elsevier Health Sciences; 2013. Available from: https://evolve.elsevier.com/cs/product/9780323239790?role=student

29. Dangin A, Tardy N, Wettstein M, May O, Bonin N. Microinstability of the hip: a review. Orthopaedics & Traumatology: Surgery & Research. 2016 Dec 1;102(8):S301-9.Available from:https://doi.org/10.1016/j.otsr.2016.09.002.

30. d'Hemecourt PA, Sugimoto D, McKee-Proctor M, Zwicker RL, Jackson SS, Novais EN, et al . Can dynamic ultrasonography of the hip reliably assess anterior femoral head translation?. Clinical Orthopaedics and Related Research. 2019 May;477(5):1086-98.Available from: https://doi.org/10.1097/CORR.0000000000000457.

31. Rodriguez M, Bolia IK, Philippon MD, Briggs KK, Philippon MJ. Hip screening of a professional ballet company using ultrasound-assisted physical examination diagnosing the at-risk hip. Journal of Dance Medicine & Science. 2019 Jun 15;23(2):51-7.Available from: https://doi.org/10.12678/1089-313X.23.2.51.

32. Philippon MJ, Schenker ML, Briggs KK, Kuppersmith DA, Maxwell RB, Stubbs AJ. Revision hip arthroscopy. The American journal of sports medicine. 2007 Nov;35(11):1918-21.https://doi.org/10.1177/0363546507305097.

33. McCormick F, Slikker W, Harris JD, Gupta AK, Abrams GD, Frank J, et al. Evidence of capsular defect following hip arthroscopy. Knee Surgery, Sports Traumatology, Arthroscopy. 2014 Apr;22:902-5.Available from: https://doi.org/10.1007/s00167-013-2591-z.

34. Riboh JC, Grzybowski J, Mather III RC, Nho SJ. Atraumatic hip instability in patients with joint hypermobility. Operative Techniques in Sports Medicine. 2015 Sep 1;23(3):203-12.https://doi.org/10.1053/j.otsm.2015.05.002.

35. Grahame R, Bird HA, Child A. The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS). The Journal of Rheumatology. 2000 Jul;27(7):1777-9. Available from: https://doi.org/10.3109/10582452.2010.501303.

36. Cerezal L, Arnaiz J, Canga A, Piedra T, Altónaga JR, Munafo R, et al. Emerging topics on the hip: ligamentum teres and hip microinstability. European journal of radiology. 2012 Dec 1;81(12):3745-54.Available from: https://doi.org/10.1016/j.ejrad.2011.04.001.

37. Dangin A, Tardy N, Wettstein M, May O, Bonin N. Microinstability of the hip: a review. Orthopaedics & Traumatology: Surgery & Research. 2016 Dec 1;102(8):S301-9.Available from: https://doi.org/10.1016/j.otsr.2016.09.002.

38. Domb BG, Brooks AG, Guanche CA. Physical examination of the hip.In: Guanche CA, ed. Hip and Pelvis Injuries in Sports Medicine. Philadelphia:Wolters Kluwer/Lippincott Williams and Wilkins; 2010:62-70. Available from: https://doi.org/10.1177/2325967117740121.

39. Kebede EB, Terfa YB, Tucho AE, Germossa GN, Hailu FB, Abdisa B, et al. Self-reported low back pain intensity and interferences among three-wheel drivers in Southwest of Ethiopia: A Community-Based Cross-sectional Study. International Journal of Occupational Safety and Health. 2023 Oct 10;13(4):512-20. Available from: https://doi.org/10.3126/ijosh.v13i4.51657.

40. Shinde S, Ghadage P. Return to Job of A Construction Worker by Comprehensive Functional and Vocational Rehabilitation. International Journal of Disabilities Sports and Health Sciences. 2022 Dec 12;5(2):150-7. Available from: https://doi.org/10.33438/ijdshs.1106819.

41. Sawant Janhavi M, Shinde S. Effect of lower limb proximal to distal muscle imbalance correction on functional pes planus deformity in young adults". Journal of medical pharmaceutical and allied sciences. 2021;10(4):3469-73. Available from: https://doi.org/10.22270/jmpas.V10I4.1477.

42. Shinde S, Arulekar R, Dhane S, Bhende R, Saptale A. Comprehensive Functional and Vocational Rehabilitation of A Kitchen Worker with Kienbocks Disease. International Journal of Disabilities Sports and Health Sciences. 2023 Feb 2;6(1):53-9. Available from: https://doi.org/10.33438/ijdshs.1191467.

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Health Effects of Pesticides among Small-scale Farmers in an Urban Municipality of Nepal: A Descriptive Study

Thapa N[1], Paudel A[1], Karki R[2], Kaphle M[3]

[1]Department of Public Health, CiST College, Kathmandu, Nepal
[2]Department of Public Health, Yeti Health Science Academy, Kathmandu, Nepal
[3]Department of Public Health, Peoples Dental College and Hospital, Kathmandu, Nepal

Corresponding author:

Maheshor Kaphle
Associate Professor, Peoples Dental College and Hospital, Kathmandu, Nepal
Email: kafmahesh@gmail.com
ORCID ID: https://orcid.org/0000-0001-8121-6206

Date of submission: 04.08.2023
Date of acceptance: 10.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.50924

ABSTRACT

Introduction: Pesticides cause short-term as well as long-term health effects. Agriculture workers are at high risk of effect. So, this study aimed to identify the health effects of pesticides among small-scale farmers in the municipality of Bhaktapur, Nepal.

Methods: This was a community-based cross-sectional descriptive study conducted in all wards of Changunarayan Municipality, Bhaktapur, Nepal. Farmers of selected households who adopted agriculture as their main occupation were included in this study. The sample size for the study was 132. Proportionate stratified sampling was used to determine the farmer from each ward and simple random sampling was used to reach every respondent. Face-to-face interview technique and semi-structured questionnaire was used for data collection. The data were analyzed using descriptive statistics and the Chi-square test was applied to measure an association between selected variables.

Results: All of the farmers used pesticides and about two-thirds 74(64.9%) experienced both immediate as well as delayed symptoms due to the use of pesticides. Majority of them showed general symptoms such as eye irritation 87(76.3%), difficulty in breathing 70(61.4%) and fatigue 55(48.2%). There was an association between the frequency of exposure and health effects due to pesticide use which was found to be statistically significant at a significance level with *p*-value 0.042.

Conclusion: Health effects such as skin rashes, effects on the eyes, and respiratory system were reported. The most prevalent effects were eye irritation, difficulty in breathing, and itching of the skin. Training on pesticide use and awareness should be conducted by municipalities to reduce the effects.

Keywords: Farming, Health effects, Pesticide effects, Pesticide use

Introduction

Pesticides are those substances that are used to get rid of, control, and repel the harmful biota which has the potential to destroy vegetation, crops, farmland, and animals. Human exposure to pesticides has been documented through many routes such as dietary intake, indoor pesticide exposure, and outdoor exposure and even secondarily through animal upon the consumption of animal products and on many levels such as mild pesticide poisoning, moderate poisoning, and severe poisoning.[1,2]

WHO has classified pesticides according to the hazard they pose, the hazard, in this case, being the acute risk to the health of people who are actively using pesticides, and classifies this hazard based on the Acute Toxicity Hazard Category which was developed by GHC (The globally harmonized system of classification and labeling of chemicals) into classes which are Ia (Extremely Hazardous), Ib (Highly hazardous), II (Moderately hazardous), III (Slightly hazardous) and U (Unlikely to present acute hazard).[3] Agriculture being one of the major occupation of people all around the world has more than a billion workers actively working which is why it is also considered one of the most dangerous occupations with nearly 170,000 deaths annually.[4]

The use of pesticides in an extensive way and period, lack of proper knowledge about the handling of the pesticides, lack of regulation in the proper labeling and marketing of pesticides, as well as the language barriers on the labels in the pesticide containers, have been seen as some of the major reasons why pesticides have affected on the health of farmers.[5] Studies suggest that female workers are at double the risk of having pesticide poisoning than their male counterparts, and that gender equity also plays a vital role in the reduction of the use of pesticides.[6,7]

The global pesticide usage has significantly increased with the increase in the population and food consumption rate. However, Nepal is relatively low in the usage of active ingredients in pesticides (396g/ha) compared to developed countries like China and India.[8] A Maximum Residual Limits (MRLs) has been developed by WHO in order to decrease the health risk possessed by the use of these active ingredients.[3,8]

Intervention programs which included training the farm workers and the pesticide retailers resulted in an improved level of practice and knowledge about pesticides, their consumption, and management.[9]

In the Philippines, a study revealed that the application of spraying the pesticide in the field (63.7%) was the major way through which farmers were getting exposed to the pesticides, and among the farmers, nearly half (49%) complained of being sick due to the agricultural works.[10] A study of tea plantation workers in India revealed that over half of the sprayers experienced musculoskeletal complaints.[11]

A study in Tanzania shows that among the farmers taken in the study, 68% reported that they felt ill with symptoms of health-related issues such as skin problems and neurological problems like headache and dizziness.[12]

A study in Ethiopia showcased a significant association between the exposure and the response to the occupational exposure of pesticide with reduced lung capacity and function, and several respiratory symptoms.[13]

A study in Thailand among the farmers who were exposed to pesticides suggested symptoms like difficulty in breathing (47.2%), nausea/vomiting (46.9%) followed by diarrhea and rashes.[4]

Nepal is also a country where pesticide consumption has been rampant with an increase of 10-20% annually, mostly in the *Terai* region and Kathmandu Valley.[14] A study in Nepal revealed that farmers who have had exposure to pesticides developed more symptoms of pesticide intoxication than the respective control group (mean 5.47 versus 2.02 respectively).[15] So, this study aimed to assess the perceived health effect of pesticide use by farmers in small-scale farming in Changunarayan Municipality, Bhaktapur, Nepal.

Methods

A community-based cross-sectional descriptive study was conducted among professional small-scale farmers from May to October 2022 in all nine wards of Changunarayan Municipality, Bhaktapur, Nepal. The sample size was calculated using Cochran's formula (z^2pq/e^2) with the prevalence of acute effect of pesticides from the previous study as 9.5%,[16] and 5% margin of error. The final sample size was 132. Data collection was done from July 1st to 15th, 2022. There were altogether 1191 households adopting farming as the main occupation from the municipality records. Proportionate stratified sampling was used to determine the farmer from each ward and simple random sampling was used to reach every respondent. One eligible participant was surveyed from each household. If there were more than one eligible person in the household, one participant was chosen by lottery method. After the estimated sample was covered in one ward, we moved to the next ward.

Ethical clearance was obtained from the institutional review committee of the Central Institute of Science and Technology (CiST) college (Ref. no: IRC162/078/079). Written informed consent was taken from each respondent and confidentiality was also maintained. Data was collected through face-to-face interviews. After an extensive literature review and multiple discussions within the research team, the

questionnaire was designed for the study.[16] The questionnaire was divided into three sections: first section with socio-demographic characteristics, second section with pesticide-related questions, and third section with behavior-related questions. Participants were given considerable time to record all their experiences during data collection.

The collected data was cleaned and edited on the same day of data collection. Epi-Data version 3.1 was used for data entry and checks were defined. To minimize the error within the limit, 10% of the randomly selected data was manually rechecked. Entered data were exported from Epi-Data to SPSS (version 22) for further analysis. Based on the objective of the study the data was analyzed using descriptive statistics. Categorical variables were described using numbers and percentages where non-normally distributed data was presented as median and interquartile range. Frequency distribution and cross-tabulation between dependent and independent variables were used to describe the basic background and respondent characteristics. The chi-square test was used to measure the association between the independent and the dependent variables. The *p*-value less than 0.05 was considered to be significant.

Results

Socio-demographic findings

The majority of the respondents 85(64.4%) were male and the median age was 41 years. More than three-fourths of the respondents were married 103(78.8%) and followed Hinduism 119(90.2%). The majority of respondents were from Advantaged *Janajati (Newar) 60* (45.5%) as their ethnicity. About one-third of the respondents 42(31.8%) had completed secondary level education and 130(98.5%) of them were involved in the production of food crops, vegetables 122(92.4%), and livestock products 92 (69.7%) (Table 1).

Pesticide Related Characteristics

All the farmers were found to use pesticides on their farms, and half of 66(50.0%) used pesticides on their fields at least once in the last three months before the time of study. More than three-fourths 108(81.8%) of farmers had less than three hours of pesticide exposure, Inhalation 127 (96.2%) followed by skin exposure 60 (45.5%) were the main route of pesticide exposure. All farmers 132 (100%) used a sprayer as the most common pesticide use method followed by dusting 73(55.3%) and Granular Application 26(19.7%). All of the farmers used Personal Protective Equipment (PPE) when using pesticides. Less than one-fifth of 25 (19%) farmers received training for pesticide use (Table 2).

Table 1: Socio-Demographic Characteristics (n=132)

Characteristics	Frequency	Percentage (%)
Age (Median, IQR)	(41,19)	
Sex		
Male	85	64.4
Female	47	35.6
Ethnicity		
Dalit	3	2.3
Advantaged *Janajati*(*Newar*)	60	45.5
Brahmin	13	9.8
Chettri	56	42.4
Educational Status		
Illiterate	8	6.1
Non-Formal Study	3	2.3
Primary Level	27	20.4
Secondary Level	42	31.8
Higher Secondary Level	35	26.5
Bachelors	14	10.6
Masters	3	2.3
Type of Agricultural Products*		
Food Crops	130	98.5
Fruits	27	20.5
Livestock Products	92	69.7
Vegetables	122	92.4

**Multiple response*

Table 2: Pesticide Related Characteristics (n=132)

Characteristics	Frequency	Percentage (%)
Frequency of Exposure		
Once	66	50
More than once	66	50
Time of exposure		
≤3 hours	108	81.8
>3 hours	24	18.2
Route of Exposure*		
Inhalation	127	96.2
Skin Exposure	60	45.5
Ingestion	10	7.6
Methods of Pesticide Use*		
Spraying	132	100
Dusting	73	55.3
Granular Application	26	19.7
Soil Drenching	1	0.8
Training for Pesticide Use		
Yes	25	18.9
No	107	81.1

**Multiple response*

Health Effects Due to Pesticide

The majority of farmers 114 (86.4%) stated that they had various symptoms of health consequences due to pesticide use. The usage of pesticides resulted in both immediate and delayed effects for the farmers 74 (64.9%). The majority of farmers experienced general symptoms like fatigue 55(48.2%), difficulty in breathing 70 (61.4 %), and eye irritation 87(76.3%). Following the use of pesticides, some study respondents experienced skin itch 89(81.7%) followed by irritation 53 (48.6%) and redness 51 (46.8%). Most of the respondents 98 (93.3%) reported itchy eyes whereas more than one-third (37.1%) reported watery eyes as the main effects of pesticides on them. The two main effects on the respiratory system caused by the use of pesticides were coughing 60(58.3%) and shortness of breath 73(70.9%). Vomiting was reported by nearly two-thirds of respondents 28(65.1%), followed by irritability 18(41.9%), and decreased sleep 6(14.0%) as the pesticide's main adverse effects on the gastrointestinal system (Table 3).

Association between health effects due to pesticide uses and behavioral characteristics

The association between behavioral characteristics and health effects due to pesticide use is given in Table 4. Smoking status is classified as non-smoker, daily, and sometimes smokers. The respondent who has not smoked different types of smoking is considered a non-smoker. A daily smoker is someone who smokes cigarettes or uses other tobacco products daily and has developed regular habits. A sometime smoker, also known as an occasional or social smoker, is a person who smokes cigarettes or uses other tobacco products only occasionally or in specific social situations. This explanation is also applied to tobacco use and alcohol consumption.

The association between the time of exposure, the smoking status, alcohol consumption status tobacco consumption status, and health effects due to pesticide usage were not statistically significant but the frequency of exposure was significantly associated with health effects due to the use of pesticides (p=0.042).

Table 3: Health effects due to pesticide use

Characteristics	Attributes	Frequency	Percentage (%)
Observation of Symptoms (n=132)	Yes	114	86.4
	No	18	13.6
Types of Symptoms (n=114)	Immediate (Within an hr.)	31	27.1
	Delayed (Within 24 hrs.)	9	7.8
	Both	74	64.91

General Symptoms* (n=114)	Fatigue	55	48.2
	Body Ache	33	28.9
	Fever	16	14.0
	Eyes Irritation	87	76.3
	Difficulty Breathing	70	61.4
Effects on Skin*(n=109)	Rashes	14	12.8
	Irritation	53	48.6
	Itching	89	81.7
	Redness	51	46.8
Effects on Eyes* (n=105)	Red Eyes	57	54.3
	Watery Eyes	39	37.1
	Itchy Eyes	98	93.3
	Blurry Vision	6	5.7
Effects on the Respiratory System (n=103)	Cough	60	58.3
	Wheeze	11	10.7
	Chest Pain	37	35.9
	Shortness of Breath	73	70.9
Effects on the Gastrointestinal System* (n=43)	Abdominal Pain	3	7.0
	Vomiting	28	65.1
	Diarrhea	2	4.7
	Irritability	18	41.9
	Trembling Hands	2	4.7
	Decreased sleep	6	14.0
	Decreased Concentration	3	7.0

**Multiple response*

Table 4: Association between behavioral characteristics and health effects due to pesticide use(n=132)

Variables	Health effects due to use of pesticide		*p*-value
	Yes n (%)	No n (%)	
Time of Exposure			
≤3hours	92(85.2)	16(14.8)	0.611
>3hours	22(91.7)	2(8.3)	
Frequency of exposure			
Once	53(80.3)	13(19.7)	0.042*
More than once	61(92.4)	5(7.6)	
Smoking Status			
Non smoker	63(91.3)	6(8.7)	
Daily	48(81.4)	11(18.6)	0.174†
Sometimes	3(75.0)	1(25.0)	
Alcohol consumption status			
Non user	67(85.9)	11(14.1)	
Daily	1(100.0)	0(0.0)	1.00†
Sometimes	46(86.8)	7(13.2)	
Tobacco Consumption status			
Non user	88(88.0)	12(12.0)	
Daily	24(80.0)	6(20.0)	0.526†
Sometimes	2(100.0)	0(0.0)	
Training for pesticide			
Yes	23(92.0)	2(8.0)	0.556
No	91(85.0)	16(15.0)	

**Significant p-value at <0.05, †P-value from Fisher's exact test*

Discussion

Changunarayan municipality lies in the Bhaktapur district. Changunarayan municipality extensively follows agriculture as the main occupation. Most of the ethnic groups of the municipality were *Janajati (Newars*) who are the primary inhabitants of the Bhaktapur district and who have been involved in agriculture for centuries. The major crops grown in the municipalities were food crops such as rice, wheat, maize, and vegetables. Our study revealed that all of the farmers used pesticides when growing vegetables to control insects and pests. The pesticide has been used on a large scale yearly, due to the growing concern of pests and vector-borne diseases.[17]

In this study, spraying was seen as the major method for the use of pesticides all of the farmers were using. Spraying is the easiest method of using pesticides. Other studies also suggested that spraying had been the major method for the use of chemical pesticides in both the western as well as eastern communities of the world.[18] More than half of the farmers use sprayers for powder pesticides on their farms, consistent with a study conducted in Lalitpur Nepal.[19] This study found that the farmers suffered from respiratory problems such as shortness of breath 73(70.9%), cough 60(58.3%), and chest pain 37(35.9%) which was similar to findings from Thailand which revealed that the prevalence of difficulty in breathing and chest pain was significantly higher in farmers than in the controls (OR 2.8, $P < 0.01$ and OR 2.5, $P < 0.05$, respectively).[20] This study has showcased the complete use of PPE sets despite showing major health problems such as respiratory and dermal problems, in contrast to the study in Ecuador which suggested very little use of PPE resulting in health problems.[21] This might be due to the use of non-health-approved masks, leaky backpack sprayers, and less use of boots. These reasons can be valid as the sprayers in Nepal are quite expensive and the fact that the result also revealed that very few people were trained for pesticide use.

This study revealed that fatigue, body aches, fever, eye irritation, and difficulty breathing were some of the major symptoms that were faced due to the use of pesticides. Several previous studies also reported that chronic fatigue and irritability were some of the most common health effects due to the use of pesticides.[22,23] This study also showcased various effects on the ophthalmic systems such as redness, itching, watery eyes, and blurry vision. Various studies conducted on the effects of organophosphate on the ophthalmic system have concluded that these symptoms could be attributed to the postsynaptic acetylcholine accumulation which results from the acetylcholine inhibition by these organophosphates.[24] The psychological symptoms including irritability, trembling of hands, decreased sleep, and decreased concentration have been recorded. Studies have shown that it is possible due to the long-term exposure of organophosphates in a small amount causing chronic neuropsychological effects and neurotoxicity.[25]

The major respiratory problems in this study were cough, wheezing, shortness of breath, and chest pain. A study on the low-level exposure to organophosphate leading to restrictive lung dysfunction showed that the organophosphates affected the respiratory system through the nicotinic action on the respiratory-muscles and the medullar center as well as direct toxic effects on the alveolar-capillary membrane.[26] Studies have also shown that the effects on the skin such as irritation, itching, and redness are due to the localized effects.[27]

This study has shown that the frequency of exposure was statistically significant (p-0.042) with the health effects due to pesticide usage. The frequency of pesticide use was significantly associated with exposure to pesticides, and exposure has been associated with chronic health effects thus backing up the evidence.[28]

Regarding training for the use of pesticides, most of the respondents 107(81.1%) weren't subjected to any training for the proper and rational use of pesticides. In Nepal, the training for the proper use of pesticides is given to the reseller more than the actual farmers who work in the field, however, District Agricultural Offices and Regional Training Centers have also conducted training for the safe use of pesticides at a consumer's level. Rapid Bioassay of Pesticide Residue (RBPR) laboratory has been established in Jhapa, Rupandehi, Banke, Kaski, Sarlahi, and Kailali districts of Nepal due to its positive impact.[29] RBPR isn't established in the Bhaktapur district which could have impacted the number of people training for the use of pesticides.

Limitations

The study is subjected to recall bias as the recall period for symptom identification was three months. This study was done in a limited sample size and only in one municipality of Nepal so findings could not be generalized to the whole farming population of the country. The effects of pesticides were reported by the respondent self,

and no clinical measures or laboratory tests were applied to verify the symptoms.

Conclusions

All of the farmers used pesticides to grow food crops, vegetables, and animal products in Changunarayan Municipality, Bhaktapur, Nepal. Most of the farmers experienced both immediate as well as delayed symptoms, the majority showing general symptoms such as eye irritation, difficulty breathing, and fatigue. The frequency of exposure and effects of pesticide use were statistically significant. The municipality should focus on providing knowledge about the use of pesticides and training for the farmers at the production level and the methods for the safe and rational use of pesticides.

Acknowledgments

The authors would like to thank the institutional review committee of CiST College for providing the ethical approval for this study. We also like to thank Changunarayan Municipality, Bhaktapur, and individual respondents who provided their valuable information in data collection.

References

1. Del Prado-Lu JL. Pesticide exposure, risk factors and health problems among cutflower farmers: a cross sectional study. J Occup Med Toxicol. 2007 Sep 18.[Cited 2022 Jan 4];2:1-9. Available from: https://link.springer.com/article/10.1186/1745-6673-2-9
2. Gesesew HA, Woldemichael K, Massa D, Mwanri L. Farmers Knowledge, Attitudes, Practices and Health Problems Associated with Pesticide Use in Rural Irrigation Villages, Southwest Ethiopia. PLoS One. 2016 Sep 13.[Cited 2022 Jan 4];11(9):1-13. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0162527
3. World Health Organization. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification Geneva: World Health Organization; 2019 [Internet].Cited 2022 Jan 5]. Available from: https://apps.who.int/iris/bitstream/handle/10665/332193/9789240005662-eng.pdf.
4. Kangkhetkron T, Juntarawijit C. Factors Influencing Practice of Pesticide Use and Acute Health Symptoms among Farmers in Nakhon Sawan, Thailand. Int J Environ Res Public Health. 2021 Aug 20.[Cited 2022 Feb 10];18(16):1-12. Available from: https://pubmed.ncbi.nlm.nih.gov/34444547/#:~:text=This%20study%20found%20about%2040,practice%20(p%20%3C%200.05)
5. Hutter HP, Poteser M, Lemmerer K, Wallner P, Kundi M, Moshammer H, et al. Health Symptoms Related to Pesticide Use in Farmers and Laborers of Ecological and Conventional Banana Plantations in Ecuador. Int J Environ Res Public Health. 2021 Jan 27.[Cited 2022 Feb 10];18(3):1-12. Available from: https://www.mdpi.com/1660-4601/18/3/1126
6. Cole DC, Orozco TF, Pradel W, Suquillo J, Mera X, Chacon A, et al. An agriculture and health inter-sectorial research process to reduce hazardous pesticide health impacts among smallholder farmers in the Andes. BMC Int Health Hum Rights. 2011 Nov 8.[Cited 2022 Feb 12];11 (2):1-6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22165981
7. Gyenwali D, Vaidya A, Tiwari S, Khatiwada P, Lamsal DR, Giri S. Pesticide poisoning in Chitwan, Nepal: a descriptive epidemiological study. BMC Public Health. 2017 Jul 3.[Cited 2022 Feb14];17(1):1-8. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-017-4542-y#auth-Prakash-Khatiwada-Aff4
8. Kafle S, Vaidya A, Pradhan B, Jors E, Onta S. Factors Associated with Practice of Chemical Pesticide Use and Acute Poisoning Experienced by Farmers in Chitwan District, Nepal. Int J Environ Res Public Health. 2021 Apr 15.[Cited 2022 Apr 20];18(8):1-14. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8071468/#:~:text=Farmers%20with%20unsafe%20practices%20of,of%20safe%20use%20of%20pesticide.
9. Koju P, Shakya PR, Shrestha A, Karmacharya BM, Shrestha S, Jaacks LM. Pilot Educational Intervention to Promote Safe Pesticide Use Practices Among Farmworkers in Nepal. Ann Work Expos Health 2020 Oct 8.[Cited 2022 Apr 20];64(8):866-75. Available from: https://pubmed.ncbi.nlm.nih.gov/32491155/
10. Lu JL. Assessment of Pesticide-Related Pollution and Occupational Health of Vegetable Farmers in Benguet Province, Philippines. J Health Pollut. 2017 Dec.[Cited 2022 Apr 20];7(16):49-57. Available from: https://pubmed.ncbi.nlm.nih.gov/30524840/
11. Ramesh N, Kannan R. Work-related musculoskeletal disorders among pesticide sprayers of tea plantations in South India. Int J Occup Safety Health. 2022 Jan 1.[Cited 2022 Apr 20];12(1):23-8. Available from: https://doi.org/10.3126/ijosh.v12i1.41034
12. Marete GM, Lalah JO, Mputhia J, Wekesa VW. Pesticide usage practices as sources of occupational exposure and health impacts on horticultural farmers in Meru County, Kenya. Heliyon. 2021 Feb.[Cited 2022 Apr 22];7(2):1-13.

Available from: https://pubmed.ncbi.nlm.nih.gov/33659728/

13. Negatu B, Kromhout H, Mekonnen Y, Vermeulen R. Occupational pesticide exposure and respiratory health: a large-scale cross-sectional study in three commercial farming systems in Ethiopia. Thorax. 2017 Jun.[Cited 2022 Apr 25];72(6):498-99. Available from: https://pubmed.ncbi.nlm.nih.gov/27879416/
14. Khanal G, Singh A. Patterns of Pesticide Use and Associated Factors Among the Commercial Farmers of Chitwan, Nepal. Environ Health Insights. 2016 Dec 11.[Cited 2022 Apr 25];10(Suppl 1):1-7. Available from: https://pubmed.ncbi.nlm.nih.gov/27980419/
15. Neupane D, Jors E, Brandt L. Pesticide use, erythrocyte acetylcholinesterase level and self-reported acute intoxication symptoms among vegetable farmers in Nepal: a cross-sectional study. Environ Health. 2014 Nov 20.[Cited 2022 Apr 25];13(98):1-7. Available from: https://doi.org/10.1186/1476-069X-13-98
16. Nisar S, Muzaffer U, Kareem O. Acute Health Effects of Pesticide Exposure among Farmers Directly Involved with Spraying: A Cross-Sectional Pilot Study from Kashmir Valley. Int J Health Sci Res. 2021 May.[Cited 2022 Apr 27];11(5):169-77. Available from: https://www.ijhsr.org/IJHSR_Vol.11_Issue.5_May2021/IJHSR-Abstract.027.html
17. 1eyaratnam J. Health problems of pesticide usage in the Third World. Br J Ind Med. 1985.[Cited 2022 Aug 25];42(8):505. Available from: https://pubmed.ncbi.nlm.nih.gov/4016001/
18. Sekiyama M, Tanaka M, Gunawan B, Abdoellah O, Watanabe C. Pesticide usage and its association with health symptoms among farmers in rural villages in West Java, Indonesia. Environ Sci. 2007 Aug.[Cited 2022 Sep 5];14(Suppl):23-33. Available from: https://pubmed.ncbi.nlm.nih.gov/18382412/
19. Jyoti S, Lama P, Yadav A, Vaidya S, Joshi SK. Knowledge, attitude, and practice of pesticide use among agricultural workers of Lamatar Village Development Committee, Lalitpur District: A cross-sectional study. Int J Occup Safety Health. 2023 Jul 15.[Cited 2022 Sep 5];13(4):441-9. Available from: https://doi.org/10.3126/ijosh.v13i4.53257
20. Sapbamrer R, Nata S. Health symptoms related to pesticide exposure and agricultural tasks among rice farmers from northern Thailand. Environ Health Prev Med. 2013 Jul 9.[Cited 2022 Sep 5];19(1):12-20. Available from: https://pubmed.ncbi.nlm.nih.gov/23835647/
21. Cropper ML. Economic and health consequences of pesticide use in developing country agriculture: discussion. Am J Agr Econ 1994 Aug 1.[Cited 2022 Sep 18];76(3):605-07. Available from: https://onlinelibrary.wiley.com/doi/abs/10.2307/1243673
22. Behan PO. Chronic fatigue syndrome as a delayed reaction to chronic low-dose organophosphate exposure. J Nutr Environ Med. 2009 Jul 13.[Cited 2021 Sep 18];6(4):341-50. Available from: https://www.tandfonline.com/doi/abs/10.3109/13590849609007262
23. Rasoul GMA, Abou Salem ME, Mechael AA, Hendy OM, Rohlman DS, Ismail AA. Effects of occupational pesticide exposure on children applying pesticides. Neurotoxicology. 2008 Sep.[Cited 2022 Sep 18];29(5):833-38. Available from: https://doi.org/10.1016/j.neuro.2008.06.009
24. Pham H, Lingao MD, Ganesh A, Capasso JE, Keep R, Sadagopan KA, et al. Organophosphate retinopathy. Oman J Ophthalmol. 2016 Apr.[Cited 2022 Sep 25];9(1):49-51. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4785709/
25. Jamal G, Hansen S, Pilkington A, Buchanan D, Gillham R, Abdel-Azis M, et al. A clinical neurological, neurophysiological, and neuropsychological study of sheep farmers and dippers exposed to organophosphate pesticides. Occup Environ Med. 2002 Jul 1.[Cited 2022 Oct 10];59(7):434-41. Available from: https://oem.bmj.com/content/59/7/434
26. Peiris-John RJ, Ruberu DK, Wickremasinghe AR, van-der-Hoek W. Low-level exposure to organophosphate pesticides leads to restrictive lung dysfunction. Respir Med. 2005 Aug 16.[Cited 2022 Oct 10];99(10):1319-24. Available from: https://pubmed.ncbi.nlm.nih.gov/16102957/
27. Segura P, Chavez J, Montano LM, Vargas MH, Delaunois A, Carbajal V, et al. Identification of mechanisms involved in the acute airway toxicity induced by parathion. Naunyn Schmiedebergs Arch Pharmacol. 1999 Dec.[Cited 2022 Oct 10];360(6):699-10. Available from: https://pubmed.ncbi.nlm.nih.gov/10619188/
28. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. Int J Environ Res Public Health. 2011 May 6.[Cited 2022 Nov 10];8(5):1402-19. Available from: https://www.mdpi.com/1660-4601/8/5/1402
29. Adhikari PR. An overview of pesticide management in Nepal. J Agric & amp; Environ 2018 May 12.[Cited 2022 Nov 10];18:95-105. Available from: https://doi.org/10.3126/aej.v18i0.19894

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Laboratory risk analysis in branch hospital: The L-type matrix

Kantaş Yılmaz F[1], Karakus S[2]

[1]Department of Health Management, Faculty of Health Sciences, University of Health Sciences, 34668, Istanbul Türkiye,
[2]Department of Health Management, Faculty of Health Sciences, University of Health Sciences, 34668, Istanbul Türkiye

Corresponding author:

Fatma Kantaş Yılmaz,
Assistant Professor,
Department of Health Management, Faculty of Health Sciences, University of Health Sciences, 34668, Istanbul Türkiye
Tel.: +902163463636,
E-mail: fatmakantas.yilmaz@sbu.edu.tr
ORCID ID: https://orcid.org/0000-0003-0512-382X

Date of submission: 10.04.2023
Date of acceptance: 06.12.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.53996

ABSTRACT

Introduction: Laboratory workers are often exposed to various risk factors, which can be classified as biological, physical, chemical, psychosocial, and ergonomic. This study aims to conduct a risk analysis in the workers of microbiology and biochemistry laboratories of a branch hospital in Istanbul, Türkiye to identify occupational health and safety risks and provide recommendations for measures to be taken.

Methods: The investigators conducted the risk analysis with a five-person team including occupational health and safety experts, a laboratory manager, and technicians. Risk assessments were performed using the L-type matrix 5x5 diagram. The level of risk was determined with the product of probability and severity.

Results: Risk analysis in the microbiology laboratory showed ten risk factors. Three of them had moderate level scores as following "working with xylene", "continuous standing work" and "insufficient free space". The remaining risks have low-risk scores, including "working in a noisy environment, "microscope light and ambient light", "working with blood", "working with feces", "non-ergonomic chairs", "insufficient airflow in the environment" and "continuous presence in a closed space". In the biochemistry laboratory, four were classified as moderate risk, including working in constant standing, exposure to bodily fluids, blood tests for bacteria and viruses and non-ergonomic furniture.

Conclusion: The priority should be to minimize the risks associated with contact with blood and body fluids. This could involve the implementation of strict safety measures and protocols, as well as providing appropriate personal protective equipment to all personnel who may encounter these fluids.

Keywords: Hospital, Laboratory, Occupational Health and Safety, Risk Analyses.

Introduction

Hospital laboratories are essential to treat patients because they deliver precise and quick findings from laboratory tests that aid medical personnel in making diagnoses. The results of laboratory tests constitute the basis for around two-thirds of significant medical decisions, including the admission and discharge of patients from hospitals and the prescription of medications.[1] Laboratory professionals' excellent work influences most medical decision-making by continuously enhancing the quality, scope, and speed of laboratory tests used for medical diagnostics.[2]

Risk analysis is crucial for hospital laboratories to identify potential hazards and implement appropriate risk mitigation strategies to minimize or eliminate risks that could threaten patient safety and laboratory operations. Risk analysis is a systematic process that involves identifying hazards, assessing the likelihood of their occurrence, and determining the potential consequences of such occurrences.[3] Hospital laboratories face various hazards, including exposure to biohazards, chemicals, radiation, and ergonomic hazards.[4]

Effective risk analysis and management in hospital laboratories require the involvement of all stakeholders, including laboratory managers, laboratory personnel, and hospital management. A study by von Kries, et al., highlighted the importance of involving laboratory personnel in risk analysis, as they possess extensive knowledge and experience in laboratory operations.[5] The involvement of hospital management is also necessary, as they provide the necessary resources and support to implement the identified risk management measures.

Risk analysis also plays a crucial role in ensuring regulatory requirements and standards compliance. Hospitals and laboratories are required to comply with various regulations and standards, such as the Occupational Safety and Health Administration (OSHA) standards, the Clinical Laboratory Improvement Amendments (CLIA) regulations, and the International Organization for Standardization (ISO) standards. Compliance with these regulations and standards requires a thorough understanding of the risks associated with laboratory operations and the implementation of appropriate risk management measures.[6]

Laboratory workers are often exposed to various risk factors, which can be classified as biological, physical, chemical, psychosocial, and ergonomic. In order to eliminate or minimize these risks, a series of measures should be taken, starting with the design and construction stages of laboratories, establishing a safety infrastructure, informing employees about potential hazards, and providing laboratory safety training. Therefore, it is mandatory to conduct risk assessment studies in laboratories.[7]

This risk analysis study by Karahan and Aydoğmuş (2023) included identifying and categorizing 50 risks. The risks were assessed and rated and classified into high, medium, and low categories. Specifically, it was found that 30 risks (60%) were classified as high risk, 18 risks (18%) were categorized as medium risk, and 2 risks (4%) were deemed to be low risk.[8]

This study aims to conduct a risk analysis in the microbiology and biochemistry laboratories of a branch hospital in Istanbul to identify occupational health and safety risks and provide recommendations for measures to be taken. The originality of this study lies in its focus on a branch hospital that provides services in the field of heart disease. Furthermore, the study will provide laboratory personnel with an understanding of all the occupational risks they are exposed to and serve as a guide for minimizing these risks and planning preventive measures.

Methods

A descriptive research design was conducted in the microbiology and biochemistry laboratories of three branch hospitals in Istanbul Türkiye in January 2023. The hospital was chosen as an easily accessible hospital for researchers as a convenient sample. Risk assessments were performed using the L-type matrix 5x5 diagram, a commonly used method for evaluating cause-and-effect relationships due to its simplicity. This method involves assessing the probability of an event occurring and the severity of its consequences if it does occur. The L-type matrix 5x5 diagram has been used in previous studies to evaluate risks in various settings, including healthcare facilities.[9,10] In this study, the L-type matrix 5x5 diagram was used to identify potential risks in the hospital's microbiology and biochemistry laboratories, which could help guide the development of effective risk management strategies.

The investigators conducted the risk analysis with a five-person team including occupational health and safety experts, a laboratory manager, and technicians. The Laboratory Information Form designed by researchers consisted of 10 questions. This form was filled out with general information about laboratory type, conducted tests, number of equipment and personnel, physical structure, chemical materials, noise, and chemical/ physical/ biological hazards.

Using an L-type (5x5) matrix, occupational health and safety risks were evaluated through the Medical Biochemistry Laboratory Safety Guide to identify potential hazards in or outside the laboratory. Risks were considered under six headings: physical, ergonomic, chemical, biological, psychosocial, and noise. The risks were summarized in a table, including the activities, hazards, affected persons, outcomes, probability value, severity value, score value, and necessary precautionary measures. The L-type (5x5) matrix typically consists of five columns and five rows, with each row representing a different aspect of laboratory risk analysis (table 1). The probability column assessed the probability of the hazard occurring. The severity column assessed the potential impact of the hazard on laboratory personnel and the environment. This can be ranked on a scale from low to high, depending on the possible consequences of the hazard. The risk = probability x severity formula will be used to determine the level of risk.[11]

The risk matrix is divided into three bands. A lower band, which may often be coloured green, represents low risks, which are tolerable; therefore, no risk treatment measures are needed. A middle band, which may be coloured orange, represents moderate risks to be reduced to as low as reasonably practicable (ALARP). An upper band, which may be coloured red, represents high risks, which are typically intolerable and, therefore, risk treatment is essential.[12]

Depending on which coloured band the risk rating is assigned to, the assessor decides whether or not to treat the risk and what actions are needed.[13]

Table 1: 5x5 L-type risk decision matrix

		SEVERITY (IMPACT)				
		VERY LOW 1	**LOW 2**	**MEDIUM 3**	**HIGH 4**	**VERY HIGH 5**
		Minor injuries or discomfort. No medical treatment.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injuries or illness resulting in impairment	Fatality
PROBABILITY	Expected to occur regularly under normal circumstances **5**	5	10	15	20	25
	Expected to occur at some time **4**	4	8	12	16	20
	May occur at some time **3**	3	6	9	12	15
	Not likely to occur in normal circumstances **2**	2	4	6	8	12
	Could happen, but probably never will **1**	1	2	3	4	5

	Extreme risk	Immediate attention & response needed
	Moderate risk	Requires response development, but not quantification
	Low risk	Requires active or passive acceptance

Results

Risk analysis in the microbiology laboratory showed ten risk factors as follows: 1. risk "working in a noisy environment" (score=2), 2. risk "microscope light and ambient light" (score=2), 3. risk "working with xylene" (score=8), 4. risk "working with blood" (score=4), 5. risk "working with feces" (score=4), 6. risk "non-ergonomic chairs" (score=4), 7. risk “continuous standing work” (score=12), 8. risk "insufficient free space" (score=6), 9. risk "insufficient airflow in the environment" (score=2) and 10. risk "continuous presence in a closed space" (score= 4). While three of the ten items (risks 3, 7, and 8) had higher risks than the others, the remaining seven items (risks 1, 2, 4, 5, 6, 9, and 10) were found to have low-risk levels (Table 1).

Upon consideration of the laboratory examinations and matrix results, biological risks are at the forefront. The severity of risks arising from contact with blood is particularly noticeable in Table 2. In addition to these risks, the ergonomic aspects of the laboratory are also of significant importance.

According to the risk analysis performed in the biochemistry laboratory, ten risk factors were identified, and the likelihood and severity of each risk factor were determined by multiplying their occurrence probability and impact (table 3). The results were presented in a matrix, classifying the risks into high- and low-risk categories. Among the ten factors, four were classified as moderate risk, including working in constant standing (risk score=12), blood tests for bacteria and viruses (risk score=10), working with gaita (risk score=10), and non-ergonomic furniture (risk score=9).

Table 2: The L-type (5x5) matrix of findings of risk analysis in the microbiology laboratory

No	Activity	Danger	Person at risk	Consequences	Probability	Severity	Risk	Measure
1	Working in noisy workplace	Noisy	Relevant workers	Ear difficulties	1	2	2	Maintenance and repair of devices that exceed the threshold limit. Performing audiometric tests on employees
2	Microscope light and ambient light	Light	All workers	Eye disease, headache	1	2	2	Adjusting the ambient light Frequency of breaks
3	Working with xylene	Occupational disease	Relevant workers	Chest pain Pulmonary edema	2	4	8	Employee training Wearing personal protective equipment
4	Working with blood	Exposure to blood	Relevant workers	Transmission of AIDS hepatitis viruses	1	4	4	Employee training Wearing personal protective equipment
5	Working with gaita	Exposure to bodily fluids	Relevant workers	Hepatitis a virus	1	4	4	Employee training Wearing personal protective equipment
6	Non-ergonomic furniture	Occupational disease	Relevant workers	Musculoskeletal problems	2	2	4	Using ergonomic office chairs
7	Continuous standing work	Occupational disease and fatigue	Relevant workers	Varicose Veins, Musculoskeletal problems	4	3	12	Establishing rest hours The use of the shift system
8	Limited free space	Falling and crashing	All workers	Injuries, Musculoskeletal problems	2	3	6	Placing items in an orderly manner Freeing up sufficient free space
9	Low airflow	Stress due to a lack of oxygen	All workers	Headache, stress	2	1	2	Placing items in an orderly manner Frequency of breaks
10	Staying indoors all the time	Concentration problems and accidents	All workers	Job stress, injuries,	2	2	4	Adjusting rest hours making encouraging practices

The remaining six factors were classified as low risk, which included working with chemicals (risk score=4), working in a noisy environment (risk score=2), working in areas with cables on the floor (risk score=1), working in closed spaces (risk score=2), working with lung fluids (risk score=4), and inadequate air circulation in the work environment (risk score=6). The matrix analysis and biochemical laboratory examination findings indicated that biological dangers are paramount. Blood and bodily fluid contact pose severe health concerns, as is evident. Ergonomic risks have a high-risk rating, with non-ergonomic seats and extended standing.

Table 3: The L-type (5x5) matrix of findings of risk analysis in the biochemistry laboratory

No	Activity	Danger	Person at risk	Consequences	Probability	Severity	Risk	Measure
1	Working with chemicals	Contact with harmful chemicals	Lab technicians and specialists	Skin problems	2	2	4	Provide training on wearing appropriate gloves and giving first aid during chemical splashes.
2	Working in a noisy workplace	Noisy	Lab technicians and specialists	Ear difficulties	1	2	2	Maintenance and repair of devices that exceed the threshold limit. Performing audiometric tests on employees
3	Working with cable on the ground	Falling	All workers	Injuries	1	1	1	Cable storage and plate placement
4	Staying indoors all the time	Light deprivation	All workers	Occupational disease and vitamin d deficiency	2	1	2	Ensuring that workers enjoy sunlight during breaks and, if necessary, administering vitamin D supplements
5	Working with lung fluids	Transmission by inhalation	Lab technicians and specialists	Tuberculosis and lung diseases	1	4	4	Using a fume hood and the proper masks
6	Working in constant standing	Occupational disease and fatigue	Lab technicians and specialists	Varicose Veins, Musculoskeletal problems	4	3	12	Establishing rest hours The use of the shift system
7	Bacteria and virus test in blood	Exposure to blood	Lab technicians and specialists	Bacterial and viral disease	2	5	10	Employee training Wearing personal protective equipment
8	Working with gaita	Exposure to bodily fluids	Lab technicians and specialists	Bacterial and viral disease	2	5	10	Employee training Wearing personal protective equipment
9	Low airflow	Stress due to a lack of oxygen	All workers	Injuries	3	2	6	Setting up break times and providing adequate ventilation
10	Non-ergonomic furniture	Occupational disease	Lab technicians and specialists	Musculoskeletal problems	3	3	9	Using ergonomic office chairs

Discussion

Hospital risk assessment is an essential step in occupational health and safety activities. By examining risk assessments, appropriate actions are taken, and workers are trained to prevent these risks. Employees receive help with problems by learning to manage risks and protect against them during this training. The risks in the microbiology and biochemistry lab of a training and research hospital in Istanbul were filled into two x-type matrices for risk assessment. Findings showed that biological risks are the most important. In the microbiology lab, samples from human fluids and tissues are used to perform culture tests, parasite tests, and tests to identify bacteria and viruses. In parallel with our findings, previous studies demonstrated that the routine activity in a microbiology laboratory offers many risks, mostly biological influencing the health of its staff, visitors, and the community.[14,15,16] In contrast, the biochemistry lab uses these samples to test hormones, hemograms, biochemistry, and coagulation. In addition, the hospital for which risk analysis is performed is a branch hospital

providing services in the field of cardiovascular disease, which brings biological risks to the fore due to the risk of contamination with blood and body fluids. While chemical and physical risks rank first in other studies,[17] it is noteworthy that psychosocial risks stand out in addition to biological risks in this study. Previous studies categorized similar risks into diverse risk groups. Demirkan identified biological, physical, psychosocial, chemical, and ergonomic dangers such as infections, stab wounds, hearing loss, violence, stress, chemical exposure, explosion/fire, and musculoskeletal disorders.[18] However, previous research identified biological, psychological, ergonomic, physical, and chemical risk categories. The most stated risks are infection, stress, an airless indoor environment, noise, chemical exposure, and violence.[19]

Conclusions

The current study aimed to conduct a risk analysis in the microbiology and biochemistry laboratories of a branch hospital in Istanbul to identify occupational health and safety risks and provide recommendations for measures to be taken.

Risk analysis in the microbiology laboratory showed ten risk factors. Three of them had moderate level scores as following "working with xylene", “continuous standing work” and "insufficient free space". The remaining risks have low-risk scores, including "working in a noisy environment, "microscope light and ambient light", "working with blood", "working with feces", "non-ergonomic chairs", "insufficient airflow in the environment" and "continuous presence in a closed space". In the biochemistry laboratory, four were classified as moderate risk, including working in constant standing, exposure to bodily fluids, blood tests for bacteria and viruses and non-ergonomic furniture The remaining six factors were classified as low risk, which included working with chemicals, working in a noisy environment and many cables on the floor, low airflow and working with lung fluids and staying all the time indoors.

The priority should be to minimize the risks associated with contact with blood and body fluids. This could involve the implementation of strict safety measures and protocols, as well as providing appropriate personal protective equipment to all personnel who may encounter these fluids. Additionally, efforts should be made to improve ergonomics in laboratory settings, such as by providing ergonomic chairs and regular breaks for personnel who are required to stand for prolonged periods of time. By taking these steps, the overall risk profile of the laboratory can be significantly reduced, ensuring a safer and more efficient working environment for all personnel involved.

Although this study was conducted in a cardiology branch hospital, this situation creates a limitation as all laboratories generally have similar characteristics.

Acknowledgments

The authors would like to express their gratitude to Hüseyin Furkan Erdoğan, Muhammed Furkan Velioğlu, Muhammed Aydın, Mahmud Elem Kara and Ahmet Emir Yolcu.

References

1. Plebani M. Exploring the iceberg of errors in laboratory medicine. Clinica Chimica Acta. 2009;404:16–23. Available from: https://doi.org/10.1016/j.cca.2009.03.022
2. Cadamuro J. Disruption vs. evolution in laboratory medicine. Current challenges and possible strategies, making laboratories and the laboratory specialist profession fit for the future. Clinical Chemistry and Laboratory Medicine (CCLM). 2023;61(4): 558-66. Available from: https://doi.org/10.1515/cclm-2022-0620
3. Pascarella G, Ross M, Montella E, Capasso A, De Feo G, Botti G, et al. Risk analysis in healthcare organizations: Methodological framework and critical variables. Risk Management and Healthcare Policy 2021; 2897-911. Available from: https://doi.org/10.2147/RMHP.S309098
4. Nankongnab N, Kongtip P, Tipayamongkholgul M, Silpasuwan P, Kaewboonchoo O, Luksamijarulkul P, et al. Occupational hazards, health conditions and personal protective equipment used among healthcare workers in hospitals, Thailand. Human And Ecological Risk Assess. 2021; 27(3): 804-24. Available from: https://doi.org/10.1080/10807039.2020.1768824
5. Thakur V, Akerele OA, Randell E. Lean and Six Sigma as continuous quality improvement frameworks in the clinical diagnostic laboratory. Critical Reviews in Clinical Laboratory Sciences. 2023;60(1):63-81. Available from:

https://doi.org/10.1080/10408363.2022.2106544

6. Ersoy S, Kaya EÇ. Bir kamu üniversitesi gıda mühendisliği laboratuvarları risk analiz uygulaması. Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi. 2019;8(4): 411-23. Available from: https://dergipark.org.tr/en/pub/gumussagbil/issue/50658/566874

7. Karahan V, Aydoğmuş E. Risk Analysis and Risk Assessment in Laboratory Studies. International Journal of Science and Technilogy. 2023 Mar; 49: 55-60. Available from: https://doi.org/10.31590/ejosat.1260340

8. Lam SS, Yeung WK. Application of L-type matrix to evaluate and manage the risks of healthcare acquired infection. Journal of Hospital Infection. 2017:95(4);408-13. Available from: https://doi.org/10.1016/j.jhin.2017.01.012

9. Chen J, Li X, Xu L, Li L. Application of L-type matrix in risk assessment of blood transfusion reaction. Journal of Clinical Laboratory Analysis. 2020;34(9): e23380. Available from: https://doi.org/10.1002/jcla.23380

10. Jorgensen D, Kolb J. Risk Assessment for Laboratories. John Wiley & Sons, 2013.

11. Macdonald D. Hazops, trips and alarms. Elsevier, 2004. Available from: https://shop.elsevier.com/books/practical-hazops-trips-and-alarms/macdonald/978-0-7506-6274-1#full-description

12. Kaya GK, Ward J, Clarkson J. A review of risk matrices used in acute hospitals in England. Risk Analysis. 2019;39(5):1060-70. Available from: https://doi.org/10.1111/risa.13221

13. Cox LA. What's wrong with risk matrices? Risk Analysis. 2008;28(2):497–512. Available from: https://doi.org/10.1111/j.1539-6924.2008.01030.x

14. Rojo-Molinero E, Alados JC, de la Pedrosa EG, Leiva J, Pérez JL. Seguridad en el laboratorio de Microbiología Clínica [Safety in the Microbiology laboratory]. Enferm Infecc Microbiol Clin. 2015;33(6):404-10. Available from: https://doi: 10.1016/j.eimc.2014.06.014. Epub 2014 Nov 8. PMID: 25444041.

15. Turk M. Bir Üniversite Hastanesi Mikrobiyoloji Laboratuvarında Risk Değerlendirmesi. Türk Tabipler Birliği Mesleki Sağlık ve Güvenlik Dergisi. 2012; 12(43):27-43ç. Available from: https://dergipark.org.tr/en/pub/msg/issue/49207/628152

16. Carraro E, Bonetta S, Bertino C, Lorenzi E, Bonetta S, Gilli G. Hospital effluents management: chemical, physical, microbiological risks and legislation in different countries. Journal of environmental management. 2016; 168:185-99. Available from: https://doi.org/10.1016/j.jenvman.2015.11.021

17. Alrawahi S, Sellgren SF, Altouby S, Alwahaibi N, Brommels M. The application of Herzberg's two-factor theory of motivation to job satisfaction in clinical laboratories in Omani hospitals. Heliyon. 2020;6(9). Available from: https://doi.org/10.1016/j.heliyon.2020.e04829

18. Demirkan CB. Sağlık Hizmetleri Sektöründe Risk Değerlendirmesi: Hastane Merkez Laboratuvarı Örneği (tez). Edirne: Trakya Üniversitesi Tıp Fakültesi, 2015. Available from: https://dspace.trakya.edu.tr/xmlui/handle/trakya/2625

19. Kaya A. Akdeniz Üniversitesi Merkez Laboratuvarı Çalışanlarının Mesleki Biyolojik Risk Algı Düzeyleri ve Etkileyen Faktörler ile Biyolojik Risk Değerlendirmesi ve Risk Analizi Çalışması (tez). Antalya: Akdeniz Üniversitesi Tıp Fakültesi. 2013. Available from: https://acikbilim.yok.gov.tr/handle/20.500.12812/28568

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Micronuclei in the exfoliated oral epithelial cell: a cross-sectional study in Peruvian artisanal miners

Pizarro-Rojas B[1], Rabanal-Sanchez J[2], Soncco-Llulluy F[3], Rosales-Rimache J[4]

[1]Facultad de Medicina, Universidad Alas Peruanas, Ica 11001, Peru
[2]Escuela de Medicina, Universidad Cesar Vallejo. Trujillo, La Libertad, Peru
[3]Carrera de Medicina Humana, Universidad Científica del Sur. Lima, Peru
[4]Centro de Investigación en Biodiversidad para la Salud, Universidad Privada Norbert Wiener, Lima 15046, Peru

Corresponding author:

Dr. Jaime Rosales-Rimache
Universidad Privada Norbert Wiener, Lima 15046, Peru
Tel.: +51 1 944-457-898,
E-mail:jaime.rosalesr@uwiener.edu.pe
ORCID ID:https://orcid.org/0000-0002-1665-2332

Date of submission: 08.08.2023
Date of acceptance: 09.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: Universidad Privada Norbert Wiener
DOI:https://doi.org/10.3126/ijosh.v14i2.56004

ABSTRACT

Introduction: Artisanal mining in Peru is an activity that generates a risk of exposure to different compounds, among which mercury and particulate matter stand out. The use of laboratory indicators to assess genotoxicity induced by work activity is a priority need. Our objective was to determine the micronucleus count in buccal cells of artisanal miners in Peru during 2020.

Methods: We designed a cross-sectional study where 80 artisanal miners were evaluated who underwent scraping in the inner area of the cheek to obtain epithelial cells that were stained with Feulgen's staining, and micronuclei and nuclear alterations were identified on a count of 2000 cells.

Results: We found that the mean micronucleus count was 27.5±8.0 (CI95: 25.7 – 29.3, min. 15, max. 48). For the other nuclear alterations such as nucleoplasmic bridges, budding, and binucleation, only up to one alteration was evidenced for each total count. The number of years of work (p=0.004) and age (p<0.001) were the only variables associated with the micronucleus count.

Conclusion: The nuclear alterations in buccal cells of artisanal miners exposed to particulate material were micronuclei, nucleoplasmic bridges, budding, and binucleations, the most frequent being the presence of micronuclei, with a mean value of 27.5 micronuclei per 2000 cells counted.

Keywords: Artisanal mining; Micronuclei; Nuclear alteration

Introduction

Artisanal mining is an activity that is associated with a high rate of occupational mortality and morbidity throughout the world. The most frequent pathological condition associated with it is cancer, with a pathophysiological basis related to DNA damage.[1] According to the reports of the Global Cancer Observatory (GLOBOCAN), it is estimated that 18.1 million new cases occur each year, of which close to 60% are attributed to working conditions, among which mining stands out.[2]

Artisanal mining is an economic activity that involves more than 70,000 miners in Peru; 400,000 people and 40,000 Peruvian families depend on it, who have found an alternative to combat unemployment with little investment, simple technology, and intensive work. For this work, those deposits that, for conventional mining, have ceased to be attractive are used.[3]

Artisanal mining involves using instruments designed to undermine the earth's surface and extract the mineral. This process generates the resuspension of dust in the air, mainly inhalable particulate matter (PM), which generates direct

exposure to the worker. Inhalable PM is the most widely studied pollutant in the world, and it is found in the atmosphere, causing various problems in vegetation and humans.[4,5]

Artisanal miners are a high-risk group due to PM's short- and long-term effects on health. Studies suggest that chronic exposure may be essential to developing diseases, including cancer.[6] The International Agency for Research on Cancer (IARC) includes air pollution as a group 1 agent and bone as a compound or mixture that can cause human cancer with sufficient evidence.[7] A carcinogenic process results from alterations involving continuous generations of cells, which progressively progress toward cancerous growth.[8] It is due to multiple exposures to risk factors that initially produce DNA alterations and damage in target cells or tissues.[9]

Among the biomarkers of early biological effect, the micronucleus count is the most widely used in studies to measure environmental genotoxicity.[10] Micronuclei appear as the most frequent alterations in interphase cells and are formed by eccentric chromosome fragments or complete chromosomes that are not included in the main daughter nuclei during nuclear division and reflect clastogenic and aneugenic events.[11]

Micronucleated cells can be investigated in different types of tissues, such as the oral mucosa, especially exfoliated buccal cells, in which the presence of alterations in the chromosome structure and oxidative stress caused by exposure to air pollutants stand out.[10,12,13]

In the case of Peru, artisanal mining is the oldest and smallest-scale way in which minerals are extracted, and it has become a source of subsistence for people with low resources.[14,15,16,17,18] Artisanal mining is distributed in different regions of Peru, mainly in the mid-south stand out.[3]

Methods

We designed a cross-sectional study to evaluate artisanal miners from Saramarca, in the province of Palpa, Department of Ica in Peru. The intervention area is located approximately 400 km south of the capital of Peru (Lima) (Figure 1). This area is characterized by high gold mining activity. In October 2020, we recruited 80 miners who carried out subsoil mining, "quimbalateo" (use of huge stone-fulling mills where they mix earth, water, and mercury), burning, and gold extraction activities. We included male miners in continuous activity during the last six months and of legal age.

Figure 1: Location of artisanal mining centers in Saramarca, Ica, Peru.

Data collection was obtained through a form; each study participant filled out this format. The sample was taken after the participants signed the informed consent and completed the form. It should be noted that the sheet was prepared based on theoretical aspects that would help determine the presence of a nuclear alteration. Likewise, additional information was collected on variables

that could alter this relationship as potential adjustment variables.

Participants were asked to rinse their mouths with water, and the inner side of the cheek was scraped with a swab; then, the swab was placed in a tube containing isotonic saline solution (NaCl 0.9%), and the swab was struck. The cells broke off at the bottom of the tube and fell into the solution. The collected cells were centrifuged for 5 minutes at 3500 rpm and kept in physiological saline (NaCl 0.9%) at 4°C for transport to the laboratory, where they were fixed in Carnoy (acetic acid and methanol in a 1:3 ratio) and washed. by gentle centrifugation (1500 rpm per minute) until a clean cell pellet is obtained. Subsequently, the smears were prepared on a clean slide in triplicate for each sample and were stained with Feulgen's stain. The reading was in visible light microscopy using 100X magnification in immersion. The average value of the three readings was taken as a measure of internal reliability, evaluating that the readings do not present a coefficient of variation more significant than 15%.

Micronucleus count in buccal epithelium cells. The recommended procedure was used by Holand et al.[19] Cells were stained with the commercial Feulgen kit (Merck, Germany) for subsequent counting of 2000 epithelial cells under a 100X visible light microscope. For the identification of Micronuclei, the following parameters were used: round or oval shape, diameter between 1/16 to 1/3 of the main nucleus, separated from the main nuclei without overlapping; they must not be refractive, they must present the same characteristics in color and condensation of the chromatic than the main nucleus.[20]

Likewise, we identified binucleated cells using the following criteria: they must present two round or oval nuclei and keep their membrane intact and distinguishable from adjacent cells. Nuclei should be separate, similar in size, and have a similar staining pattern. The nuclei can touch but not overlap; the nuclear membrane must be distinguished. A nucleoplasmic bridge can link both nuclei. Finally, we identified nucleoplasmic bridges and budding. For this, we evaluated the microscopic shape, and the homogeneity of the staining and texture of the structures similar to the nuclear ones was evaluated.[20]

The micronuclei count, and other nuclear alterations were presented according to their median and interquartile range. The micronucleus count was dichotomized; we considered 30 micronuclei per 2000 epithelial cells as the cut-off point, according to the criteria used by Shahsavari et al.[21] age and working time were categorized according to their tertiles. We compared micronucleus count ratios using Pearson's Chi-square test. Additionally, we used a Poisson regression model and log linkage from the family of generalized linear models (GLM) and calculated the exponentiated coefficient and its 95% confidence interval. We consider $p<0.05$ as a significant difference. The calculations were made with the statistical program Stata version 17. (StataCorp Collegue Station, TX, USA).

The study was approved on June 18, 2020, by the Universidad Alas Peruanas review committee, with RD N° 237-2020- EPTM-FCS-UAP. The artisanal miners received a talk before they participated in the study. They were informed about the study's objectives, risks, and benefits of their voluntary participation, signing informed consent. The data generated was handled coded and with exclusive access to the research team.

Results

The 80 miners evaluated presented an average age of 46.5 (35.5-62.5) years. Labor seniority in the mining activity averaged 19.5 (10.0-30.0) years (table 1). The average hours worked per day was 8 hours, and the jobs in the mining activity were approximately proportional. About forty-three percent of those evaluated reported consuming cigarettes continuously, and 56.25% alcoholic beverages (table 1). On the other hand, we found a median micronucleus count per 2000 buccal epithelial cells of 27 (IQR:18-32.5). In the case of other nuclear alterations, such as nucleoplasmic bridges, budding, and binucleation, only up to one alteration was evidenced for each total count.

Table 1: Descriptive characteristics of the study population.

Characteristics	N	%	CI 95%
Age (years)	46.5 (35.5-62.5)		
Job seniority (years)	19.5 (10.0-30.0)		
Daily exposure (hours/day)	8.0 (6.0-8.0)		
Job position			
Extraction	17	21.25	13.5-31.7
Transport	21	26.25	17.7-37.1

Pallaqueo	23	28.75	19.8-39.8
Quimbaleteo	19	23.75	15.6-34.4
Smoking			
No	45	56.25	45.1-66.8
Yes	35	43.75	33.2-54.9
Consumption of alcoholic beverages			
No	35	43.75	33.2-54.9
Yes	45	56.25	45.1-66.8

Table 2 shows that micronucleus count and associated factors in bivariate analysis. We found significant differences according to age groups (p=0.004), the count being higher in people over 60. A moderate increase in the micronucleus count is shown concerning the increase in age (R^2=0.504). It can also be seen that the micronucleus count presented significant differences according to job seniority (p<0.001), obtaining the highest count in those workers with more than 25 years of seniority. A moderate increase in the micronucleus count is shown for the increase in job seniority (R^2=0.542). Regarding the number of daily hours worked, this did not generate significant differences (p=0.947) between the micronucleus count. The job position, smoking, and consumption of alcoholic beverages were not significantly associated with the micronucleus count. In the multivariate analysis of the generalized linear model, no independent variables were associated with a micronucleus count more significant than 30 MN/2000 cells.

Table 2.: Micronuclei count and associated factors in bivariate analysis.

Independent variables	**Micronuclei count (MN)**						**p-value***
	MN≤30			**MN>30**			
	n	**%**	**CI95%**	**n**	**%**	**CI95%**	
Age							
<40 years	24	92.3	73.5-98.1	2	7.7	1.9-26.5	0.004
40-60 years	18	54.6	37.4-70.6	15	45.5	29.4-62.6	
>60 years	12	57.1	35.7-76.2	9	42.9	23.8-64.3	
Labor old							
<10 years	19	100.0	--	0	0.0	--	<0.001
10-25 years	23	67.6	50.2-81.3	11	32.4	18.7-49.8	
>25 years	12	44.4	27.0-63.4	15	55.6	36.6-73.0	
Daily working day							
≤8 hours	46	67.7	55.5-77.8	22	32.3	22.2-44.5	0.947
>8 hours	8	66.7	37.2-87.1	4	33.3	12.9-62.8	
Job position							
Extraction	10	58.8	34.9-79.2	7	41.2	20.8-65.1	0.579
Transport	14	6.7	44.3-83.4	7	33.3	16.6-55.7	
Pallaqueo	18	78.3	56.8-90.8	5	21.7	9.2-43.2	
Quimbaleteo	12	63.2	39.9-81.5	7	36.8	18.5-60.1	
Smoking							
No	30	66.7	51.6-79.0	15	33.3	21.0-48.4	0.857
Yes	24	68.6	51.4-81.8	11	31.4	18.2-48.6	
Consumption of alcoholic beverages							
No	25	71.4	54.3-84.0	10	28.6	16.0-45.7	0.508
Yes	29	64.4	49.4-77.1	16	35.6	22.9-50.6	

*Chi2 Pearson

--Omitted

Discussion

Our results show that the micronucleus count in the evaluated population is high compared to a similar study reported by Rosales-Rimache et al.,[3] where only 15% of the artisanal miners evaluated presented MN. A study carried out in Brazil found that coal miners presented MN in buccal epithelium cells. Therefore the increase in MN was associated with genotoxic damage.[22] This event is related to the evidence found in a systematic review that supports the evaluation of MN in the oral epithelium as a biomarker of genotoxic damage since these MN would be a consequence of chromosomal instability caused by exposure to radiation and toxic chemical agents.[23] In this sense, our results could reflect a certain degree of genotoxicity in buccal epithelial cells related to work activity and open possibilities for the generation of future studies that assess not only the genotoxicity induced by artisanal mining activity but also its evaluation as a rapid, reliable, and valid effect biomarker in the assessment of cancer risk.

Artisanal mining activity in Peru varies, and the vast majority is aimed at extracting gold. For this, it requires chemical inputs such as mercury to achieve amalgamation and subsequent extraction; however, the mercury used is in its liquid form, it tends to evaporate at ambient temperatures above 16°C, and these vapors are inhaled and swallowed by the workers, whose epithelial cells receive direct and continuous damage.[24] In our study, this is reflected by the increase in the micronucleus count, which, in particular, presents higher figures than those reported in other studies.[3]

We found that the micronucleus count per 2000 buccal epithelial cells evaluated was 27.5±8.0, a level that is above that reported in other studies. For example, Rosales-Rimache et al.[3] reported a median of 6 micronuclei per 1000 buccal epithelial cells of Ica artisanal miners exposed to mercury. They also showed that "quimbalateo" was the activity that generated the most significant risk in obtaining high counts. In our study, this was different since labor activity was not associated with the micronucleus count, while the number of years as an artisanal miner was a significantly associated variable. Another study has also reported that mining activity generates dust exposure, which induces micronuclei formation 1.34 times in buccal cells. In addition, micronuclei formation is not the only nuclear alteration; increased rates of condensed chromatin, karyorrhexis, and karyolysis also accompany them. Furthermore, working time is once again the variable determining the highest mining population count.[25] In our study, the formation of other nuclear alterations was not absent; however, its count did not exceed one change per 2,000 cells counted.

In the case of Peru, there have yet to be any national studies that evaluate the nuclear effect on oral cells generated by exposure to chemical agents in mining workers or other work activities. Therefore, our findings constitute a relevant source of information that shows genotoxicity could be related to artisanal mining activity, which implies exposure to multiple chemical agents, among which silica dust in its inhalable fraction and metallic mercury stand out. The main limitation of our study was the declaration of a national health emergency due to COVID-19, a situation that forced many workers to quarantine. As a result, the sample size was small. On the other hand, micronuclei are indicators of cell damage, and therefore, any genotoxic agent can induce the production of these alterations.

Conclusions

We found the presence of micronuclei in mining workers, which is associated with their age and length of work as miners. This finding is similar to other studies in other countries and supports the micronucleus count as a biomarker of genotoxic damage. We recommend carrying out more studies of this type in the mining population to evaluate the effect of this economic activity on Peruvian miners.

Acknowledgments

We thank the RUBLAB Clinical Laboratory of Ica for providing support with supplies and equipment for the execution of this research.

References

1. Cortes-Ramirez J, Naish S, Sly P, Jagals P. Mortality and morbidity in populations in the vicinity of coal mining: a systematic review. BMC Public Health. 2018;18(1):721. Available from: https://doi.org/10.1186/s12889-018-5505-7
2. Bray F, Ferlay J, Soerjomataram I, Siegel R, Torre L, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68(6):394–424. Available from: https://doi.org/10.3322/caac.21492
3. Rosales-Rimache J, Malca N, Alarcon J, Chavez M, Gonzales M. Daño genotóxico en trabajadores de minería artesanal expuestos al mercurio [Genotoxic

damage in artisanal mining workers exposed to mercury]. Rev Peru Med Exp Salud Publica. 2013;30(4):595–600.Available from: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1726-46342013000400009

4. Arciniégas-Suárez C. Diagnóstico y Control de Material Particulado: Partículas Suspendidas Totales y Fracción Respirable [Diagnosis and Control of Particulate Material: Total Suspended Particles and Respirable Fraction]. Rev Luna Azul. 2012;195–213. Available from: https://dialnet.unirioja.es/servlet/articulo?codigo=8173838

5. Huaman-Paredes E, Vicuña-Puente D, Visitacion-Figueroa L, Flores del Pino L. Efecto tóxico y ecotoxicológico de arenas negras de la minería artesanal en Madre de Dios [Toxic and ecotoxicological effect of black sands from artisanal mining in Madre de Dios]. Rev la Soc Química del Perú. 2017;83(4):403–11. Available from: http://www.scielo.org.pe/scielo.php?pid=S1810-634X2017000400005&script=sci_abstract

6. Kloog I, Ridgway B, Koutrakis P, P Coull BA, Schwartz JD. Long- and short-term exposure to PM2.5 and mortality: using novel exposure models. Epidemiology. 2013;24(4):555–61. Available from: https://doi.org/10.1097/EDE.0b013e318294beaa

7. Cho C, Hsieh W, Tsai C, Chen C, Chang H, Lin C. In Vitro and In Vivo Experimental Studies of PM2.5 on Disease Progression. Int J Env Res Public Heal. 2018;15(7):1380. Available from: https://doi.org/10.3390/ijerph15071380

8. Sanchez C. Conociendo y comprendiendo la célula cancerosa: Fisiopatología del cáncer [knowing and understanding the cancer cell: Pathophysiology of cancer]. Rev Médica Clínica Las Condes. 2013;24(4):553–62. Available from: https://www.elsevier.es/es-revista-revista-medica-clinica-las-condes-202-pdf-S071686401370659X

9. Longhin E, Holme J, Gutzkow K, Arlt V, Kucab J, Camatini M. Cell cycle alterations induced by urban PM2.5 in bronchial epithelial cells: characterization of the process and possible mechanisms involved. Part Fibre Toxicol. 2013;10:63. Available from: https://doi.org/10.1186/1743-8977-10-63

10. Zalacain M, Sierrasesúmaga L, Patiño A. El ensayo de micronúcleos como medida de inestabilidad genética inducida por agentes genotóxicos [The micronucleus assay as a measure of genetic instability induced by genotoxic agents]. An Sist Sanit Navar. 2005;28(2):27–36. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1137-66272005000300007

11. Torres B, Ramos I. Utilidad de la Prueba de Micronúcleos y Anormalidades Nucleares en Células Exfoliadas de Mucosa Oral en la Evaluación de Daño Genotóxico y Citotóxico [Utility of the Micronucleus and Nuclear Abnormalities Test in Exfoliated Oral Mucosal Cells in the Evaluation of Genotoxic and Cytotoxic Damage]. Int J Morphol. 2013;31:650–7. Available from: https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-95022013000200050

12. Muñoz M, Mazure R, Culebras J. Obesidad y sistema inmune [Obesity and the immune system]. Nutr Hosp. 2004;19(3):19–24. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0212-16112004000600002

13. Goyzueta G, Trigos C. Riesgos de salud pública en el centro poblado minero artesanal La Rinconada (5200 msnm) en Puno, Perú [Public health risks in the artisanal mining town center of La Rinconada (5200 meters above sea level) in Puno, Peru]. Rev Peru Med Exp Salud Publica. 2009;26(4):41–4. Available from: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1726-46342009000100008

14. Franco J, Segura-Contreras J. Exposición de peatones a la contaminación del aire en vías con alto tráfico vehicular [Pedestrian exposure to air pollution on roads with high vehicular traffic]. Rev Salud Pública. 2016;18(2):179–87. Available from: https://www.redalyc.org/articulo.oa?id=42245920003

15. Pippo A, Llambí L, Parodi C, Barros M, NÚñez V, Minacapilli M. Humo de tabaco en vehículos: medición de partículas de materia 2,5 micras [Tobacco smoke in vehicles: measurement of 2.5 micron particles of matter]. Rev Médica del Uruguay. 2018;34(4):222–7. Available from: http://www.scielo.edu.uy/scielo.php?script=sci_arttext&pid=S1688-03902018000400084

16. Medina M, Cravioto P, Villatoro J, Kuri P. Del tabaco al uso de otras drogas: ¿el uso temprano de tabaco aumenta la probabilidad de usar otras drogas? [From tobacco to other drug use: does early tobacco use increase the likelihood of using other drugs?]. Salud Publica Mex. 2002;44:109–15. Available from: https://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S0036-36342002000700016

17. Guiza-Suarez L. La Minería Manual en Colombia: Una Comparación con América Latina [Manual Mining in Colombia: A Comparison with Latin America]. Boletín Ciencias la Tierra. 2014;35:37–44. Available from: http://www.scielo.org.co/scielo.php?pid=S0120-36302014000100005&script=sci_abstract&tlng=es

18. Oyarzun M. Contaminación aérea y sus efectos en

la salud [air pollution and its effects on health]. Rev Chil enfermedades Respir. 2010;26:16–25. Available from: https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-73482010000100004

19. Holland N, Kirsch-volders M, Bonassi S, Zeiger E, Knasmueller S, Fenech M. The micronucleus assay in human buccal cells as a tool for biomonitoring DNA damage: the HUMN project perspective on current status and knowledge gaps. Mutant Res. 2008;659(1–2):93–108. Available from: https://doi.org/10.1016/j.mrrev.2008.03.007

20. Fenech M, Chang W, Kirsch-Volders M, Holland N, Bonassi S, Zeiger E. HUMN project: detailed description of the scoring criteria for the cytokinesis-block micronucleus assay using isolated human lymphocyte cultures. Mutat Res. 2003;534(1–2):65–75. Available from: https://doi.org/10.1016/s1383-5718(02)00249-8

21. Shahsavari F, Mikaeli S, Ghorbanpour M. Micronucleus assay in the exfoliated cells of buccal mucosa of gasoline station workers in Tehran. J Cancer Res Ther. 2022;18(4):1030–5. Available from: https://doi.org/10.4103/jcrt.JCRT_875_20

22. Gupta N, Rakshit A, Srivastava S, Suryawanshi H, Kumar P, Naik R. Comparative evaluation of micronuclei in exfoliated oral epithelial cells in potentially malignant disorders and malignant lesions using special stains. Oral Maxillofac Pathol. 2019;23(1):157. Available from: https://doi.org/10.4103/jomfp.JOMFP_164_17

23. Diaz-Caballero A, Mora-Solano E, Herrera-Herrera A. Presencia de micronúcleos en células epiteliales de encías, como marcador de inestabilidad cromosomal [Presence of micronuclei in gum epithelial cells, as a marker of chromosomal instability]. Revisión sistemática. Av Odontoestomatol. 2013;29(2):95–102. Available from: https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0213-12852013000200005

24. Weinhouse C, Gallis J, Ortiz E, Berky A, Morales A, Diringer S, et al. A population-based mercury exposure assessment near an artisanal and small-scale gold mining site in the Peruvian Amazon. J Expo Sci Env Epidemiol. 2021;31(1):126–36. Available from: https://doi.org/10.1038/s41370-020-0234-2

25. Wultsch G, Nersesyan A, Kundi M, Al-Serori H, Knasmüller S. Induction of chromosomal damage in exfoliated buccal and nasal cells of road markers. J Toxicol Env Heal A. 2019;82(17):969–76. Available from: https://doi.org/10.1080/15287394.2019.1673578

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Multicenter investigation of moral distress among physicians and its impact on the intention to leave working position

Schizas N[1,2,6], Nazos A[3], Schiza I[1], Nazou G[4], Apostolopoulos A[1], Anagnostopoulos I[5], Angouras DC[1], Paliouras D[6]

[1]National and Kapodistrian University of Athens, Athens, Greece
[2]Department of Thoracic and Cardiovascular Surgery, Evangelismos General Hospital, Athens, Greece
[3]Department of Economics, School of Social, Political and Economic Sciences, Democritus University of Thrace, Komotini, Greece
[4]Anesthesiology Department, Evangelismos General Hospital, Athens, Greece
[5]Department of Cardiology, "G. Gennimatas" General Hospital, Athens, Greece
[6]Hellenic Open University, Patra, Greece

Corresponding author:
Nikolaos Schizas, MD, MSc, National and Kapodistrian University of Athens,
Pindou 27, Vrilissia, Greece Zipcode:15235
Tel. : +306936820715
E-mail: nikschizas@gmail.com
ORCID ID:https://orcid.org/0000-0002-3523-4881

Date of submission: 20.12.2022
Date of acceptance: 18.12.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.47182

ABSTRACT

Introduction: Moral Distress (MD) is relatively poorly studied for physicians. The purpose of this study is the investigation of Moral Distress among physicians in Greece and the validation Moral Distress Scale-Revised (MDS-R) as a reliable method for the measurement of MD in the Greek language.

Methods: This is a multicenter study in which 200 physicians of all specialties and degrees participated. A self-reporting questionnaire was used. The MDS-R questionnaire is constituted of 21 items that describe conditions met in clinical practice, aiming to investigate the frequency and intensity of such cases. This study was conducted from March 2020 to May 2020 in seven hospitals in Athens and Thessaloniki. The questionnaire was translated and validated in the Greek language.

Results: All 21 items of the MDS-R questionnaire were found suitable for inclusion in the Greek version of MDS-R, as the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.85, above the commonly recommended value of 0.60. A model of four main factors emerged after the analysis of the results with a total variance of 46.8% and all these factors were correlated with each other. MD was detected to a significant degree in more than half participants. The incidence and intensity of MD were higher in physicians who worked in general hospitals compared to those working in cancer hospitals.

Conclusions: The Greek version of MDS-R is a valid and reliable instrument for the investigation of MD among Greek physicians. MD is also associated with the intention to leave a working position among Greek physicians.

Keywords: burnout, Greek version MDS-R Moral Distress, Moral Distress Scale-Revised (MDS-R), syndrome, validation

Introduction

In 1984, Jameton was the first author to describe the term Moral Distress (MD) in nurses by the following definition: "Moral distress is the feeling nurses experience when institutional constraints prevent the ethically appropriate course of action from being carried out".[1] It should be mentioned that such thoughts and feelings can be triggered by simple matters, such as pointless laboratory tests, to very serious conditions, such as life and death decisions. According to Corley et al., moral distress is the consequence of the individual's effort to maintain his personal integrity and dignity during actions that are opposite to his ethical beliefs.[2]

MD is quite often among all health care professionals and subsequently physicians are also experiencing such feelings. However, the role of the physician differs substantially from the other health workers, as the central responsibility for the clinical outcome is in his hands. More specifically, the physician's responsibility is multilevel, as it constitutes the responsibility for the individual (coverage of the patient's needs in health), social responsibility (promotion of public health), legislative responsibility and personal responsibility (need to be accepted as a good doctor by his colleagues and patients).[3] All these factors can contribute to the development of non-controlled MD with presentations such as outbursts of rage, burnout syndrome and secondary acute anxiety disorders.[4] Moreover, MD is associated with inadequate medical judgment which can lead to serious medical errors.[5]

A lot of studies have been performed worldwide regarding MD in nursing staff, but the evidence for the physicians is limited.[6] However, the incidence of MD is high among physicians. Houston et al. found that the incidence and severity of MD were higher for nurses, but physicians followed in proximity, especially the residents.[7] The investigation of MD among physicians is limited worldwide and in Greece, there is no evidence reported in this field.

Methods

The purpose of this research was the investigation of MD among Greek physicians of all specialties who are working in the Greek National Health System GNHS. This study was conducted from March 2020 to May 2020 in seven hospitals (6 general hospitals and 1 cancer hospital) in Athens and Thessaloniki. Through the personal interview, the participants fulfilled the Moral Distress Scale-Revised (MDS-R) questionnaire which was translated by two independent bilingual speakers from English to the Greek language. A total number of randomly chosen 200 physicians, of all specialties and degrees, participated in the survey through direct interview.

The MDS-R questionnaire, as revised by Hamric et al. in 2012, was used for the purposes of this study.[7] This questionnaire constituted 21 items that describe situations commonly met in clinical practice that are associated with MD. The score for each item ranges from 0 (never) to 4 (very frequently) for the frequency and from 0 (none at all) to 4(very extended) for the intensity respectively. The aggregate of all the items, which is a composite score ranging from 0 to 336, reveals the degree of MD. More specifically, the greater score of the MDS-R corresponds to a higher degree of MD, with a cutoff value for its presence at 100 units.[7]

The study was conducted after written approval of the ethics committee of Evangelismos General Hospital (141-23/04/2020). All participants were informed about the purpose of the study. The whole investigating and experimenting process is in accordance with the Declaration of Helsinki and the Greek legislation in Bioethics. The personal data and rights were protected according to the law.

Quantitative variables were expressed as mean values (Standard Deviation) or as median (Interquartile Range), while qualitative variables were expressed as absolute and relative frequencies. Exploratory factor analysis was carried out to evaluate construct validity, disclose underlying structures and reduce the number of variables of MD scale. Principal component

analysis (PCA) was chosen as the extraction method using Varimax rotation. Kaiser-Meyer-Olkin procedure for measuring sample adequacy was applied. The cut-off point for factor loadings was 0.40 and for Eigenvalues it was 1.00. Intraclass correlation coefficients (ICCs) were used in the test-retest procedure. Internal consistency reliability was determined by the calculation of Cronbach's α coefficient. Scales with reliabilities equal to or greater than 0.70 were considered acceptable. Convergent validity was tested through intercorrelations (Spearman's rho) among the factors that emerged from the factor analysis. All reported p values are two-tailed. Statistical significance was set at $p<0.05$ and analyses were conducted using Statistical Package for Social Sciences (SPSS) statistical software (version 22.0).

Results

The sample consisted of 200 physicians with a mean age of 36.8 years (SD=11.5 years). Participants' sociodemographic characteristics are reported in Table 1. Six out of ten were males, 63% were unmarried and 35% had children. The majority of the participants had a bachelor's degree and were working in a general hospital, with the percentages being 61% and 62.5% respectively. Mean working experience was 10 years (SD=9.6 years) and 28% of the sample had worked abroad as a physician.

Table 1. Demographic characteristics

Characteristics	N (Total number 200) (%)
Sex	
Males	120 (60.0)
Females	80 (40.0)
Family status	
Unmarried	126 (63)
Married	72 (35)
Divorced-Widowed	2 (1)
Children	70 (35)
Educational status	
Bachelor degree	122 (61.0)
MSc	36 (18.0)
PhD	34 (17.0)
University title holder	8 (4.0)
Hospital	
General	124 (62)
Oncological	76 (38)
Working experience (years), mean (SD)	10.0 ± 9.6
Ever worked abroad as a physician	56 (28)

Table 2. Descriptive measures for items of the Moral Distress scale

	Frequency		Level of disturbance		Frequency x Level of disturbance	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
1. Provide less than optimal care due to pressures from administrators or insurers to reduce costs.	2.27 (1.28)	2 (1 – 3)	2.37 (1.37)	3 (1 – 4)	6.19 (5.21)	6 (2 – 12)
2. Witness healthcare providers giving "false hope" to the patient or family.	1.98 (1.33)	2 (1 – 3)	2.41 (1.4)	3 (1 – 4)	5.48 (5.27)	5 (1 – 9)
3. Follow the family's wishes to continue life support even though I believe it is not in the best interest of the patient.	2.6 (1.21)	3 (2 – 4)	2.13 (1.32)	2 (1 – 3)	6.18 (5.29)	6 (2 – 9)

	Frequency		Level of disturbance		Frequency x Level of disturbance	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
4. Initiate extensive life-saving actions when I think they only prolong death.	2.53 (1.32)	3 (1.5 — 4)	2.22 (1.35)	2 (1 — 3)	6.20 (5.20)	6 (2 — 9)
5. Follow the family's request not to discuss death with a dying patient who asks about dying.	2.25 (1.37)	2 (1 — 3)	2.31 (1.39)	2 (1 — 4)	5.94 (5.32)	4 (2 — 9)
6. Feel pressure from others to order what I consider to be unnecessary tests and treatments.	2.28 (1.37)	2 (1 — 3)	2.27 (1.33)	2 (1 — 3)	6.17 (5.36)	6 (1 — 12)
7. Continue to participate in care for a hopelessly ill person who is being sustained on a ventilator, when no one will make a decision to withdraw support.	1.98 (1.46)	2 (1 — 3)	1.96 (1.40)	2 (1 — 3)	4.83 (5.14)	3 (0 — 9)
8. Avoid taking action when I learn that a physician or nurse colleague has made a medical error and does not report it.	1.61 (1.34)	1 (1 — 3)	1.95 (1.42)	2 (1 — 3)	3.74 (4.46)	2 (0 — 6)
9. Assist another physician who in my opinion is providing incompetent care.	2.24 (1.30)	2 (1 — 3)	1.92 (1.46)	2 (0 — 3)	4.95 (5.09)	4 (0 — 8)
10. Be required to care for patients I don't feel qualified to care for.	1.80 (1.29)	2 (1 — 3)	1.98 (1.51)	2 (0 — 3)	4.38 (4.82)	3 (0 — 6)
11. Let medical students perform painful procedures on patients solely to increase their skills.	1.43 (1.38)	1 (0 — 3)	1.20 (1.38)	1 (0 — 2)	1.91 (3.45)	0 (0 — 3)
12. Provide care that does not relieve the patient's suffering because I fear that increasing the dose of pain medication will cause death.	1.54 (1.28)	1 (1 — 3)	1.56 (1.36)	1 (0 — 3)	2.73 (3.73)	1 (0 — 4)
13. Request nurses or others not to discuss the patient's prognosis with the patient or family.	1.58 (1.36)	1 (0 — 3)	1.73 (1.40)	2 (0 — 3)	3.25 (4.27)	2 (0 — 4)
14. Increase the dose of sedatives/opiates for an unconscious patient that I believe could hasten the patient's death.	0.95 (1.26)	0 (0 — 2)	1.77 (1.64)	1.5 (0 — 3)	1.94 (3.79)	0 (0 — 2)
15. Take no action about an observed ethical issue because the involved staff member or someone in a position of authority requested that I do nothing.	1.57 (1.3)	1 (1 — 2)	2.28 (1.52)	3 (1 — 4)	4.28 (4.88)	3 (0 — 7)
16. Follow the family's wishes for the patient's care when I do not agree with them, but do so because of fears of a lawsuit.	1.61 (1.33)	1 (0 — 3)	2.59 (1.54)	3 (1 — 4)	4.67 (5.09)	3 (0 — 8)
17. Work with nurses or other healthcare providers who are not as competent as the patient care requires.	2.12 (1.31)	2 (1 — 3)	2.47 (1.37)	3 (1 — 4)	6.12 (5.23)	4 (1 — 12)
18. Witness diminished patient care quality due to poor team communication.	2.01 (1.27)	2 (1 — 3)	2.55 (1.37)	3 (2 — 4)	5.91 (5.04)	4 (2 — 9)
19. Ignore situations in which patients have not been given adequate information to ensure informed consent.	1.46 (1.25)	1 (0 — 2)	2.18 (1.44)	2 (1 — 3)	3.37 (4.06)	2 (0 — 6)
20. Watch patient care suffer because of a lack of provider continuity.	1.96 (1.37)	2 (1 — 3)	2.46 (1.48)	3 (1 — 4)	5.46 (5.25)	4 (0 — 9)

	Frequency		Level of disturbance		Frequency x Level of disturbance	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
21. Work with levels of nurse or other care provider staffing that I consider unsafe.	2.08 (1.32)	2 (1 – 3)	2.64 (1.46)	3 (1 – 4)	6.17 (5.5)	4 (1 – 12)

*Standard Deviation (SD), Interquartile Range (IQR)

Moral distress items are presented in Table 2.

The test-retest procedure was undergone in a sample of 18 physicians and it was found significant and high agreement in all of the MD scale items, as shown in Table 3.

Initially, the factorability of the 21 items was examined. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.85, above the commonly recommended value of 0.60. Bartlett's test of sphericity (test of at least one significant correlation between 2 of the items studied) was also significant at $p<0.001$. The loadings for all items were above 0.40, further confirming that each item shared some common variance with other items. Given these overall indicators, factor analysis was regarded to be suitable for all the 21 items.

Table 3. Test-retest results (N=18)

Item	ICC	95% CI	P
1	1.00	.98 - 1.00	<.001
2	.99	.97 - 1.00	<.001
3	.99	.98 - 1.00	<.001
4	.99	.96 - .99	<.001
5	1.00	1.00 - 1.00	<.001
6	.97	.92 - .99	<.001
7	.98	.95 - .99	<.001
8	.98	.95 - .99	<.001
9	.98	.94 - .99	<.001
10	.98	.95 - .99	<.001
11	.97	.91 - .99	<.001
12	1.00	.99 - 1.00	<.001
13	1.00	.99 - 1.00	<.001
14	1.00	.98 - 1.00	<.001
15	.99	.97 - 1.00	<.001
16	1.00	1.00 - 1.00	<.001
17	.98	.93 - .99	<.001
18	1.00	1.00 - 1.00	<.001
19	1.00	.99 - 1.00	<.001
20	1.00	1.00 - 1.00	<.001
21	1.00	1.00 - 1.00	<.001

Four factors emerged from exploratory factor analysis, whose results are presented in Table 4. The first factor "Ability/ Adequacy" consisted of 8 items and explained 17.7% of the variance.

The second factor "Utility" consisted of 4 items and explained 14.3% of the variance. The third factor "Bioethics" consisted of 5 items and explained 13.4% of the variance. Finally, the fourth factor "Fear of sanctions" consisted of 4 items and explained 1.4% of the variance. All factors combined explained 46.8% of the variance.

Table 4. Exploratory factor analysis results with PCA method and Varimax rotation

	Factor loadings			
	Ability/ Adequacy	**Utility**	**Bioethics**	**Fear of sanctions**
1. Provide less than optimal care due to pressures from administrators or insurers to reduce costs.	.46			
2. Witness healthcare providers giving "false hope" to the patient or family.		.53		
3. Follow the family's wishes to continue life support even though I believe it is not in the best interest of the patient.		.78		
4. Initiate extensive life-saving actions when I think they only prolong death.		.72		
5. Follow the family's request not to discuss death with a dying patient who asks about dying.		.69		
6. Feel pressure from others to order what I consider to be unnecessary tests and treatments.				.44
7. Continue to participate in care for a hopelessly ill person who is being sustained on a ventilator, when no one will make a decision to withdraw support.				.60
8. Avoid taking action when I learn that a physician or nurse colleague has made a medical error and does not report it.			.45	
9. Assist another physician who in my opinion is providing incompetent care.	.50			
10. Be required to care for patients I don't feel qualified to care for.	.60			
11. Let medical students perform painful procedures on patients solely to increase their skills.			.83	
12. Provide care that does not relieve the patient's suffering because I fear that increasing the dose of pain medication will cause death.			.71	
13. Request nurses or others not to discuss the patient's prognosis with the patient or family.			.66	
14. Increase the dose of sedatives/opiates for an unconscious patient that I believe could hasten the patient's death.			.73	
15. Take no action about an observed ethical issue because the involved staff member or someone in a position of authority requested that I do nothing.				.71
16. Follow the family's wishes for the patient's care when I do not agree with them, but do so because of fears of a lawsuit.				.48
17. Work with nurses or other healthcare providers who are not as competent as the patient care requires.	.70			
18. Witness diminished patient care quality due to poor team communication.	.71			
19. Ignore situations in which patients have not been given adequate information to ensure informed consent.	.48			
2. Watch patient care suffer because of a lack of provider continuity.	.70			

21. Work with levels of nurse or other care provider staffing that I consider unsafe.	.81			
% Variance explained	**17.7**	**14.3**	**13.4**	**10.4**

Table 5. Cronbach's α coefficient for each factor

Factor	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Ability/ Adequacy	1	.52	.84	.85
	9	.45	.85	
	10	.47	.84	
	17	.68	.82	
	18	.68	.82	
	19	.51	.84	
	20	.64	.82	
	21	.72	.81	
Utility	2	.45	.79	.78
	3	.69	.67	
	4	.65	.70	
	5	.57	.74	
Bioethics	8	.37	.78	.76
	11	.64	.68	
	12	.54	.71	
	13	.53	.71	
	14	.59	.69	
Fear of sanctions	6	.47	.65	.70
	7	.44	.66	
	15	.50	.63	
	16	.54	.60	

Cronbach's α coefficients were all above 0.7, indicating acceptable reliability in all factors, as shown in Table 5.

All four factors were positively correlated with each other, as presented in Table 6. Thus, higher ability/adequacy is correlated significantly with greater utility and bioethics concerns. Also, greater utility is correlated significantly with greater bioethics concerns. Furthermore, greater fear of sanctions is positively correlated with greater ability/adequacy, utility and bioethics concerns.

Table 6. Descriptive measures and correlation coefficients among factors

Factor		Number of items	Mean (SD)	Median (IQR)	Correlation coefficients			
					1	2	3	4
1	Ability/ Adequacy	8	5.18 (3.48)	4.84 (2.25 — 7.50)	1.00	.52	.58	.62
2	Utility	4	5.93 (4.12)	4.88 (2.75 — 9.00)		1.00	.35	.63
3	Bioethics	5	2.66 (2.83)	1.80 (0.60 — 3.60)			1.00	.49

4	Fear of sanctions	4	4.97 (3.73)	4.50 (2.00 — 7.50)	1.00

Note. All correlation coefficients were significant at p<.0.001

The score for MD ranged from 0 to 266 units with a mean value of 101, 4 units (SD=57, 0 units). There was no correlation detected between MD and demographic characteristics and educational level. On the contrary, MD was found higher for consultants in comparison to the other hierarchical levels (p=0.031) (values according to hierarchical level: residents 102, fellow 74, resident 121, head of department 104). The study also revealed a significant difference in the MDS-R score between general and cancer hospitals. More specifically, the mean score for workers in general hospitals was 109 (36) compared to 87 (9) for workers in cancer hospitals (p=0.021). In addition, in the physicians who declared intention to leave their current clinical position, the score of MD was significantly higher (p=0.001).

Discussion

The impact of MD is a field that concerns the scientific society more and more due to the consequences of this phenomenon for both the health workers and the quality of the medical care provided. According to Fumis et al., the incidence of burnout syndrome was elevated for the individuals who recorded scores of the MDS-R greater than 100 units.[9] In this study, most of the scores of most participants surpassed the limit of 100 units and this is indicative of increased incidence of MD among Greek physicians.

Although other studies in the field of disorders related to work showed that these entities are correlated with demographic characteristics, in this research there wasn't any such correlation detected.[10] However, the degree of the consultant and working in a general hospital were independent factors contributing to higher MDS-R scores. Austin et al. showed that MD was higher for physicians with 6-10 years of working experience which is compatible with the findings of this research.[11] One useful finding of this survey is that physicians who worked in general hospitals presented higher scores of MD compared to those working in cancer hospitals. This result is reported for the first time in the literature, as far as we know from our research. Additionally, MD was associated with the intention to leave the current job, a finding that was also reported from other studies.[12,13]

The results of this study showed that MDS-R, in its Greek version, is a reliable and valid instrument for the investigation of MD among physicians working on GNHS. Moreover, the factor analysis confirmed that all the items of MDS-R are suitable for inclusion in the Greek version of the questionnaire.

The examination of factorability revealed four factors that implicate MD, which are the following: Ability/ Adequacy, Utility, Bioethics, and Fear of sanctions. In previous studies on this domain, the emerging factors were either 3 to 6. More specifically, three factors were used by Corley et al., by whom the MDS was introduced for MD measurement in nurses, and by Hamric et al., who made a revision of the initial scale (MDS-R) which is suitable for the study of others categories of health workers.[2,8] On the other side, the Italian version of MDS-R used the following four factors: futile care, deceptive communication, ethical misconduct and poor teamwork. Moreover, the total variance was found 59% for the four-factor model, significantly more suitable than the 3-factor model in which the variance was 19%.[14] Other researchers used 5 or 6 factors in the analysis of MD concerning nursing stuff.[15,16] In our research, the total variance was 46,8% which is quite satisfactory. In addition, all the factors were positively correlated with each other, although the degree of correlation varied. (Table 6)

In daily practice, physicians find ways to cope with MD intentionally or unconsciously. The diligence, the autonomy, the compromise and the intuition are some techniques used for this purpose based on the statements of physicians and nurses.[17] However, MD is a condition that affects the organization's function. Morris and

Dracup support that methods and mechanisms for the detection of MD are required and at the same time, the collection of more evidence is essential for the investigation of this multimodal phenomenon.[18] According to Tigard, interventions are needed and the recording of their efficacy will permit the evaluation of these measures. Therefore, the experience will augment this domain during experimenting with more effective choices in the future.[19] In any case, Garros declares that the culture of frank dialogue and good team communication is a beneficial preventative measure for the elimination of MD among physicians.[20]

The sample of the study constituted physicians of all specialties, all degrees, and different hospitals of the two largest cities of Greece. In this thought, the results of the study can be generalized and depict the MD incidence and characteristics among physicians of the GNHS. In regard to the study limitations, it should be mentioned that the research took place during the first wave of the pandemic COVID-19 in Greece (March 2020 – May 2020) under unusual conditions. Despite this fact, the validity and the integrity of MDS-R for the investigation of MD in the Greek language were proven by the results.

Conclusions

In this study, the MDS-R questionnaire was translated and validated in its Greek version. The examination of factorability showed that all 21 items of MDS-R are suitable for inclusion in the Greek version. Four main factors emerged from the exploratory factor analysis and the total variance was 46.8%. MD was detected in a significant degree in more than half participants. The incidence and intensity of MD were higher in physicians who worked in general hospitals compared to those working in cancer hospitals, which is reported for the first time. In addition, MD was higher for the individuals with the intention to leave their current clinical position. To sum up, the Greek version of MDS-R is a valid and reliable instrument for the investigation of MD among physicians working in GNHS.

Acknowledgments

The statistical analysis was performed by CharaTzavara, Biostatistician, MSc, PhD.

References

1. Morley G, Field R, Horsburgh CC, Burchill C. Interventions to mitigate moral distress: A systematic review of the literature. Int J Nurs Stud. 2021 Sep;121:103984. Available from: https://doi.org/10.1016/j.ijnurstu.2021.103984
2. Corley MC, Elswick RK, Gorman M, Clor T. Development and evaluation of a moral distress scale. J Adv Nurs. 2001 Jan;33(2):250-6. Available from: https://pubmed.ncbi.nlm.nih.gov/11168709/
3. Shanafelt TD, Balch CM, Bechamps G, Russell T, Dyrbye L, Satele D, et al. Burnout and medical errors among American surgeons. Ann Surg. 2010 Jun;251(6):995-1000. Available from: https://doi.org/10.1097/SLA.0b013e3181bfdab3
4. Rushton CH, Kaszniak AW, Halifax JS. A framework for understanding moral distress among palliative care clinicians. J Palliat Med. 2013 Sep;16(9):1074-9. Available from: https://doi.org/10.1089/jpm.2012.0490
5. Wurm W, Vogel K, Holl A, Ebner C, Bayer D, Morki S, Szilagyi IS, et al. Depression-Burnout Overlap in Physicians. PLoS One. 2016 Mar 1;11(3):e0149913. Available from: https://doi.org/10.1371/journal.pone.0149913
6. Tessman L. Moral distress in health care: when is it fitting? Med Health Care Philos. 2020 Jun;23(2):165-77. Available from: https://doi.org/10.1007/s11019-020-09942-7
7. Houston S, Casanova MA, Leveille M, Schmidt KL, Barnes SA, Trungale KR, et al. The intensity and frequency of moral distress among different healthcare disciplines. J Clin Ethics. 2013 Summer;24(2):98-112. Available from: https://pubmed.ncbi.nlm.nih.gov/23923809/

8. Hamric AB, Borchers CT, Epstein EG. Development and Testing of an Instrument to Measure Moral Distress in Healthcare Professionals. AJOB Primary Research. 2012 Feb 29;3(2):1-9.Available from: https://doi.org/10.1080/21507716.2011.652337

9. Fumis R., Amarante G., Nascimento A., Vieira Junior J., Moral distress and its contribution to the development of burnout syndrome among critical care providers. Ann. Intensive Care. 2017 June;7:71. Available from: https://doi.org/10.1186/s13613-017-0293-2

10. Salpigktidis II, Paliouras D, Gogakos AS, Rallis T, Schizas NC, Chatzinikolaou F, et al. Burnout syndrome and job satisfaction in Greek residents: exploring differences between trainees inside and outside the country. Ann Transl Med. 2016 Nov;4(22):444. Available from: https://doi.org/10.21037/atm.2016.11.33

11. Austin CL, Saylor R, Finley PJ. Moral distress in physicians and nurses: Impact on professional quality of life and turnover. Psychol Trauma. 2017 Jul;9(4):399-406. Available from: https://doi.org/10.1037/tra0000201

12. Colville GA, Dawson D, Rabinthiran S, Chaudry-Daley Z, Perkins-Porras L. A survey of moral distress in staff working in intensive care in the UK. J Intensive Care Soc. 2019 Aug;20(3):196-203. Available from: https://doi.org/10.1177/1751143718787753

13. Abbasi M, Nejadsarvari N, Kiani M, Borhani F, Bazmi S, Tavaokkoli SN, et al. Moral distress in physicians practicing in hospitals affiliated to medical sciences universities. Iran Red Crescent Med J. 2014 Oct 5;16(10):e18797. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4270679/

14. Lamiani G, Setti I, Barlascini L, Vegni E, Argentero P. Measuring Moral Distress Among Critical Care Clinicians: Validation and Psychometric Properties of the Italian Moral Distress Scale-Revised. Crit Care Med. 2017 Mar;45(3):430-37. Available from: https://doi.org/10.1097/CCM.0000000000002187

15. Barlem ELD, Lunardi VL, Linardi GL, Tomaschewski-Barlem JG, Almeida AS, Hirsch CD. Psycometric characteristics of the Moral Distress Scale in Brazilian nursi ng professionals. Texto and contexto - enferm. 2014 Jul-Sep;23(3):563-72. Available from: https://doi.org/10.1590/0104-07072014000060013

16. Barth PO, Ramos FRS, Barlem ELD, Dalmolin GL, Schneider DG. Validation of a moral distress instrument in nurses of primary health care. Rev Lat Am Enfermagem. 2018;26:e3010. Available from: https://doi.org/10.1590/1518-8345.2227.3010

17. Lievrouw A, Vanheule S, Deveugele M, Vos M, Pattyn P, Belle V, et al. With Moral Distress in Oncology Practice: Nurse and Physician Strategies. Oncol Nurs Forum. 2016 Jul 1;43(4):505-12. Available from: https://doi.org/10.1188/16.ONF.505-512

18. Morris PE, Dracup K. Time for a tool to measure moral distress? Am J Crit Care. 2008 Sep;17(5):398-401. Available from: https://pubmed.ncbi.nlm.nih.gov/18775992/

19. Tigard DW. Rethinking moral distress: conceptual demands for a troubling phenomenon affecting health care professionals. Med Health Care Philos. 2018 Dec;21(4):479-88. Available from: https://doi.org/10.1007/s11019-017-9819-5

20. Garros D. Moral Distress in the Everyday Life of an Intensivist. Front Pediatr. 2016 Aug 29;4:91. Available from: https://doi.org/10.3389/fped.2016.00091

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Practices of personal protective measures against SARS-Cov-2 among undergraduate medical students in South India

Joseph N[1], Sharma E[2]

[1]Department of Community Medicine, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, India.

[2]MBBS Student, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, India.

Corresponding author:

Nitin Joseph,
Associate Professor,
Department of Community Medicine, Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, India
Tel.: +91 9448732896
E-mail: nitin.josep@manipal.edu
ORCID ID:https://orcid.org/0000-0002-3639-510X

Date of submission: 04.06.2023
Date of acceptance: 11.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.55315

ABSTRACT

Introduction: Personal protective measures (PPMs) hold relevance despite mass coverage of COVID-19 vaccination. Medical students can be vital in training people in infection control practices. This study was therefore done to assess the practices of PPMs among undergraduate medical students against COVID-19.

Methods: A cross-sectional study was done in January 2021 among first to final-year students at a private medical college in Mangalore. Data were collected using a Microsoft form. A sample size of 282 was calculated. However, a sample size of 302 was achieved.

Results: The mean age of the 302 participants was 21.2±1.6 years. The majority of them were females 179 (59.3%). Face mask was worn by 295 (97.7%) participants. Non-recommended types of face masks like using cloth masks 108 (36.6%) and handkerchiefs 7 (2.4%) were reported by face mask users. Face mask was worn incorrectly on most occasions by 35 (11.9%) users. Replacement of disposable type of face masks was not done every day by 181 (61.4%) face mask users. Discarding of disposable masks was not done whenever it became moist on every occasion by 142 (48.1%) users. Only 79 (26.8%) users always practiced proper disposal of face masks. Hand sanitizer to disinfect hands was always used by 102 (33.8%) participants. Only 42 (13.9%) participants always practiced the six steps of hygienic hand washing. Only 58 (19.2%) participants had a good level of practice of PPMs against COVID-19. Practice level was significantly poorer among males and first-year students.

Conclusion: Several gaps in PPMs against COVID-19 were identified among participants which need to be addressed during future training programs.

Keywords: COVID-19, Personal protective measures, Practices, Undergraduate medical students

Introduction

Personal protective measures (PPMs) hold relevance despite mass immunization coverage of COVID-19 vaccination in the population. This is because vaccination only gives protection from severe COVID-19 and does not prevent of risk of infection. Moreover, there is always a persistent risk of transmission of new strains of SARS-Cov-2, which are more infectious than previous strains.[1]

Essential components of personal protective equipment (PPE) for preventing SARS-Cov-2 infection comprise wearing facemasks, face shields, and hand gloves, amongst others.[2] The

effectiveness of PPEs further depends upon the method of wearing the facemask, wearing time, and the storage, disposal, and periodicity of decontamination of reusable products. Adherence to these recommendations is a must, as improperly worn facemasks do not offer the desired level of protection. It would rather predispose the user to spread the infection to others. Other preventive measures, such as hygienic hand washing and periodic disinfection of frequently used surfaces, are also beneficial to prevent SARS-Cov-2 transmission.

There is a need to raise the awareness of the general population to continue using PPEs despite being fully vaccinated against SARS-Cov-2. This requires the support of undergraduate medical students who are role models in society. Non-compliance with any of the COVID-19 preventive practices among them gives stakeholders crucial information for planning content to be covered in future training programs. This will enhance the skills of young medical graduates to deal with public health emergencies similar to COVID-19 in the future. Hence there was a need to test the hypothesis of whether the practices of PPMs against COVID-19 were satisfactory or not among medical students in the settings.

Very few studies on this topic have been done in India despite the presence of COVID-19 from the beginning of 2020.[3] Prior studies done elsewhere had limitations. For instance, medical students of only particular semesters were included in a study done in Russia.[4] A study done in Jordan, presented findings combining medical with other health science students.[5] To address these limitations in the review of the literature, and to improve epidemic preparedness among medical students in the setting for dealing with infectious diseases in the future, this study was essential. The objective of the present study was therefore to assess the practices of undergraduate medical students regarding PPMs against COVID-19.

Methods

This cross-sectional study was done in January 2021 among undergraduate medical students of a private institution in Mangalore situated in south India. The ethics committee approval was taken on December 16th, 2020 from the institutional ethics committee. The approval number was IECKMCMLR-12/2020/414. Permission to collect information from students was subsequently taken from the Dean of this institution.

The sample size was calculated using the formula $4pq/d^2$. In a study done in Poland[6], during the first wave of COVID-19, 62.8% of medical students wore face masks. Based on this proportion, at 95% confidence interval and 90% power, the sample size was calculated as 237. Adding 20% as the non-response rate, the final sample size that was targeted in the present study was 285.

A semi-structured questionnaire designed as a Microsoft form was used for data collection. It was prepared with the help of literature available online. The questionnaire was content-validated with the help of faculty members from the Department of Medical Education. It was then pilot-tested among five medical students who were not part of the main study.

The data collection tool was circulated among all medical students of this institution with the help of WhatsApp and email. The first page of the questionnaire contained the information sheet and consent form. Those participants who did not consent to participate and those below 18 years were excluded from participation. Incompletely filled questionnaires were also excluded.

The questionnaire had two sections. The first section enquired about the socio-demographic details of the participants. The second section enquired about their preventive practices since the onset of the COVID-19 pandemic. The frequency of practices was assessed on a five-point Likert scale using responses “always”, “most of the time”, “sometimes”, “rarely”, and “never”.

The level of practice was assessed by assigning scores to each component of PPMs against COVID-19. The practice of wearing any recommended face mask outside the house, if reported “always” by the respondent, was scored 1, the method of wearing a face mask by covering the bridge of the nose to the bottom of the chin if

reported "always" was scored 1, the practice of preserving disposable face mask in a plastic bag for subsequent usage or disposing of it in a covered bin if reported "always" was scored 1, replacement of disposable mask if done every day was scored 1, the practice of discarding disposable masks as and when it becomes moist if reported "always" was scored as 1, the practice of using hand sanitizers to disinfect the hands if reported "always" was scored as 1, the practice of disinfecting the surfaces at the workplace if reported "always" was scored as 1, and method of washing hands by following all six steps of hygienic hand wash if reported "always" was scored as 1. The minimum and maximum possible scores ranged from 0 to 8. The scores assigned to the most essential components of practices, namely, always wearing any recommended facemask, always following the right method of wearing the facemask, always following the right method of preserving or disposing of the face mask, always practicing the right periodicity of replacement of the disposable mask, always discarding disposable masks when it becomes moist, and always using hand sanitizers totaled to 6 points. Hence, non-achievement of 6 points (or 75% of the maximum score) was considered a poor level of practice against the prevention of COVID-19. Achievement of 7 or 8 points was considered a good level of practice among the participants. The data was analyzed using IBM Statistical Package for Social Sciences for Windows version 25.0, Armonk, New York. Descriptive statistics like percentages, mean and standard deviation were calculated. Univariate analysis was done using the Chi-square test. All variables associated with a p-value of 0.20 or less in univariate analysis were introduced into the binary logistic regression model. p value less than 0.05 was taken as the cut-off to assess significance. The reliability of the questionnaire was analyzed. Cronbach's alpha value was 0.903, indicating excellent internal consistency.

Results

A total of 340 participants consented to take part in this study. However, filled questionnaires were submitted by only 302 of them giving a response rate of 88.8%.

The mean age of the participants was 21.2±1.6 years and it ranged from 18 to 25 years. The majority were females 179 (59.3%), and a majority of them were permanent residents of urban areas 249 (82.4%) as shown in Figure 1.

The face mask was worn by 295 (97.7%) participants as shown in Figure 2.

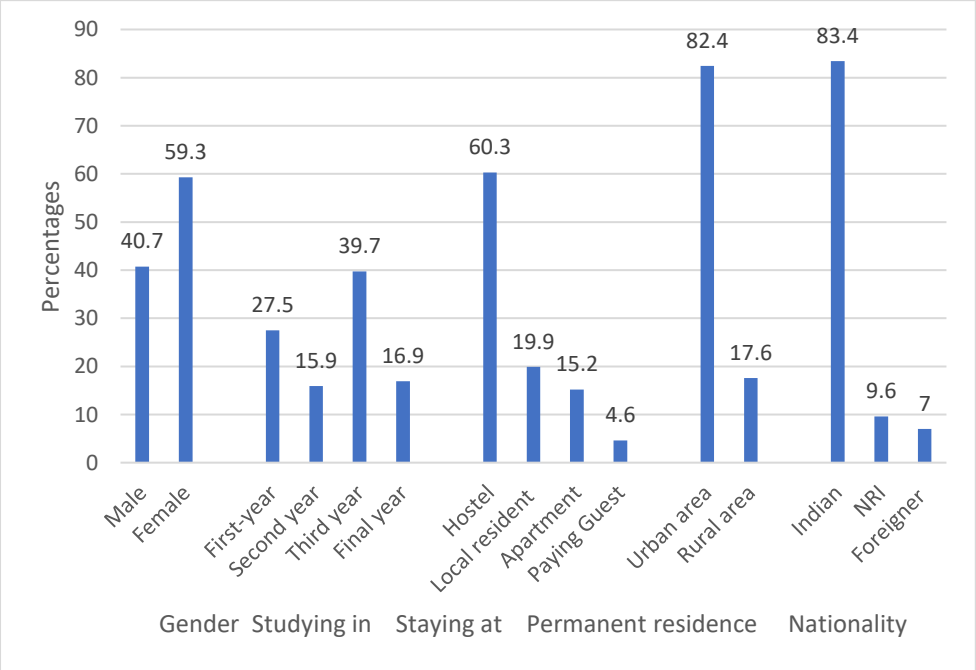


Figure 1: Socio-demographic distribution of the study participants (n=302).

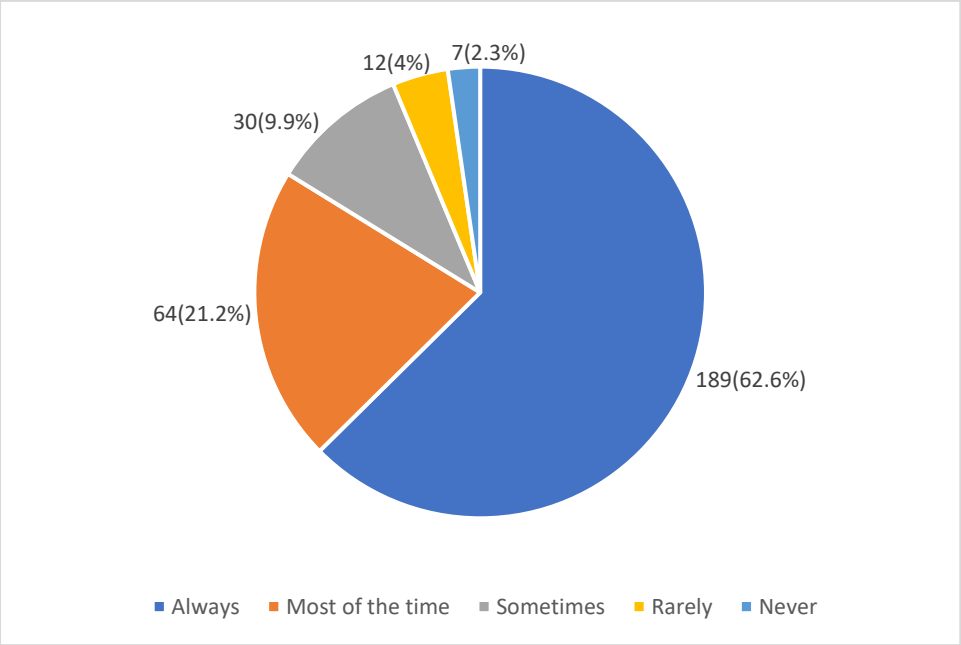


Figure 2: Frequency of wearing face masks outside the house among the participants (n=302)

Table 1: Practices of using face masks against COVID-19 among the participants since the onset of the COVID-19 pandemic (n=302).

Description	N	%
The practice of using a face mask		
Yes	295	97.7
No	7	2.3
Type of face mask used (n=295)*		
Triple-layered surgical masks	164	55.6
N95 masks	155	52.5
Cloth masks	108	36.6
Single-layered surgical masks	83	28.1
FFP2	10	3.4
Handkerchief	7	2.4
Method of wearing a face mask (n=295)		
Covering the bridge of the nose to the bottom of the chin on most occasions	260	88.1
Covering only the mouth on most occasions	18	6.1
By placing it below the chin on most occasions	8	2.7
By strapping it around the neck on most occasions	9	3.1
Number of face masks worn on each occasion (n=295)		
Single	245	83.0
Double	48	16.3
Triple	2	0.7
Frequency of usage of multiple masks (n=50)		
Always	8	16.0
Most of the time	12	24.0
Sometimes	17	34.0
Rarely	13	26.0

*Multiple responses

All of them were using disposable type of face masks. The most common type of face mask used was triple-layered surgical mask 164 (55.6%) among the face mask users as shown in Table 1. Non-recommended types of face masks like using cloth masks were reported by 108 (36.6%) and handkerchiefs to cover their face by seven face mask users.

Out of 295, 260 (88.1%) participants wore the mask in the right way by covering from the bridge of the nose to the bottom of the chin on most occasions. Only 79 (26.8%) face mask users always practiced proper disposal of face masks. Periodicity of replacement of disposable type masks at least once a day was reported by 114 (38.6%) out of the 295 face mask users.

Out of 295 face mask users, 153 (51.9%) always practiced discarding disposable masks whenever they became moist as shown in Table 2.

Table 2: Practices of preserving, replacing, and discarding disposable type of face masks after usage among the participants using face masks since the onset of the COVID-19 pandemic (n=295).

Description	N	%
The practice of preserving disposable face masks in a plastic bag for subsequent usage or disposing of the same day in a covered bin		
Always	79	26.8
Most of the time	98	33.2
Sometimes	91	30.8
Rarely	23	7.8
Never	4	1.4
Periodicity of replacing disposable face mask		
After every use	67	22.7
Once a day	47	15.9
Once in 2 days	50	17.0
Once in 3 days	50	17.0
Once a week	47	15.9
Once in 2 weeks	22	7.4
Once a month	12	4.1
The practice of discarding disposable mask when it becomes moist		
Always	153	51.9
Most of the time	112	38.0
Sometimes	27	9.1
Rarely	3	1.0
Never	0	0

Hand sanitizers were used by 273 (90.4%) participants as shown in Figure 3.

Out of the 273 hand sanitizer users, 218 (79.8%) used alcohol-based sanitizers, 22 (8.1%) used ayurvedic sanitizers (non-alcohol-based sanitizers) and 33 (12.1%) used both types of sanitizers. Among the 251 alcohol-based sanitizer users, the frequency of checking its alcohol content was reported always by 21 (8.4%), most of the time by 23 (9.2%), sometimes by 39 (15.5%), rarely by 57 (22.7%), and never by 111 (44.2%) of them.

The practice of washing hands by following all six steps of hygienic hand washing was always done by 42 (13.9%) participants as shown in Table 3.

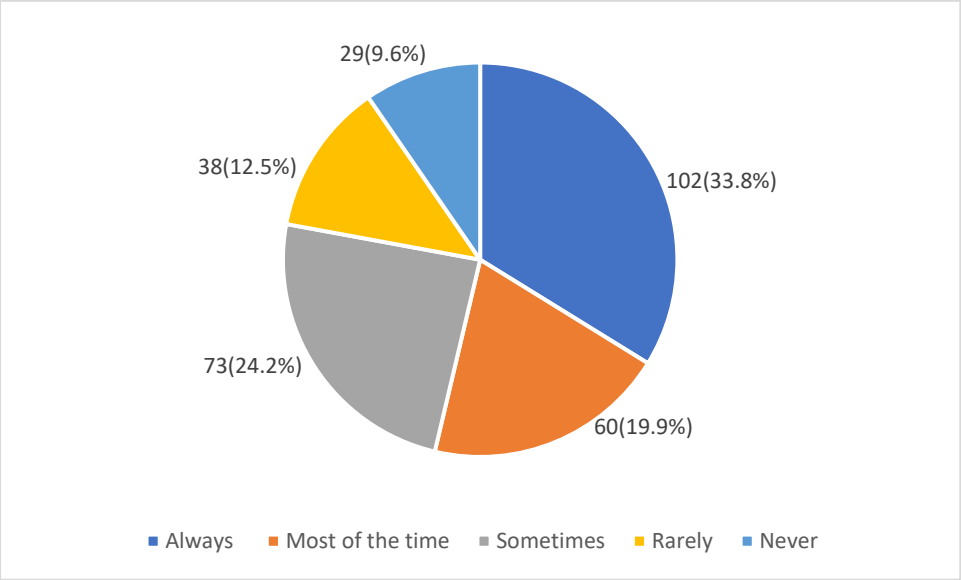


Figure 3: Frequency of usage of hand sanitizers among the participants (n=302).

Table 3: Practices of usage of other personal protective measures against COVID-19 among the participants since the onset of the pandemic (n=302).

Description	Frequency of usage									
	Always		Most of the time		Sometimes		Rarely		Never	
	N	%	N	%	N	%	N	%	N	%
The pattern of usage of face shields outside the house	12	4.0	23	7.6	38	12.6	60	19.8	169	56.0
The practice of wearing hand gloves	12	4.0	23	7.6	36	11.9	70	23.2	161	53.3
Frequency of disinfecting the surfaces at the workplace	76	25.2	65	21.5	108	35.8	31	10.2	22	7.3
The practice of washing hands by following all the six steps of hygienic hand wash	42	13.9	58	19.2	100	33.1	61	20.2	41	13.6

The pattern of handwashing was reported as and only when required by 225(74.5%), prophylactically every 30 minutes by 29(9.6%), and prophylactically every hour by 48(15.9%) participants.

The level of practice of using PPMs during the COVID-19 pandemic was found to be of a good level among 58(19.2%) participants.

In both univariate and multivariable analyses, males and first-year students significantly reported poorer practices concerning the usage of PPMs against COVID-19 infection as shown in Table 4. However, no association of the same was seen with the participant's current place of stay (p=0.424) and permanent place of residence (p=0.222).

Table 4: Association of socio-demographic variables with the level of practices of personal protective measures among the participants during the COVID-19 pandemic (n=302).

Socio-demographic variables	Good level of practice		Poor level of practice		Total	UOR (95% CI)	χ^2 value, p-value	AOR (95% CI)	p-value
	N	%	N	%					
Age (years)									
≥20	51	21.0	192	79.0	243	1.973 (0.846-4.604)	X^2=2.547 p=0.111	1.644 (0.395-6.84)	0.494
≤19	7	11.9	52	88.1	59	1		1	
Gender									
Females	44	24.6	135	75.4	179	2.538 (1.322-4.872)	X^2=8.185 p=0.004	2.764 (1.422-5.373)	0.003
Males	14	11.4	109	88.6	123	1		1	
Year of study									
2nd to final year	50	22.8	169	77.2	219	2.774 (1.253-6.138)	X^2=6.751 p=0.0094	3.331 (1.48-7.498)	0.004
1st year	8	9.6	75	90.4	83	1		1	
Nationality									
Indians	52	20.6	200	79.4	252	1.907 (0.771-4.717)	X^2=2.0 p=0.157	2.234 (0.884-5.648)	0.089
NRIs/ Foreigners	6	12.0	44	88.0	50	1		1	
Total	58		244		302				

χ^2: Chi-square, UOR: Unadjusted Odds Ratio, AOR: Adjusted Odds Ratio, NRIs: Non-Residential Indians

Discussion

In the present study, 97.7% of participants wore face masks in comparison to 62.8% reported in a study done in Poland,[6] 70.3% reported in a study done in Raipur, India,[3] and 94.9%,[7] and 97.5%[4] in studies done in Russia among medical students during the COVID-19 pandemic. Although none of the above-mentioned studies reported 100% usage, it becomes a civic responsibility to wear face masks both for personal protection and for others during the COVID-19 pandemic.[7]

The majority of the participants in this study used the recommended triple-layered surgical mask, which was similar to the findings of the Polish study,[6] where 42.4% and in a study done in Georgia,[8] where 80.8% medical students used the same. In the study done in Raipur, India, N95 was used by 74.5% of medical students.[3] This meant that most students used the correct type of face mask during the COVID-19 pandemic. However non-recommended types of face masks like cloth type of face masks and usage of handkerchiefs as face masks were used by 36.6% and 2.4% of face mask users respectively in the present study. In the Russian study,[4] 27.4% and in the Polish study,[6] 42.9% participants too had used cloth type of face masks.

As much as 17% of the 295 face mask users in this study, reported having used multiple face masks simultaneously, as also practiced by 35.1% of participants in the Polish study.[6] Use of multiple masks, although may feel discomforting, is known to improve the efficacy of face masks.[10]

In this study, 11.9% of the face mask users had worn the face mask incorrectly, which defeats the purpose of wearing it and gives a false assurance

of protection to both users and others. Similarly in the Polish study,[6] 14.3% and in the Russian study,[4] 24.8% respondents did not cover their mouth and nose while using the face masks. The correct method of wearing a face mask is by covering the bridge of the nose to the bottom of the chin.[11] The correct method of wearing face masks needs to be emphasized in future training programs among medical students by demonstration and back demonstration methods.

As many as 61.4% of face mask users in this study did not replace the disposable type of face mask every day, as also reported by 58.9% of participants in a study done in Georgia.[8] As per the recommendations, disposable face masks need to be replaced every day.[12]

In the present study, disposable face masks, when moist, were not discarded on every occasion by 48.1% of the 295 face mask users. Other studies also reported that 13.6%[3] and 69.5%[13] participants continued wearing masks despite being moist. Moist face masks do not offer any protection and hence need to be discarded immediately.[14]

73.2% of the 295 face mask users in this study did not practice appropriate disposal of face masks on every occasion. In prior studies too, 22.9%,[3] 39.2%,[6] and 44.3%[4] did not practice the same. As per recommendations, disposable face masks need to be kept in a closed plastic bag after usage or, if intended to be discarded, to be done in a covered bin.[12,14]

Appropriate usage and disposal of face masks are crucial in avoiding the contamination of the mouth and nose by infective droplets during the pandemic.[2] Faulty practices will reduce the efficacy of infection control practices. These issues should therefore be addressed in future training programs for medical undergraduates.

Other gaps in practices identified among participants in this study, such as non-compliance with the six steps of hygienic hand washing recommended by the World Health Organization,[15] and not disinfecting the hands and other frequently touched surfaces also need to be covered in future training programs. Although these are not known to be the predominant modes of transmission of COVID-19, these practices are however essential among medical students for preventing infections during their clinical postings.[2]

In the present study, females and second to final-year students had a better practice level of PPMs compared to males and first-year students. In other studies, practice scores were significantly higher among medical students with prior volunteering experiences, among females, students from private universities, and among third-year students.[3,16]

Through their clinical exposure during hospital postings, second to final-year students are expected to have better information and experience in using PPE and practicing other preventive measures for infection control. This may be the reason behind their practice level being significantly better than the pre-clinical students in the first year. Male students need to be motivated to exhibit greater seriousness in following preventive practices for infection control. Methods of proper usage and handling of PPEs need to be covered in the medical curriculum. Such skill training in pandemic response will enable them to be competent volunteers in assisting healthcare professionals in the fight against COVID-19 and other similar medical emergencies in the future.

Conclusions

Several gaps in the practices of PPMs against COVID-19 were identified in this study. Face mask was incorrectly worn, recommended wearing time was exceeded, repeated use of moist disposable masks was practiced, masks were not properly disposed of, and hand sanitation practices were not followed by several participants. Dangerous practices like not wearing face masks or using handkerchiefs as face masks were reported by a few participants. Hardly one in five participants had a good level of practice of following PPMs against COVID-19. Practice level was significantly poorer among males and first-year students. These issues need to be addressed in future training programs particularly among

males and first-year students to make them better prepared to deal with medical emergencies like COVID-19 in the future. The findings of this study might help relevant stakeholders and policymakers design an appropriate medical curriculum to update and train medical students to enhance their skills in infection control.

Limitations

This was a unicentric study, and hence its findings may not be generalizable to all medical students.

Acknowledgments

The authors would like to thank all the medical students who enthusiastically took part in this research study.

References

1. Otto SP, Day T, Arino J, Colijn C, Dushoff J, Li M, et al. The origins and potential future of SARS-CoV-2 variants of concern in the evolving COVID-19 pandemic. Curr Biol . 2021 Jul 26 ;31(14): R918-29. Available from: https://doi.org/10.1016/j.cub.2021.06.049
2. Directorate General of Health Services. Novel Coronavirus Disease 2019 (COVID-19): Guidelines on rational use of Personal Protective Equipment. [Internet]. Ministry of Health and Family Welfare; 2021. Available from: https://www.mohfw.gov.in/pdf/GuidelinesonrationaluseofPersonalProtectiveEquipment.pdf
3. Verma S, Verma N, Chandrakar T, Kothari P, Sahu N. A Cross-Sectional Study on Knowledge Attitude and Practice of Wearing Mask During COVID -19 Pandemic Among Students of Pt. J.N.M. Medical College, Raipur(C.G.). IJHCR . 2022 Jan 18 ;5(3):687-92. Available from: https://ijhcr.com/index.php/ijhcr/article/view/4763/3242
4. Shashina EA, Makarova VV, Shcherbakov DV, Isiutina-Fedotkova TS, Zabroda, NN, Ermakova NA, et al. Use of Respiratory Protection Devices by Medical Students during the COVID-19 Pandemic. Int J Environ Res Public Health. 2021 May 28;18(11):5834. Available from: https://doi.org/10.3390/ijerph18115834
5. Alzoubi H, Alnawaiseh N, Al-Mnayyis A, Abu-Lubada M, Aqel A, Al-Shagahin H. COVID-19 - Knowledge, Attitude and Practice among Medical and Non-Medical University Students in Jordan. J Pure Appl Microbiol [Internet]. 2020 Apr 2 ;14(1):17-24. Available from: https://doi.org/10.22207/JPAM.14.1.04
6. Matusiak L, Szepietowska M, Krajewski P, Białynicki-Birula R, Szepietowski J. Face masks use during the COVID-19 pandemic: Differences in attitudes and practices between medical and non-medical students. A survey of 2256 students in Poland. Adv Clin Exp Med . 2020 Oct 30;29(10):1201-3. Available from: https://doi.org/10.17219/acem/126295
7. Mitrokhin OV, Shashina EA, Makarova VV. The Use of Masks by Medical University Students during A Pandemic as a Means of Non-Specific Coronavirus Infection Prevention. The 3rd International Electronic Conference on Environmental Research and Public Health. 2021. Available from: https://sciforum.net/manuscripts/8988/manuscript.pdf
8. Perera MH, Joshi M, Govindan AK, Edpuganti S, Korrapati NH, Kiladze N. Impact of mask wear on the skin of clinical year medical students during the COVID-19 pandemic: A cross-sectional study. CosmoDerma. 2022 Oct 18 ;2:96. Available from: https://doi.org/10.25259/CSDM_100_2022
9. Chughtai AA, Seale H, Macintyre CR. Effectiveness of Cloth Masks for Protection Against Severe Acute Respiratory Syndrome Coronavirus 2. Emerg Infect Dis . 2020 Oct 1;26(10). Available from: https://doi.org/10.3201/eid2610.200948
10. Sickbert-Bennett EE, Samet JM, Prince SE, Chen H, Zeman KL, Tong H, et al. Fitted Filtration Efficiency of Double Masking During the COVID-19 Pandemic. JAMA Intern Med . 2021 Aug 1;181(8):1126-8. Available from: https://doi.org/10.1001/jamainternmed.2021.2033
11. Krstic Z. Here's How to Wear a Face Mask Properly,

According to Medical Experts. [Internet] 2020 Oct 6 Available from: https://www.goodhousekeeping.com/health/a32193198/how-to-wear-a-face-mask-properly/

12. Narayana Health. Know about proper usage, disposal and reuse of mask. [Internet]. Gurugram. 2020 Apr 6 [cited 2021 Sep 10]. Available from: https://www.andamanchronicle.net/index.php/features/19195-know-about-proper-usage-disposal-and-reuse-of-mask

13. Szepietowska M, Krajewski PK, Matusiak Ł, Białynicki-Birula R, Szepietowski JC. Do University Students Adhere to WHO Guidelines on Proper Use of Face Masks during the COVID-19 Pandemic?—Analysis and Comparison of Medical and Non-Medical Students. Appl. Sci . 2021 May 16;11(10):4536. Available from: https://doi.org/10.3390/app11104536

14. World Health Organization. Coronavirus disease (COVID 19): Masks. [Internet]. Geneva; 2022 May 20. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19-masks

15. World Health Organization How to handwash? [Internet]. Geneva. 2009 May 1 [cited 2021 Sep 10]. Available from: https://www.who.int/docs/default-source/patient-safety/how-to-handwash-poster.pdf?sfvrsn=7004a09d_2#:~:text=Rotational%20rubbing%20of%20left%20thumb,Your%20hands%20are%20now%20safe

16. Adli I, Widyahening IS, Lazarus G, Phowira J, Baihaqi LA, Ariffandi B, et al. Knowledge, attitude, and practice related to the COVID-19 pandemic among undergraduate medical students in Indonesia: A nationwide cross-sectional study. PLoS ONE. 2022 Jan 21;17(1). Available from: https://doi.org/10.137/journal.pone.0262827

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Prevalence of accidents and injuries and related factors of fishermen fishing offshore in the North of Vietnam

Nguyen VT[1], Nguyen BN[2], Nguyen TS[1], Tran TQC[2], Ho VH[3], Nguyen THH[4]

[1]Hai Phong University of Medicine and Pharmacy, 72A Nguyen Binh Khiem, Dang Giang, Ngo Quyen, Hai Phong, Vietnam
[2]Vietnam National Institute of Maritime, 21 Vo Nguyen Giap, Kenh Duong, Le Chan, Hai Phong, Vietnam
[3]Laval University, 2325, rue de l'Université, Québec, Canada, G1V 0A6
[4]Ministry of Health, 138A, Giang Vo, Ba Đinh, Ha Noi, Vietnam

Corresponding author:
Van Hoa Ho, PhD Candidate, Department of Social and Preventive Medicine, Laval University, 2325, rue de l'Université, Québec, Canada, G1V 0A6
Tel.: +1 367 380 1492,
E-mail: mickyhohoa@gmail.com
ORCID ID: https://orcid.org/0000-0002-1540-6885

Date of submission: 07.08.2023
Date of acceptance: 12.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.56367

ABSTRACT

Introduction: Seafaring, particularly offshore fishing, exposes fishermen to various occupational risks leading to diseases and injuries. This study aimed to determine the prevalence of occupational risks, injury accidents, and contributing factors among offshore fishers in North Vietnam, to develop evidence-based recommendations to enhance their safety and well-being.

Methods: A cross-sectional study was conducted involving 420 fishermen with a minimum of two years of experience. Interviews were conducted between 2018 and 2020.

Results: The findings indicated that there is a 41.7% prevalence of accidents and an average injury rate of 280.2 per person per year. Most incidents occurred at night with 104 cases (59.4%), slips and falls 48 cases (27.4%), broken winch lines 40 cases (22.9%), and ship collisions 14 cases (8.0%) being the primary causes. The most common injuries included soft wounds in 92 cases (52.5%) and sprains/dislocations in 14 cases (8.0%). Fishermen with fewer than 10 years of experience exhibited a higher accident risk (odds ratio = 1.54; 95% confidence interval: 1.05-2.72), as did those in the role of a fisherman (odds ratio: 1.68; CI: 0.97-2.94) and those working without labor protection (odds ratio: 3.68; CI: 1.05-12.93).

Conclusion: Lack of labor protection equipment increased the risk by 3.68 times, and fishermen had a 2.02 times higher risk of injury. Addressing these risks requires adherence to labor protection regulations and safe working procedures.

Keywords: Accidents and Injuries, Fishing Vessels, Fishermen, Occupational Hazard

Introduction

Annually, out of the 4.4 million deaths attributed to injuries, approximately 3.16 million lives are claimed by unintentional injuries, while violence-related injuries account for 1.25 million fatalities.[1] The consequences of accidents and injuries extend beyond the physical harm inflicted upon victims, significantly impacting socioeconomic aspects, and severely compromising their quality of life.[2–5] Seafaring, particularly the fishing industry, entails a demanding and perilous occupation. Fishing vessels serve as both living quarters and workplaces for fishermen during their journeys at sea. Working conditions in these maritime environments are exceedingly challenging, characterized by harsh natural elements such as large waves, high winds, and substandard working conditions (e.g. vibrations, noise) that fail to meet recommended standards. It is worth

noting that fishing trips typically last for two to three weeks, and the workforce endures isolation, loneliness, and detachment from the mainland.[6,7] Working conditions on board fishing vessels often fall short of recommended standards, with factors like vibrations and noise contributing to the overall difficulty and potential risks.[8–10]

In Vietnam, accidents are progressively emerging as leading causes of mortality within healthcare facilities, exhibiting higher rates of fatalities and injuries when compared to infectious and non-communicable diseases.[11] With a vast territorial sea and exclusive economic zone, rich marine resources, and thousands of inhabited islands, Vietnam's fishing industry plays a vital role in the country's economy and food security.[12] The reliance on fishing as a livelihood exposes a large number of Vietnamese fishermen to the hazards and risks associated with seafaring. The statistics further emphasize the significance of the fishing industry in Vietnam, with over 45.3 thousand small-scale fishing vessels and a total of 95.24 thousand motorized marine fishing vessels as of December 2021.[13]

The study aimed to provide insights into various aspects, including the socio-demographic profiles of fishermen, the challenging working conditions they encounter at sea, the prevalent types of accidents they experience, and the characteristics of injuries in terms of their nature and location. By addressing these facets, the study aimed to enhance our understanding of the complexities surrounding accidents and injuries in this occupational setting, ultimately informing strategies and interventions to improve the safety and well-being of fishermen.

Methods

The study used a descriptive cross-sectional design. The research topic obtained approval from the research ethics committee of the Institute of Marine Medicine, Vietnam (Ref. No: 29/2018/QĐ-YHB). All subjects voluntarily participated in the study, and a consent form was obtained from each participant.

The research focused on fishermen working on offshore fishing vessels in the Northern region of Vietnam. The inclusion criteria were fishermen with a minimum working experience of more than 2 years who agreed to participate in the study. Exclusion criteria encompassed those with less than 2 years of fishing experience, those who declined to participate, and those who were primarily engaged in occupations other than fishing, as their experiences and risks may differ significantly from those of full-time fishermen.

The research was conducted in various locations within the Northern region of Vietnam, including Quang Ninh, Hai Phong, Nam Dinh, and Thanh Hoa. These four northern provinces were selected due to their proximity to the sea, making them suitable for studying offshore fishing activities, the associated occupational risks in the region and the study period spanned from 5 June 2018 to 5 June 2020.

The sample size determination employed the formula:

$$n = Z^2 * p(1-p) / \varepsilon^2$$

Where:

n: required sample size

Z: confidence coefficient,

chosen as Z = 1.96 for a 95% confidence level

p: rate of accidents and injuries in the community, set at 50%

ε: margin of error, set at 5%

By substituting the values into the formula, the minimum sample size was determined to be 385. However, to ensure higher reliability, the study included a sample size of 420 participants. The sampling method employed was simple random sampling.

Data were collected through direct interviews with the 420 participants engaged in offshore fishing in the Northern region of Vietnam. Data were collected by trained research assistants using structured questionnaires. The research content encompassed the following aspects:

Outcome variables characteristics related to accidents and injuries in the last two years were collected, such as the rate, timing, and location of accidents and injuries on the ship, causes of

accidents, and the place of injuries on the body.

The study investigated several socio-demographic characteristics of fishermen as independent variables, including age, sex, length of service, educational level, ship's operating range, types of fishing boats utilized, and rank on board. Furthermore, descriptive variables about accidents were examined, such as the location of the body damaged by accidents and the cause of the most recent accident on the boat.

Data entry, cleaning, and processing for preliminary data analysis were performed using Stata version 15. The collected data were summarized through descriptive analysis, presenting frequencies, proportions, and graphs. Bivariate analysis was conducted using either the chi-square test or Fisher's exact test, aiming to examine the associations between study variables. Additionally, binary logistic regression analysis was calculated. The model inclusion criteria were set at a significance level of $p < 0.05$. Adjusted risk ratios (ARRs) with corresponding 95% confidence intervals were calculated. Statistical significance was determined at a p-value < 0.05.

Results

Table 1 provides an overview of the sociodemographic characteristics of the participants. Age distribution showed a substantial representation across various age groups, with a significant proportion falling in the 30-39 years category with 158 participants (37.6%). In terms of occupational experience, a notable number of 187 (44.5%) participants had from 10 to 19 years of experience in the fishing industry. Academic qualifications indicated a range of educational backgrounds, with a significant portion of 174 (41.1%) having completed middle school education. The study also highlighted the prevalence of 319 (76%) individuals in the role of fishermen, comprising the majority of the sample, along with fishing boat captains and mechanics.

Table 1: General characteristics of participants (n=420)

Variable		N (%)
Age (years)	20-29	92 (21.9)
	30-39	158 (37.6)
	40-49	125 (29.8)
	50	45 (10.7)
Occupation (year)	< 10	151 (36.0)
	10-19	187 (44.5)
	20	82 (19.5)
Academic level	Illiteracy	31 (7.4)
	Elementary	169 (40.2)
	Middle School	174 (41.4)
	High school and above	46 (11.0)
Position on the ship	Fishing boat captain	67 (16.0)
	Mechanic	34 (8.0)
	Fishermans	319 (76.0)

Table 2 provides a comprehensive overview of the rate of accidents and injuries among fishermen involved in offshore fishing activities during the study period. A total of 175 participants, constituting 175 cases (41.7%) of the sample, reported experiencing injuries, while 245 participants (58.3%) had not suffered injuries. Among those who experienced accidents, the majority of participants 82(46.9%) reported having been involved in accidents only once, followed by 44 cases (25.1%) who had two accidents, 22 cases (12.6%) with three accidents, and 27 cases (19.4%) experiencing four accidents. Furthermore, the study examined

the time of accidents, with 104 cases (59.4%) occurring during nighttime hours and 71 cases (40.6%) during the daytime. Regarding the location of accidents, the deck was the most common site, accounting for 121 cases (69.1%), followed by the machine tunnel in 21 cases (12.0%), boat side in 14 cases (8.0%), and underwater in 19 cases (10.9%).

Table 2: Characteristics of fisherman's accident and injury

Variable		**N (%)**
Injury	Yes	175 (41.7)
	No	245 (58.3)
Frequency of accidents	1 time	82 (46.9)
	2 times	44 (25.1)
	3 times	22 (12.6)
	4 times	27 (19.4)
Time of accidents	Daytime	71 (40.6)
	Night	104 (59.4)
The location of the accident occurred	Deck	121 (69.1)
	Machine tunnel	21 (12.0)
	Boatside	14 (8.0)
	Underwater	19 (10.9)

Table 3: Causes and nature of injury of accidents and injuries

Variable		**N (%)**
Reason	Complications due to pressure	8 (4.6)
	Ship engine repair	11 (6.3)
	Poisoning	6 (3.4)
	Sea snake bites, fish fins stab	14 (8.0)
	Winch, winch rope broken	40 (22.9)
	Fall	48 ()27.4
	The train collided	14 ()8.0
	Labor tools on board	13 (7.4)
	Burn	12 (6.9)
	Fight	9 (5.1)
The nature of the damage	Software wound	92 (52.5)
	Sprains, dislocations	14 (8.0)
	Fracture	12 (6.9)
	Partial amputation	7 (4.0)
	Joint pain (reduced pressure)	4 (2.3)
	Traumatic brain injury	4 (2.3)
	Falling into the sea	14 (8.0)
	Poisoning	6 (3.4)
	Vascular wound	6 (3.4)
	Paralysis (hypotension)	4 (2.3)
	Burn	12 (6.9)

Table 3 presents a detailed breakdown of the leading causes of accidents and injuries among fishermen involved in offshore fishing activities. Among the reported reasons for injuries, several

factors were identified. The most common cause of injuries was "fall" accounting for 48 cases (27.4%), followed by winch, winch rope broken at 40 cases (22.9%). Additionally, injuries resulting from ship engine repair, sea snake bites, fish fins stabbing, and the train collision were also noted. When examining the nature of the injuries sustained, soft tissue wounds constituted the majority, with 92 cases (52.5%).

Table 4 displays a comprehensive breakdown of the specific locations of injuries resulting from accidents among fishermen. Among the reported locations of injury, the most commonly affected area was the shoulder, forearm, arm, and hand, accounting for 79 cases (45.1%). In addition, thighs, legs, and feet were affected in 43 cases (24.6%), indicating the vulnerability of lower extremities to injuries. Body injuries were 20 cases (11.4%, followed by abdomen, back, and pelvis with 14 cases (8%). While head, eye, and dento-maxillo facial injuries were less common, they underscored the diverse range of injuries experienced by the participants.

Table 4: Injury locations on the body caused by accidents and injuries

Location of injury	N (%)
Body	20 (11.4)
Head	10 (5.7)
Eye	2 (1.2)
Dentomaxillo facial	3 (1.7)
Chest	4 (2.3)
Abdomen, back, pelvis	14 (8.0)
Thighs, legs, feet	43 (24.6)
Shoulder, forearm, arm, hand	79 ()45.1

Table 5 provides valuable insights into the association between various factors and the risk of injury among fishermen. In terms of academic level, participants with high school and above education exhibited a lower percentage of injuries with 13 cases (28.3%) compared to those with below middle school 96 cases (48%) or middle school 66 cases (37.9%). Furthermore, career experience played a role, as participants with less than 10 years of experience had a higher injury percentage with 67 cases (44.4%) than those with 10 or more years of experience 108 cases (40.1%), with a statistically significant OR of 1.54.

Additionally, working position showed associations with injuries, with fishermen participants having a significantly higher injury percentage of 148 cases (46.4%) than the mechanic group with 5 cases (14.7%), accompanied by an OR of 3.87. Ship capacity and the use of labor protection were also significantly associated with injury rates.

Table 5: Multivariate analysis of factors related to injury accidents

Variables	Injuries		95% CI	p-value
	Yes (%)	No (%)		
Academic level				
Below Middle School	96 (48)	104 (52)		
High school and above	13 (28.3)	33 (71.7)	2.47 (1.23-4.95)	0.01
Career age (year)				
<10	67 (44.4)	84 (55.6)		

Variables	Injuries		95% CI	p-value
	Yes (%)	No (%)		
≥10	108 (40.1)	161 (59.9)	1,54 (1,05-2,72)	0.027
Working position				
Fisherman	148 (46.4)	171 (53.6)		
Mechanic Group	5 (14.7)	29 (85.3)	3,87 (1,11-13,55)	0.034
Ship capacity				
< 150 CV	27 (75)	9 (25)		
150-400CV	115 (40.9)	166	5,49 (2,39-12,64)	<0.001
> 400CV	33	70	8,39 (3,37-20,87)	<0.001
Using labor protection				
No	173	228		
Yes	3	15	3,68 (1,05-12,93)	0.03
Rank				
Fisherman	152	186		
Ship owner	23	59	2,02 (1,18-3,39)	0.009

Discussion

The present study provides valuable insights into the factors associated with accidents and injuries among fishermen working on offshore fishing vessels in the North of Vietnam. The analysis of sociodemographic characteristics revealed that the majority of fishermen had a working age of 10-19 years, followed by less than 10 years, while those with a working age of ≥20 years constituted a smaller proportion. This finding is consistent with a study conducted by Amadou Barrow in a different region, indicating similarities in the age distribution of fishermen.[14] Regional differences in the age composition of the fishing workforce can be attributed to various factors, including economic opportunities, cultural traditions, regulatory policies, migration patterns, economic incentives, and technological advancements. These factors collectively influence the number of younger and older individuals engaged in fishing in different regions, highlighting the need for tailored approaches to address the unique challenges faced by fishermen in each area.

Regarding education levels, the present study's findings align with previous research, which emphasized a prevalent low level of education among fishermen, with a significant proportion having only primary or lower secondary education.[15,16] These findings collectively emphasize the need for targeted interventions and educational initiatives to improve the socio-demographic characteristics of fishermen. Enhancing access to education and vocational training programs could potentially contribute to safer working conditions and reduce the risk of accidents and injuries. Furthermore, the findings underscore the importance of considering the unique characteristics of the local fishing workforce when designing preventive measures and safety regulations.

The study also examined the rate of accidents and injuries among the fishermen during the study period, revealing a relatively high overall rate of incidents, with 41.7% of the participants reporting accidents and injuries. The calculated rate of accidents per person per year further emphasizes the significant occupational risks faced by fishermen in this region. The findings regarding the timing and location of accidents and injuries align with previous research by the U.S. Department of Health and Human Services Centers for Disease Control and Prevention, highlighting a substantial number of incidents occurring at night and on deck. This emphasizes the importance of implementing appropriate lighting and safety measures during nighttime

operations and emphasizing safety protocols for deck activities.[17]

Moreover, the leading causes of accidents and injuries identified in this study, such as slip and fall incidents, broken winch lines, sea snake bites, and fish fin stabs, are consistent with findings from previous studies.[18,19] These findings underscore the need for targeted interventions focusing on slip and fall prevention, improving winch line safety, and enhancing first aid and emergency response capabilities to address the specific injury patterns observed.

The analysis of the location of injuries on the body revealed that the upper extremities were the most commonly affected area, followed by lower limb injuries. Systemic damage, such as drowning and poisoning, accounted for a smaller proportion of injuries, while head injuries were relatively infrequent.[20,21] These findings highlight the importance of promoting safety practices that specifically address upper extremity and lower limb protection, such as the use of personal protective equipment and ergonomic measures.

The logistic regression analysis provided valuable insights into the factors associated with the risk of injury among fishermen. It was observed that fishermen with a working age of less than 10 faced a significantly higher risk of injury than those with a working age of ≥10 years (with a p-value of 0.027). This suggests that experience and familiarity with the occupational hazards associated with fishing may play a role in reducing the risk of injuries.[14] Additionally, the group of professional friends, responsible for direct involvement in fishing activities, exhibited a higher risk of injury compared to the boat drivers and engine group. This highlights the importance of training and safety measures targeted specifically at the tasks performed by the group of professional friends.

Furthermore, the analysis revealed that fishermen working on ships with a capacity of <150CV were at a significantly higher risk of injuries compared to those operating ships with higher capacities (with p-value < 0.001). This suggests that vessel characteristics and functionality may contribute to the occurrence of accidents and injuries, with small vessels potentially being more susceptible to adverse sea conditions and other hazards.[22] The study also found that fishermen who did not use labor protection measures or used them infrequently had a higher risk of accidents or injuries. This underscores the significance of promoting and enforcing the use of appropriate safety equipment and practices to reduce the risk of harm.

This study sheds light on the sociodemographic characteristics, rates, causes, and nature of accidents and injuries among fishermen working on offshore fishing vessels in the North of Vietnam. The findings are consistent with global trends. Commercial fishery is a hazardous occupation, with hundreds of fishers injured and more than 80 fishers dying daily while involved in fishing operations.[23] In developing countries, between 20% and 50% of the workforce is exposed to health risks. The fishing industry is reported to be one of the most dangerous occupations with about 120 million accidents and 200,000 fatalities annually at the global level.[24] These data underscore the significant occupational risks faced by fishermen worldwide and highlight the need for targeted interventions and safety measures to reduce accidents and injuries in this sector.

One limitation of this study is that it focused solely on offshore fishing vessels in the North of Vietnam, which may limit the generalizability of the findings to other regions or types of fishing operations. Additionally, the study relied on self-reported data, which could introduce reporting bias and under-reporting of incidents.

Conclusions

The findings highlight the need for targeted interventions and comprehensive safety measures to mitigate the risks faced by fishermen. These results underscore the need for tailored interventions and safety measures that account for the unique characteristics of the local fishing workforce. With a high incidence of accidents and injuries, particularly in the context of occupational

risks faced by fishermen globally, there is an urgent call for comprehensive safety initiatives and targeted interventions. By addressing the specific challenges related to age, education, timing, location, and causes of incidents, policymakers and industry stakeholders can work together to enhance the safety and well-being of fishermen in Vietnam and set an example for safer practices in the fishing industry worldwide.

Acknowledgments

The authors would like to express their sincere gratitude to the Vietnam Marine Medicine Institute for providing support and resources throughout the research process. The cooperation and assistance of the provincial authorities in Quang Ninh, Hai Phong, Nam Dinh, and Thanh Hoa provinces are also greatly acknowledged. Their valuable contributions in facilitating access to the research participants and providing necessary information are deeply appreciated.

References

1. WHO. Injuries and violence. World Health Organization 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/injuries-and-violence (accessed June 1, 2023)
2. Ford JD, Grasso DJ, Elhai JD, Courtois CA. 11 - Social, cultural, and other diversity issues in the traumatic stress field. In: Ford JD, Grasso DJ, Elhai JD, Courtois CA, editors. Posttraumatic Stress Disorder (Second Edition), San Diego: Academic Press. 2015;503–46. Available from: https://doi.org/10.1016/B978-0-12-801288-8.00011-X
3. Sabet FP, Tabrizi KN, Khankeh HR, Saadat S, Abedi HA, Bastami A. Road traffic accident victims' experiences of return to normal life: A qualitative study. Iran Red Crescent Med J. 2016;18(4). Available from: https://doi.org/10.5812/ircmj.29548
4. Leppink N. Socio-economic costs of work-related injuries and illnesses: Building synergies between Occupational Safety and Health and Productivity [Internet]. Bologna; 2015 Oct [cited 2023 Nov 15]. Available from: https://www.ilo.org/wcmsp5/groups/public/---europe/---ro-geneva/---ilo-rome/documents/genericdocument/wcms_415608.pdf
5. Ozomata EA, Osagiede EF, Onyebujoh TJ. Occupational health hazards and use of personal protective equipment among automobile mechanics in Surulere local government area of Lagos State, Nigeria - a descriptive study. Int J Occup Saf Health. 2022;12:35–44. Available from: https://doi.org/10.3126/ijosh.v12i1.41035
6. Adumene S, Ikue-John H. Offshore system safety and operational challenges in harsh Arctic operations. Journal of Safety Science and Resilience. 2022;3:153–68. Available from: https://doi.org/10.1016/j.jnlssr.2022.02.001
7. Islam R, Khan F, Abbassi R, Garaniya V. Human error assessment during maintenance operations of marine systems –What are the effective environmental factors? Saf Sci. 2018;107:85–98 Available from: https://doi.org/10.1016/j.ssci.2018.04.011
8. Kyvelou SSI, and DGI. Fisheries Sustainability through Soft Multi-Use Maritime Spatial Planning and Local Development Co-management: Potentials and Challenges in Greece. 2020;12(5). Available from: https://doi.org/10.3390/su12052026
9. Karthick S, Kermanshachi S, Pamidimukkala A, Namian M. A Review of Construction Workforce Health Challenges and Strategies in Extreme Weather Conditions. Int J Occup Saf Ergon. 2022. Available from: https://doi.org/10.1080/10803548.2022.2082138
10. Mansi F, Cannone E, Caputi A, De Maria L, Lella L, Cavone D, et al. Occupational Exposure on Board Fishing Vessels: Risk Assessments of Biomechanical Overload, Noise and Vibrations among Worker on Fishing Vessels in Southern Italy. Environments. 2019;6:127. Available from: https://doi.org/10.3390/environments6120127
11. Nguyen TT, Trevisan M. Vietnam a country in transition: health challenges. BMJ Nutr Prev Health. 2020;3(1):60-6. Available from: https://doi.org/10.1136/bmjnph-2020-000069
12. Lin T-Y, van Onselen V, Vo P. Coastal erosion in

Vietnam: Case studies and implication for integrated coastal zone management in the Vietnamese south-central coastline. IOP Conf Ser Earth Environ Sci. 2021;652:012009. Available from: https://doi.org/10.1088/1755-1315/652/1/012009

13. Minh-Ngoc Nguyen. Number of motorized marine fishing vessels in Vietnam in 2021, by vessel length. Statista 2022. Available from: https://www.statista.com/statistics/1330462/vietnam-fishing-vessels-with-at-least-90-horsepower/ (accessed June 1, 2023).

14. Barrow A, Kongira A, Nget M, Sillah SO, Jatta SPS, Badjie M, et al. Epidemiology of occupational hazards and injuries among fishermen at Tanji fishing site in The Gambia: an analytical cross-sectional study design. Environ Health Insights. 2022;16:11786302221088700. Available from: https://doi.org/10.1177/11786302221088699

15. Westaway E, Barratt C, Seeley J. Educational attainment and literacy in Ugandan fishing communities: Access for All? MAST. 2009;8(2);73-97. Available from: https://www.marecentre.nl/mast/documents/Mast82_westaway_barratt_seeley.pdf

16. Bhuyan M, Akhtar A, Saim K, Islam M. Present Status of Socio-economic Conditions of the Fishing Community of the Meghna River Adjacent to Narsingdi District, Bangladesh. J Entomol Zool Stud. 2016;4(4);641–6. Available from: https://doi.org/10.4172/2332-2608.1000192

17. CDC. Fatal and Nonfatal Injuries Involving Fishing Vessel Winches — Southern Shrimp Fleet, United States, 2000–2011 . Morbidity and Mortality Weekly Report 2013. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6209a1.htm

18. Nabian MH, Zadegan SA, Leila , Zanjani O, Mehrpour SR. Epidemiology of Joint Dislocations and Ligamentous/ Tendinous Injuries among 2,700 Patients: Five-year Trend of a Tertiary Center in Iran. vol. Arch Bone Jt Surg. 2017 5(6);426-34. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5736892/

19. Marshall SW, Kucera K, Loomis D, McDonald MA, Lipscomb HJ. Work related injuries in small scale commercial fishing. Injury Prevention. 2004;10:217-21. Available from: https://doi.org/10.1136/ip.2003.005058

20. Dabholkar TA, Nakhawa P, Yardi S. Common musculoskeletal problem experienced by fishing industry workers. Indian J Occup Environ Med. 2014;18(2):48–51. Available from: https://doi.org/10.4103/0019-5278.146888

21. Miner T, Kincl LD, Bovbjerg VE, Vaughan A, Jacobson K. Emergency Medical Training for the Commercial Fishing Industry: An Expanded Role for Wilderness Medicine. Wilderness Environ Med. 2019;30:281–6. Available from: https://doi.org/10.1016/j.wem.2019.05.008

22. Aalberg AL, Bye RJ, Ellevseth PR. Risk factors and navigation accidents: A historical analysis comparing accident-free and accident-prone vessels using indicators from AIS data and vessel databases. Maritime Transport Research. 2022;3:100062. Available from: https://doi.org/10.1016/j.martra.2022.100062

23. World Health Organization. Preventing drowning in the fishing industry. 2023. Available from: https://www.who.int/news-room/feature-stories/detail/preventing-drowning-in-the-fishing-industry (accessed November 5, 2023)

24. Barrow A, Kongira A, Nget M, Sillah SO, Jatta SPS, Badjie M, et al. Epidemiology of occupational hazards and injuries among fishermen at Tanji fishing site in The Gambia: an analytical cross-sectional study design. Environ Health Insights. 2022;16. Available from: https://doi.org/10.1177/11786302221088699 .

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Prevalence of work-related musculoskeletal disorders among laundry workers in North Sulawesi Province, Indonesia

Suarjana IWG[1], Negara NLGAM[2]

[1]Department of Public Health, Faculty of Sport Science and Public Health, Universitas Negeri Manado, Tondano, North Sulawesi 95618, Indonesia

[2]Department of Occupational Health and Safety, Faculty of Health Sciences, Bali International University, Bali 80239, Indonesia

Corresponding author:
I Wayan Gede Suarjana, M.Erg
Department of Public Health,
Faculty of Sport Science and Public Health,
Universitas Negeri Manado,
Tondano, North Sulawesi 95618, Indonesia
Jl. Kampus Unima, Tonsaru, Kec. Tondano Sel., Kabupaten Minahasa, Sulawesi Utara 95618, Indonesia
Tel.: +62 897 099 103 33,
E-mail:iwg.suarjana@unima.ac.id
ORCID ID:
https://orcid.org/0000-0002-4072-6813

Date of submission: 19.12.2023
Date of acceptance: 06.03.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.60842

ABSTRACT

Introduction: Work-related musculoskeletal disorders (WMSDs) are a serious problem that can affect the health and productivity of laundry workers. Workers who experience such disorders may experience pain, muscle stiffness, joint inflammation, and even serious injury. This study aimed to investigate the prevalence of work-related musculoskeletal disorders among laundry workers in North Sulawesi.

Methods: This study is a quantitative descriptive cross-sectional survey conducted in March 2023 – April 2023 in Minahasa District North Sulawesi Province, specifically Tondano-Tomohon City. A total sample of 225 laundry workers was taken using the convenient sampling technique. The questionnaire used to assess WMSDs was the Nordic Body Map. The chi-square test was applied to find the association between age and musculoskeletal disorders among laundry workers.

Results: 5.38% of participants categorized pain felt in all parts of the body as very painful, 17.81% as painful, 36.39% as rather painful, and 39.67% as not painful. The body part that experienced the most complaints of severe pain was back at 10.2%, feeling pain was the waist at 37.3%, feeling rather pain was the right arm at 47.1%, and no pain was the left elbow at 71.6%.

Conclusion: The prevalence of work-related musculoskeletal disorders among the study population was significantly associated with age, sex, nutritional status, and work experience with musculoskeletal complaints ($p<0.05$). While there is no relationship between work duration and education level with musculoskeletal complaints ($p>0.05$). Appropriate interventions may be needed to improve working conditions, protect workers' health, and minimize the risk of work-related musculoskeletal disorders in the laundry industry.

Keywords: Laundry Workers, Nordic Body Map, North Sulawesi, Risk Factors, Work Related Musculoskeletal Disorders (WMSDs)

Introduction

Musculoskeletal Disorders (MSDs) related to work also referred to as Work-Related Musculoskeletal Disorders (WMSDs) have become a serious problem in various work environments around the world. These diseases are associated with abnormalities in the musculoskeletal system, which includes muscles, tendons, ligaments, and bones. In recent years, attention to WMSDs has increased rapidly due to their detrimental impact on worker well-being

and work productivity. Some of the common symptoms of WMSDs are pain, stiffness, numbness, tingling, and reduced range of motion in the affected body parts. The most frequently reported locations of WMSDs are the lower back, neck, wrist, ankle, shoulder, and knee. According to a study conducted on 408 domestic workers in India, WMSDs were reported as knee pain (38.2%), upper back pain (31.9%), lower back pain (27.5%), ankle pain (26.0%), shoulder pain (23.8%) and neck pain (19.6%).[1] In Indonesia, a study by Yosineba et al. in 2020 found that the prevalence of WMSDs among orthopedic surgeons was 50% for the lower back, 46.5% for neck, 28.6% for wrist and ankle, 21.4% for shoulder, 10.7% for knee, thigh, and buttocks, 7.1% for upper back, and 0% for elbow.[2] WMSDs can affect the quality of life and work performance of the workers, as well as increase the health care costs and compensation claims for the employers. Therefore, prevention and management of WMSDs are essential for both workers and employers.

According to the World Health Organisation (WHO), musculoskeletal disorders (MSDs) are disorders of the muscles, tendons, ligaments, and nerves that can be caused by work, lifestyle, or a combination of both. Work-related MSDs are disorders caused by factors in the workplace, such as repetitive movements, unergonomic postures, heavy loads, and vibrations, hot or cold working environments, and work stress.[3,4] Based on WHO data in 2019, MSDs are the second leading cause of disability in the world, after heart disease. WMSDs are estimated to cause 3.5% of all years of life lost due to disability (YLDs). According to WHO, there were an estimated 264 million cases of work-related MSDs in the world in 2019.[5] The most common types of work-related MSDs are low back pain, neck pain, shoulder pain, wrist and hand pain, and foot pain. One group of workers who are vulnerable to WMSDs are workers in the laundry section.[6,7]

Laundry workers, both in commercial laundries and hospitals, are often involved in tasks that involve heavy lifting, repetitive movements, and prolonged standing. However, research on the frequency and risk factors of WMSDs among laundry workers is limited. Laundry workers are workers who have a high risk of developing musculoskeletal disorders (MSDs) because the tasks they perform routinely involve physical activities that can cause excessive stress on their musculoskeletal system. Some of the job tasks that pose a high risk of MSDs in laundry workers include: Heavy lifting, one of the main tasks of laundry workers is lifting and moving linen that is often wet and heavy, such as sheets and large towels. Heavy lifting without the use of appropriate assistive equipment can cause stress to the lower back, shoulders, and arms, increasing the risk of musculoskeletal injuries and complaints.[8] Repetitive Motion, laundry workers often have to perform repetitive motions such as folding clothes, rolling linen, or sewing. These repetitive motions can cause excessive stress on joints, tendons, and muscles, which can eventually lead to disorders such as tendinitis or carpal syndrome.[9] Unergonomic body positions, some laundry work tasks require workers to stand for long periods or operate in unergonomic body positions. This can result in strain on the back, legs, and neck, which in turn can cause complaints such as back pain, leg pain, and neck discomfort.[10] Use of heavy equipment, laundry workers often use heavy equipment such as commercial washing machines, dryers, and irons. Operating this equipment repetitively or for long periods can affect their joints and muscles. Sorting and Sifting, linen sorting and sorting tasks often require careful and precise hand movements.[11] Laundry workers have to carefully select, roll, and organize linen, which can result in stress on their wrists and fingers. Work environment discomfort, some laundry workers may have to operate in uncomfortable work environments, such as cramped spaces or with extreme temperatures. This discomfort can affect their physical well-being.

Previously, many studies have been conducted in various work sectors to understand and identify the risk factors associated with WMSDs. These studies cover the manufacturing industry,

healthcare, and transport sectors, and the results have revealed that the risk of WMSDs can be found in various work environments. Research conducted by Purwati et al.[11] showed that there is a significant relationship between work posture and musculoskeletal disorders (MSDs) complaints among laundry workers in Batam City, Indonesia. The majority of respondents were under 35 years old. WMSDs are a common occupational risk for laundry workers, and factors such as excessive muscle stretching, repetitive activities, and unnatural work postures contribute to the development of these disorders. Research conducted by Gumilang, et al.[12] stated that the majority of laundry workers in Denpasar, Bali have a moderate level of risk of developing Musculoskeletal Disorders (MSDs) during the ironing process. Factors contributing to the moderate risk level include female sex, age greater than or equal to 30 years, duration of work per day greater than 8 hours, tenure greater than or equal to 4 years, and adequate nutritional status. [12]

However, although many previous studies have provided important insights into WMSDs in various occupational sectors, research on these conditions among laundry workers is still very limited and has not been widely discussed.[13–15] This can increase the risk of developing WMSDs, especially on body parts such as the lower back, shoulders, and wrists. This study aims to fill this knowledge gap by investigating the extent of WMSDs among laundry workers in North Sulawesi Province. Specifically, this study focuses on laundry workers from two cities in North Sulawesi, namely Tondano and Tomohon. These two cities were chosen because they have a large number of laundry businesses and workers, as well as a high demand for laundry services.

Methods

This study is cross-sectional, carried out in some of the largest laundry places in Tomohon and Tondano City, North Sulawesi, from March to April 2023. The subjects of this study were laundry workers who met the following inclusion criteria: They worked in the Tomohon and Tondano areas of North Sulawesi Province. They were between 20 and 60 years old. They had at least one year of work experience. They agreed to participate in the study and signed the informed consent form. The following exclusion criteria: They had muscle injuries, ligament tears, or joint problems.

The sampling technique used is convenience sampling. The calculation of the sample size using the incidental sampling technique is a technique based on chance, that is, anyone who happens to meet the researcher can be used as a sample if it is deemed that the person is suitable as a data source. This technique is usually used if the population is unknown or difficult to reach. The formula that can be used is as follows:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

$$n = \frac{1.645^2 \times 0.5 \times 0.5}{0.1^2}$$

$$n = 225$$

Notes:

Z = 1.645 (z-score value for 90% confidence level)
p = 0.5 (expected population proportion)
q = 0.5 (1 - p)
d = 0.1 (margin of error)

Therefore, the minimum sample size was 225 respondents who met the inclusion criteria and were willing to participate.

The sample was recruited based on the availability and accessibility of laundry workers in the two cities, inviting laundry workers to participate in the study, with inclusion and exclusion criteria to determine who can become respondents: laundry workers aged 20-60 years, have at least 1 year of work experience, and are willing to fill out the questionnaire. Sample data collected in Tondano City can be recorded and meet the criteria of as many as 91 workers, while in Tomohon City as many as 134 workers, so the total data and sample is 225 workers.

This research data is in the form of primary data collected using the Nordic Body Map questionnaire to measure complaints of musculoskeletal disorders.[16] In addition, demographic data taken were age, sex, nutritional

status, education level, marital status, work experience, and work duration.

Statistical data analysis using SPSS v.25 for macOS software and presented in the form of narratives, graphs and tables to describe the characteristics of subjects, the distribution of WMSDs risk levels, as well as the distribution of WMSDs risk levels on each variable.

This research has been approved by the Bali International University Research Ethics Commission with permit number 01.036/UNBI/EC/IV/2022, dated 09 January 2023.

Results

The results of data collection in this study have been organized into two groups, namely demographic data and skeletal muscle complaints data. The participants in this study consisted of 225 laundry workers. Data on the distribution of subject characteristics are presented in Table 1 below.

Table 1: Distribution of Respondent Characteristics

Socio-Demographic Variable	Subcategory	Number (n) N = Total 225
Age (year)	19-27	87 (38.7%)
	28-36	67 (29.8%)
	37-45	40 (17.8%)
	46-54	19 (8.4%)
	>54	12 (5.3%)
Sex	Female	155 (69.9%)
	Male	70 (31.1%)
BMI (Kg/m^2)	Very Underweight: <17	7 (3.1%)
	Underweight: 17 - <18.5	13 (5.8%)
	Normal 18.5 – 25.0	170 (75.6%)
	Overweight >25 - 27	35 (15.6%)
	Obese >27	0 (0%)
Education Level	Primary School	7 (3.1%)
	Junior High School	11 (4.9%)
	High School / Vocational School	182 (80.9%)
	Bachelor	25 (11.1%)
Marital Status	Single	104 (46.2%)
	Married	121 (53.8%)
Work Experience	New	178 (79.1%)
	Old	47 (20.9%)
Work Duration	< 8hr	200 (88.9%)
	> 8hr	25 (11.1%)

The majority of respondents are relatively young individuals, with 38.7% of them being in the age group of 19 to 27 years old and 29.8% being between 28 to 36 years old. In this study, the total number of respondents was 225 respondents, with 155 female respondents and 70 male respondents. Whereas, sex also played an important role in this sample, with females dominating the respondent population at 69.9%. Regarding physical health, the majority of respondents had a Body Mass Index (BMI) within the normal range of 170 (75.6%), indicating a good level of health in this sample. In terms of education, most of the respondents (80.9%) had a high school or vocational school level of education at 182 (80.9%), which may have resulted in a better understanding of the issues under study. Meanwhile, in terms of marital status, there was a fairly balanced difference between married at 121 (53.8%) and single at 104 (46.2%) respondents.

In addition, most of the respondents had recent work experience of less than 2 years (79.1%), and most of them worked less than 8 hours a day (88.9%).

The results of data collection on musculoskeletal complaints in 225 laundry workers using the Nordic Body Map questionnaire with 4 Likert Scales, namely Score 1 (No Pain), Score 2 (Rather Pain), Score 3 (Pain), Score 4 (Very Pain). Data collection was carried out on 28 body areas and more details are presented in table 2.

Table 2: Prevalence of Work-related Musculoskeletal Disorders of Laundry Workers with Nordic Questionnaire

Body Areas	Complaints			
	No Pain (%)	Rather Pain (%)	Pain (%)	Very Pain (%)
Upper Neck	21.8	59.1	14.2	4.9
Lower Neck	38.2	41.3	16.0	4.4
Left Shoulder	36.0	40.9	16.0	7.1
Right Shoulder	21.3	44.9	24.0	9.2
Left Upper Arm	40	37.3	17.8	4.9
Back	19.6	40.9	29.3	10.2
Right Upper Arm	20	20.4	32.0	7.6
Waist	19.6	35.1	37.3	7.6
Hip	37.3	39.1	18.7	4.9
Buttocks	58.7	27.6	9.8	4.0
Left Elbow	71.6	22.2	2.7	3.6
Right Elbow	54.7	27.1	13.3	4.9
Left Forearm	48	36.4	11.6	4.0
Right Forearm	29.3	47.1	14.2	9.3
Left Wrist	46.2	35.1	15.6	3.1
Right Wrist	25.8	42.7	26.2	5.3
Left Hand	40.9	39.1	15.1	4.9
Right Hand	24.9	41.8	23.6	9.8
Left Thigh	54.2	31.6	12.9	1.3
Right Thigh	47.6	41.3	8.0	3.1
Left Knee	58.2	29.3	7.6	4.9
Right Knee	51.6	36.9	7.1	4.4
Left Leg	37.8	36.4	18.7	7.1
Right Leg	26.2	40.9	24.9	8.0
Left Ankle	49.3	31.1	16.9	2.7
Right Ankle	42.2	39.1	15.1	3.6
Left Foot	47.6	24.4	25.3	2.7
Right Foot	42.2	29.8	24.9	3.1

Based on the data results in Table 2. shows the prevalence of work-related musculoskeletal disorders in laundry workers. The prevalence of WMSDs complaints in 28 body areas is based on the level of complaints felt, where Most of the complaints (71.6%) were about the left elbow, which did not cause any pain. The right forearm was the second most common complaint (47.1%), which caused some pain. The waist was the third most common complaint (37.3%), which also caused pain. The back was the least common complaint (10.2%), but it caused the most pain.

The results of the chi-square test between the characteristics of respondents and complaints of musculoskeletal disorders in laundry workers can be seen in Table 3 below.

Table 3: Chi-Square Test Results Characteristics of Respondents of WMSDs

Characteristics	No WMSDs	WMSDs	p-value
	n (%)	n(%)	
Age			
19-27	58 (66.7%)	29 (33.3%	0.018*
28-36	40 (59.7%)	27 (40.3%)	
37-45	18 (45%)	22 (55%)	
46-54	6 (31.6%)	13 (68.4%)	
>54	5 (41.7%)	7 (58.3%)	
Gender			
Female	52 (74.3%)	18 (25.7%)	0.001*
Male	75 (48.4%)	80 (51.6%)	
Body Mass Index (Kg/m^2)			
Very Underweight <17	7 (100%)	0 (0%)	0.037*
Underweight: 17 -<18.5	10 (76.9%)	3 (23.1%)	
Normal 18.5 – 25.0	90 (52.9%)	80 (47.1%)	
Overweight >25 - 27	20 (57.1%)	15 (42.9%)	
Obese >27	0 (0%)	0 (0%)	
Education Level			
Primary School	5 (71.4%	2 (28.6%)	0.059
Junior High School	2 (18.2%)	9 (81.8%)	
High School/Vocational School	105 (57.7%)	77 (42.3%)	
Bachelor	15 (60%)	10 (40%)	
Marital Status			
Single	73 (70.2%)	31 (29.8%)	0.001*
Married	54 (44.6%)	67 (55.4%)	
Work Experience			
Not at risk	111 (62.3%)	67 (37.7%)	0.001*
At risk	16 (34.1%)	31 (65.9%)	
Work Duration			
< 8 hr	117 (58.5%)	83 (41.5%)	0.090
> 8 hr	10 (40%)	15 (60%)	

Several characteristics have a significant relationship with WMSDs, namely age, sex, BMI, marital status, and work experience.

The 19-27 years age group had the largest proportion of those without WMSDs (66.7%), while the 46-54 years age group had the smallest proportion (31.6%). Females had a significantly greater proportion of no WMSDs (74.3%) compared to males (48.4%). Respondents who had a very lean BMI (<17 kg/m^2) all did not experience WMSDs (100%), while respondents who had a normal BMI (18.5-25 kg/m^2) were almost equal between those who experienced and those who did not experience WMSDs (52.9% and 47.1%). Single living had a greater proportion who did not experience WMSDs (70.2%) compared to those who were married (44.6%). Respondents who were not at risk of MSDs had a greater proportion who did not experience WMSDs (62.3%) compared to those at risk (34.1%).

Discussion

In this study, it is known that the age category is dominated by young age >19 years as many as 87 respondents. Based on age characteristics, it

shows that age has a significant relationship with the incidence of musculoskeletal complaints in laundry workers with a significance value of 0.018. According to Thetkathuek et al. (2016) in the age range of 35-55 years, the problem of pain caused by musculoskeletal disorders increases to 70%. Meanwhile, according to research conducted by Shobur, et al, one of the things that affects muscle work is age, because the increasing age of a person in this condition reduces muscle strength, this shows that there is a relationship between age and musculoskeletal complaints with workers aged ⩾ 30 years because they are at risk of 4.4 times experiencing high levels of musculoskeletal complaints compared to workers aged <30 years.[17]

According to sex in this study, was dominated by respondents with female sex as many as 155 respondents than male respondents. Based on the results of the chi-square test, there is a significant relationship between sex and complaints of musculoskeletal disorders with a significance value of 0.001. Sex is a factor related to muscle endurance between women and men. Related to that, sex is related to complaints of musculoskeletal disorders this is because physiologically the ability of male muscles is stronger than the ability of female muscles. Women's muscle ability is only about two-thirds of men's muscle strength, so women's muscle capacity is lesser when compared to men's muscle capacity.[18]

Based on the nutritional status in this study, the majority were in the normal category as many as 170 respondents. Based on the results of the chi-square test, there is a significant relationship between nutritional status and complaints of musculoskeletal disorders with a significance value of 0.037. This is in accordance with another study conducted by Zhang et al.[19] who found that nutrition-related disorders, such as metabolic syndrome, diabetes, hypertension, hypertriglyceridemia, and obesity, may increase the risk of or exacerbate musculoskeletal disorders, such as osteoarthritis, tendinopathy, intervertebral disc degeneration, and sarcopenia1. Our research is also in line with research by Calvo-Lobo, César, et al.[20] which provides information on how nutrients, especially vitamin D, calcium, magnesium, and protein, can help prevent musculoskeletal disorders by increasing bone strength and reducing inflammation. Excess body mass index tends to lead to increased mechanical stress on the body structures responsible for supporting body mass. When viewed from biomedical dynamics, the greatest pressure will be received by the body parts and joints that support the human body, especially the lower extremities and back.[21]

The period of employment is the time when individuals work, which is calculated from the start of employment until the time of the study. The longer the working time, the longer the worker is exposed to the workplace's increased musculoskeletal complaints.[22] Physical work that is carried out continuously and repeatedly over a long period will affect the mechanisms in the body (circulatory, digestive, muscular, nervous, and respiratory systems).[23]

The results of the chi-square statistical test show a relationship between work experience or tenure and musculoskeletal complaints. This is because the longer the working period, the longer the exposure in the workplace which results in a higher risk of musculoskeletal complaints.[24] Periods of working can affect workers both positively and negatively. The positive influence is seen in the increase in experience and expertise in accordance with the length of work. Conversely, a long working period will also have a negative effect because it causes fatigue and boredom.

Based on the results of the study, it is known that laundry workers have a long working period of more than 2 years and a new working period of less than 2 years. The data shows that 65.9% of laundry workers with a working period of >2 years are at risk of musculoskeletal complaints. The longer laundry workers work with non-ergonomic work attitudes, the higher the risk of musculoskeletal complaints. This is because musculoskeletal complaints will increase as work experience increases.[11] Previous research also found that the majority of respondents with a

working period of >2 years had a risk of experiencing musculoskeletal complaints. A long working period will provide accumulated work pressures so that over a long time it will result in clinical or chronic fatigue.[22]

Work duration is the amount of time spent by workers to perform work activities in one day or one week. Work duration can affect musculoskeletal complaints, which are pain or discomfort in the human skeletal and muscular systems.[25]

The results of the chi-square statistical test showed no relationship between work duration and musculoskeletal complaints. This is because the workers are still within the normal working duration range of around 88.8% working <8 hours. Prolonged work duration can cause static loads on muscles and joints, which can lead to fatigue, strain, and inflammation. Long work duration can also reduce rest and muscle recovery time, which can worsen musculoskeletal conditions. Work duration that is too long can increase the risk of musculoskeletal disorders, especially in body parts that are often used in work, such as the neck, shoulders, back, hands, and feet. The results of research conducted by Zulhijjah found that there was no significant relationship between work duration (p = 0.250) and musculoskeletal complaints. Work duration is not associated with musculoskeletal complaints because work duration does not affect the physical burden experienced by workers. The physical burden experienced by workers is more influenced by other factors such as length of service, workload, and work posture.[26] The duration of working time can lead to a decrease in muscle and joint function. High workloads can cause muscle and joint fatigue. Unergonomic work postures can cause muscle and joint strain. Therefore, work duration was not a major risk factor for musculoskeletal complaints in PT PLN (Persero) Jeneponto Transmission Service Unit and Substation workers.[26]

Conclusions

The majority of respondents' characteristics were based on age 19-29 years (38.7%), female 155 workers (69.9%), nutritional status in the normal category as many as 170 workers (75.6%), high school education level as many as 182 workers (80.9%), marital status as many as 121 workers (53.8%), work experience <2 years as many as 178 workers (79.1%), and work duration <8 hours as many as 200 workers (88.9%). The prevalence of musculoskeletal complaints in 28 body parts was felt to be very painful with a percentage of 10.2% felt in the back, 37.3% felt pain in the waist, 47.1% felt somewhat pain in the right forearm, and 71.6% felt no pain in the left elbow. Based on the chi-square statistical test, there was a relationship between age, sex, nutritional status, and work experience with musculoskeletal complaints ($p<0.05$). While there is no relationship between work duration and education level with musculoskeletal complaints ($p>0.05$). Therefore, appropriate interventions need to be made to improve working conditions, protect workers' health, and minimize the risk of work-related musculoskeletal disorders in the laundry industry.

Acknowledgments

Thanks to the laundry workers in the Tomohon City and Tondano City areas of North Sulawesi who have been willing to be the object of this research and also to all those who have helped researchers for the smooth running of this research.

References

1. Gibran K, Dewi WN, Damanik SRH. Identifikasi Masalah Muskuloskeletal Pada Pengendara Transportasi Umum. J Ners Indones. 2020 Mar 31;10(2):216. Available from: https://doi.org/10.31258/jni.10.2.216-228

2. Deviandri R, Ismiarto YD. The Prevalence of Musculoskeletal Disorders among Orthopaedic and Traumatology Residents in Indonesia. J Ilmu Kedokt J Med Sci. 2021 Dec 14;15(2):87. Available from: https://doi.org/10.26891/JIK.v15i2.2021.87-90

3. Instituto de Ciências da Saúde, Soares CO, Universidade Federal do Pará, Pereira BF, Instituto de Ciências da Saúde, Universidade Federal do Pará, et al. Preventive factors against work-related

musculoskeletal disorders: narrative review. Rev Bras Med Trab. 2019;17(3):415–30. Available from: https://doi.org/10.5327/Z1679443520190360

4. Murtoja Shaikh A, Bhusan Mandal B, Mangani Mangalavalli S. Causative and risk factors of musculoskeletal disorders among mine workers: A systematic review and meta-analysis. Saf Sci. 2022 Nov 1;155:105868. Available from: https://doi.org/10.1016/j.ssci.2022.105868

5. Dagne D, Abebe SM, Getachew A. Work-related musculoskeletal disorders and associated factors among bank workers in Addis Ababa, Ethiopia: a cross-sectional study. Environ Health Prev Med. 2020 Dec;25(1):33. Available from: https://doi.org/10.1186/s12199-020-00866-5

6. Wami SD, Abere G, Dessie A, Getachew D. Work-related risk factors and the prevalence of low back pain among low wage workers: results from a cross-sectional study. BMC Public Health. 2019;19(1):1–9. Available from: https://doi.org/10.1186/s12889-019-7430-9

7. Arcangeli G, Montalti M, Sderci F, Giorgi G, Mucci N. Risk Assessment in an Industrial Hospital Laundry. In Springer; 2019. p. 438–45. Available from: https://doi.org/10.1007/978-3-319-96083-8_57

8. Mahestri S, Jayanti S, Wahyuni I. Hubungan Berat Beban, Frekuensi Angkat, Postur Kerja Dengan Keluhan Thoracic Outlet Syndrome Pada Penambang Pasir Tradisional Desa Banjarparakan. J Kesehat Masy. 2021 Jan 6;9(1):72–8. Available from: https://ejournal3.undip.ac.id/index.php/jkm/article/view/28596

9. Descatha A, Evanoff BA, Leclerc A, Roquelaure Y. Occupational Determinants of Musculoskeletal Disorders. In: Bültmann U, Siegrist J, editors. Handbook of Disability, Work and Health [Internet]. Cham: Springer International Publishing. 2020;169–88. (Handbook Series in Occupational Health Sciences). Available from: https://doi.org/10.1007/978-3-030-24334-0_8

10. Chaitanya MK. Designing and Evaluating an Ergonomic Intervention to Minimise Risk of Musculoskeletal Disorders in Indian Small and Medium Scale Cashew Nut Processing Mills [Internet] [Thesis]. 2022 [cited 2023 Sep 11]. Available from: https://shodhganga.inflibnet.ac.in/bitstream/10603/424833/1/01_fulltext.pdf

11. Purwati K, Ipaljri Saputra A, Taolin A. Hubungan Antara Postur Kerja Dengan Keluhan Musculoskeletal Disorders Pada Pekerja Laundry Di Kecamatan Batam Kota Kota Batam 2023. Zona Kedokt Program Studi Pendidik Dr Univ Batam. 2023 Jul 22;13(2):392–401. Available from: https://doi.org/10.37776/zked.v13i2.1180

12. Gumilang PGA. Gambaran Tingkat Risiko Musculoskeletal Disorders (MSDs) Berdasarkan Metode Reba Saat Proses Menyetrika Pada Pekerja Laundry Di Denpasar, Bali. 2020. Available from: https://jurnal.harianregional.com/eum/full-71943

13. Oranye NO, Bennett J. Prevalence of work-related musculoskeletal and non-musculoskeletal injuries in health care workers: the implications for work disability management. Ergonomics. 2018;61(3):355–66. Available from: https://doi.org/10.1080/00140139.2017.1361552

14. Urban E. The condition of female laundry workers in Ireland 1922-1996: A case of labour camps on trial. Études Irl. 2012;(37–2):49–64. Available from: https://doi.org/10.4000/etudesirlandaises.3143

15. Tamene A, Afework A, Mebratu L. A qualitative study of barriers to personal protective equipment use among laundry workers in government hospitals, Hawassa, Ethiopia. J Environ Public Health. 2020;2020:1–8. Available from: https://doi.org/10.1155/2020/5146786

16. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon. 1987 Sep 1;18(3):233–7. Available from: https://doi.org/10.1016/0003-6870(87)90010-X

17. Shobur S, Maksuk M, Sari FI. Faktor Risiko Musculoskeletal Disorders (MSDs) Pada Pekerja Tenun Ikat Di Kelurahan Tuan Kentang Kota Palembang. J Med Media Inf Kesehat. 2019 Nov 30;6(2):113–22. Available from:

https://doi.org/10.36743/medikes.v6i2.188

18. Tarwaka, Solikhul HA, Sudiajeng L. Ergonomi untuk Keselamatan, Kesehatan dan Produktivitas. Surakarta: UNIBA Press; 2004. Available from: https://library.uniba-bpn.ac.id/index.php?p=show_detail&id=13519
19. Zhang M, Shan B, Lin S, Xu J, Zhang N. Nutrition and metabolism in musculoskeletal disorders. Front Nutr. 2023;10:1269939. Available from: https://doi.org/10.3389/fnut.2023.1269939
20. Calvo-Lobo C, Becerro-de-Bengoa-Vallejo R, Losa-Iglesias ME, Rodríguez-Sanz D, López-López D, San-Antolín M. Biomarkers and Nutrients in Musculoskeletal Disorders. Nutrients. 2021;13(2):283. Available from: https://doi.org/10.3390/nu13020283
21. Tandirerung FJ, Male HDC, Mutiarasari D. Hubungan Indeks Massa Tubuh Terhadap Gangguan Muskuloskeletal Pada Pasien Pralansia dan Lansia di Puskesmas Mamonji Palu. J Kesehat Tadulako. 2019;5(2):9–17. Available from: https://jurnal.fk.untad.ac.id/index.php/htj/article/view/115
22. To KE, Berek NC, Setyobudi A. Hubungan Masa Kerja, Jenis Kelamin dan Sikap Kerja dengan Keluhan Muskuloskeletal pada Operator SPBU di Kota Kupang. Media Kesehat Masy. 2020 Nov 20;2(2):42–9. Available from: https://media.neliti.com/media/publications/330953-hubungan-masa-kerja-jenis-kelamin-dan-si-c0e025a8.pdf
23. Wulan M, Hilal S. Perbandingan Keluhan Low Back Pain pada Pekerja Batik Tulis dan Cap di Kecamatan Danau Teluk Kota Jambi Tahun 2020. 2020. Available from: https://e-journal.ivet.ac.id/index.php/ijheco/article/download/1391/1037
24. Saputra A. Sikap Kerja, Masa Kerja, dan Usia terhadap Keluhan Low back pain pada Pengrajin Batik. HIGEIA J Public Health Res Dev. 2020 Oct 1;4(Special 1):147–57. Available from: https://journal.unnes.ac.id/sju/higeia/article/view/36828
25. Mourad BH. Prevalence of work-related musculoskeletal disorders among Egyptian printing workers evidenced by using serum biomarkers of inflammation, oxidative stress, muscle injury, and collagen type I turnover. Toxicol Ind Health. 2021 Jan 1;37(1):9–22. Available from: https://doi.org/10.1177/0748233720977399
26. Zulhijjah A. Faktor Yang Berhubungan Dengan Keluhan Musculoskeletal Disorders Pada Pekerja PT. PLN (Persero) Unit Layanan Transmisi Dan Gardu Induk Jeneponto. [Makassar]: Universitas Hasanuddin; 2021. Available from: http://repository.unhas.ac.id:443/id/eprint/6009

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Safety measures in the workplace: a case study of Federal Road Safety Corps (FRSC) vehicle plate manufacturing plant, Ojodu – Lagos, Nigeria

Adje DU[1], Anyalebechi CJ [2], Williams FE[3]

[1]Department of Clinical Pharmacy and Pharmacy Administration, Delta State University, Abraka, Nigeria
[2]Federal Road Safety Corps, Lagos, Nigeria
[3]Department of Clinical Pharmacy and Pharmacy Practice, University of Ilorin, Ilorin, Nigeria

Corresponding author:
Adje U David,
Delta State University, Abraka
Nigeria
Tel.: +2348023241125,
E-mails: a_udave77@yahoo.com, duadje@delsu.edu.ng
ORCID ID: https://orcid.org/0000-0002-4196-2703

Date of submission: 10.02.2023
Date of acceptance: 06.11.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.52192

ABSTRACT

Introduction: Hazards associated with vehicle number plate manufacturing processes in developing countries have not been well elucidated. There is a need to investigate hazards in the vehicle number plate manufacturing plant. The study aimed to identify self-reported hazards in the vehicle plate manufacturing factory, explore their effect on workers' health and recommend mitigation strategies.

Methods: A descriptive cross-sectional study of workers in the vehicle plate manufacturing plant was done to identify hazards, protective measures and self-reported effects on workers' health. Biochemical analysis of blood samples was also done and outliers were noted. ANOVA test was performed to determine differences in mean values of selected biochemical parameters. A p-value of less than 0.05 was considered statistically significant.

Results: Exposure to toxic chemicals 38 (69%), excessive noise 36 (65%) and heat 28 (51%) were the major hazards in the factory. Major health problems were stress and fatigue 41 (71%), skin disorders 28 (51%), respiratory problems 18 (33%) and hearing loss 16 (29%). More than one quarter, 17 (30 %) of the workers admitted not using personal protective equipment (PPE) regularly. Periodic medical tests were not done for 13 (24%) of the workers. Potassium (3%), Urea (10%), Creatinine (7%), Aspartate transaminase (18%) and Alanine transaminase (8%) were elevated among the workers but no significant association could be established between elevated levels and work post.

Conclusion: Workers in the plate number manufacturing plant were mostly exposed to toxic chemicals and noise. Elevated electrolyte levels cut across departments. There is a need for better enforcement of safety rules, and periodic medical examinations should be conducted more consistently.

Keywords: Biochemical parameters, Hazards, PPE, Safety and health, Toxic Chemicals

Introduction

One of the functions of the Federal Road Safety Corps (FRSC) of Nigeria is the production of vehicle plate numbers.[1] The FRSC factories located in different parts of the country manufacture uniform plate numbers for different categories of vehicles.[2]

Potential health hazards associated with number plate manufacture could be biological, chemical, physical, biochemical, or psychosocial. The hazards affecting workers in the vehicle plate manufacturing factory arise from the raw materials used in the production process. The raw

materials include aluminum sheets, reflective sheeting, 3M roll coat color 4856 opaque blue and thinner 4954. The process begins with straightening the roll of raw stock aluminum sheets to remove dents. Then the aluminum rolls are cut into individual rectangular-shaped license plates with the aid of a blanking press. Original images such as state and country names, national flags etc. are then printed on the plate. Embossing involves using steel dies to create raised characters such as alphabets and numbers for each flat plate with the aid of a hydraulic embossing press. A roll coating machine is then used to apply solvent-based ink to the raised portions of the embossed plate. 3M™ roll coat inks are used with 3M™ reflective license plate sheeting to produce fully reflective, long-lasting vehicle registration plates. Roll coat inks may be thinned with 3M 4954 thinner for ease of coating. Oven drying is the last step in the process.

Workers are exposed to organic solvents that may cause a variety of symptoms. The symptoms range from transient (euphoria, headache, and dizziness) to serious symptoms (fainting, respiratory and circulatory failure). Toluene and acetone are the most abundant compounds in commercial thinners used in plate manufacturing plants. Cumene 1,2,4 Trimethylbenzene, toluene, and xylenes (BTXs) are known carcinogens and long-term exposure may cause damage to the Central Nervous System (CNS), such as cognitive and emotional deficits. Other less serious but equally important hazards are cuts and bruises from handling the aluminum sheets, noise and vibration from heavy machinery, collisions or falls while driving forklifts used to carry heavy materials, heat from ovens used to dry the plates after coating and ergonomic hazards including musculoskeletal strains from repetitive awkward movements involved in the production process.[3-4] Published statistics of hazards associated with industrial processes are sobering. Every year about 2.3 million people globally die from unintentional injuries at work and work-related diseases. Non-fatal workplace accidents affect some 268 million people annually.[5-6] The annual cost of job accidents to the global economy is a staggering 1.25 trillion dollars and indirect costs can be four to ten times greater than the direct costs.[7] The daily toll of occupational accidents, injury, or ill health is approximately 860,000.[8]

Some of the industries with the highest risk of accidents worldwide are mining, agriculture, including forestry and logging, and construction.[9] Although workplace accidents are a global phenomenon, fatal injury rates are 3–4 times higher in developing countries than the developed.[6] Africa is especially beleaguered with unsafe working conditions in industries.[6] Despite recent improvements in occupational safety and the enactment of worker-friendly labor laws, employers generally assume little responsibility for the protection of workers' health and safety.[10] As a key member of the International Labor Organization (ILO), Nigeria is expected to implement the provisions of the body regarding the safety and health of workers.[7] However, it is not clear to what extent this is being done, largely because of inadequate accident data, poor disease recognition, and sub-optimal or non-existent record-keeping and reporting mechanisms.[10-11]

This study was carried out to identify the specific hazards and risks peculiar to workers in the number plate production factory and to recommend measures that can minimize or eliminate such hazards to reduce the negative impact on the health of the workers.

Methods

The study was conducted in the Federal Road Safety Corps Vehicle Plate Manufacturing Plant, Ojodu – Berger in Ikeja Local Government Area (LGA) of Lagos State, Nigeria. The plant was established in 1993 and currently has a total of 103 workers. The factory produces plate numbers for all categories of vehicles and all states in the federation.

There is a staff clinic located within the FRSC premises where staff can assess healthcare in the event of an accident. In addition, each staff is enrolled under the National Health Insurance Scheme (NHIS) and is entitled to receive medical

care for themselves and their families from any hospital of their choice.

The study was done in two phases. One phase was a descriptive cross-sectional study extracting information about the work processes, hazards, protective measures and self-reported effects on the health of workers at the vehicle plates manufacturing factory.

For this aspect of the study, a pre-tested structured self-administered questionnaire designed by the authors based on a literature search was used to collect data from the study participants. Pre-testing was done among 15 workers in the Abuja plate manufacturing plant. The questionnaire had two sections. Section A collected demographic data while Section B addressed issues of hazard exposure, self-reported incidence of accidents, availability and use of Personal Protective Equipment (PPE) and other preventive measures at the disposal of the factory workers. There were no personal details on the questionnaire to ensure confidentiality. Participation was voluntary. The aim of the study was explained to each participant and all who agreed to participate by signing a written informed consent form were enrolled for the study. The take-home, self-administered questionnaires were returned within a few days at the workers' convenience since filling the questionnaire during work hours could disrupt the factory workflow. Completed and usable questionnaires were retrieved for data analysis.

The second phase involved the collection of blood samples from employees for analysis to determine plasma levels of electrolytes and biomarkers of organ damage resulting from exposure to potentially hazardous chemicals. This phase was made mandatory for all workers by the management and therefore all 103 workers employed in the factory participated.

A volume of 2 ml of venous blood was collected aseptically from each participant after an overnight fast (12-16 hours). The sample was dispensed into a red-top Vacutainer and allowed to clot. The sample was then centrifuged at 3000 rpm for 10 minutes using a table centrifuge to separate the serum from the whole blood. The serum was pipetted into sterile containers using a micropipette and stored at 20^0C until biochemical analysis could be performed. Serum levels of sodium, potassium, chlorine, uric acid, blood urea, creatinine, aspartate transaminase (AST), alanine transaminase (ALT) and inorganic phosphorus were determined using the Semi-automatic Biochemistry Analyzer Chem 5v3 (Erba Diagnostic Incorporated Mannheim, Germany).[12] The values obtained were compared to standard values and deviations from normal were noted.

The data collected was entered into Microsoft Excel and was double-checked for accuracy. Categorical data was presented as frequency and percentages while continuous data from the biochemical assays were expressed as means and standard deviation. The departments were divided into three groups and a one–way Analysis of Variance (ANOVA) was used to compare mean biochemical values. A p-value of less than 0.05 was considered statistically significant. Outliers were also calculated from the reference ranges given to determine their deviation from normal.

Ethical approval for the study was granted by the Health Research Committee of the Lagos State University Teaching Hospital with ethical approval no. NHRECO4/04/2008. All participants were informed of the objectives and nature of the tests and written informed consent forms were obtained. The participants were also informed that they were free to withdraw at any time.

Results

A total of 103 workers comprising 88 males (85.4%) and 15 females (14.6%) were employed in the factory, but only 80 workers were willing to participate in the questionnaire-based survey since this aspect of the study was not mandatory. Of these, fifty-five (55) questionnaires consisting of 47 (85.5%) males and 8 (14.5%) females were retrieved giving a response rate of 68.8%. The low response rate was because the questionnaires were self-administered and workers were allowed to take them home and return them within a few days in order not to interfere with production processes during working hours. Many workers

did not return the questionnaires because of their low level of education and the misunderstanding that their health status was being audited despite explanations to the contrary.

The majority of the workers were males 47 (85.5%) and married 48 (87.3%). The predominant age group was age 31-40 years 21 (38.2%) followed by 41-50 years 18 (32.7%). The highest academic qualification obtained was Bachelor of Science (BSc) 13(23.6%), followed by Higher National Diploma (HND) 11(20%). More than half of the workers had been employed in FRSC for 11-20 years 30 (54.5%). Nearly half, 24(43.6%) had worked for between 6-10 years. Core production departments were Blanking 6 (11%), Screen Printing 6 (11%), Embossing 6 (11%), Packaging and Dispatch 7 (13%), and Coating 4 (7%), (Table 1).

Table 1: Socio-demographic characteristics of factory workers, n = 55

Characteristic	Frequency (%)
Gender	
Male	47 (85.5)
Female	8 (14.5)
Age (years)	
21-30	7 (12.7)
31-40	21 (38.2)
41-50	18 (32.7)
51-60	9 (16.4)
Marital Status	
Single	6 (10.9)
Married	48 (87.3)
Separated/Divorced	1 (1.8)
Level of Education	
School Certificate	10 (18.2)
NCE	5 (9.1)
OND	7 (12.7)
HND	11 (20)
Bachelor	13 (23.6}
Postgraduate	9 (16.4)
Number of working years in the factory	
1-5 years	25 (45.5)
6-10 years	24 (43.6)
10 or more years	6 (10.9)
Departments	
Blanking	6 (10.9)
Embossing	6 (10.9)
Screen Printing	6 (10.9)
Coating	4 (7.3)
Inspection and packing	4 (7.3)
Dispatch	3 (5.5)
Departments outside production	26 (47.2)

A majority, 52 (93%) of the workers agreed that they were mostly exposed to occupational hazards. Of these, 38 (69%) reported being exposed to chemicals considered toxic, 36 (65%) to noise and 28 (51%) to excessive heat, 24 (43%) to poor ventilation, 38 (69%) to toxic chemicals, 16

(29%) to vibrations from heavy machinery and 16 (29%) believed they were excessively exposed to particulate matter of metallic nature.

Additionally, a majority of the workers, 53 (96%) said they were provided with PPE. Specifically, 54 (98%), 22 (39%), 45 (81%) and 42 (77%) were provided with safety boots, helmets, and hand gloves respectively. Also, 36 (66%), 29 (53%), and 18 (32%) were provided with work coats (overalls), ear muffs, and face shields respectively. Although nearly three-quarters 39 (70%) use PPE regularly, 17 (30%) of workers admitted not using PPE. Pre-employment medical test was done for three quarters, 41 (75%) of workers while periodic medical tests were not done for only 13 (24%) of workers.

Stress and fatigue were the most commonly self-reported health problems among factory workers 39 (71%), followed by machine injuries 35 (64%), chemical burns 28 (51%), skin disorders 28 (51%), respiratory problems 18 (33%), hearing impairment 16 (29%), slips, trips and falls 13 (24%), impaired vision, musculoskeletal injuries 12 (22%), and risk of fire, explosions. Actions taken by victims of industrial accidents in the past included receiving treatment in the FRSC Clinic 42, (76%), receiving First Aid on the factory floor 36 (65%), and referral to the hospital 18 (33%). Only 1 (2%) admitted concealing his injuries while 2, 4% did not know what to do.

More than half 32 (58%) of factory workers were aware of safety measures put in place by the company. Some of these interventions mentioned were a provision of one capsule of multivitamins per day for one month 40 (72%), one tin (157 ml) of milk daily for one month 33 (60%), a first aid box 19 (35%), FRSC Clinic/Health and Safety Officer 12 (22%), and fire extinguishers 9 (16%).

Biochemical analyses of blood samples were carried out on all 103 workers in the factory. A majority 88 (85.4%) were males while 15 (14.6%) were females. The results showed outliers outside normal reference values. The clinically significant deviations were sodium (hypernatremia 7%, hyponatremia 9%); potassium (hyperkalemia 3%, hypokalemia 24%); uremia 10%, and elevated creatinine, AST and ALT levels, 7%, 18% and 8% respectively (Figures 1-6). Other deviations include chloride 15%, uric acid (32%) and inorganic phosphorus (12%).

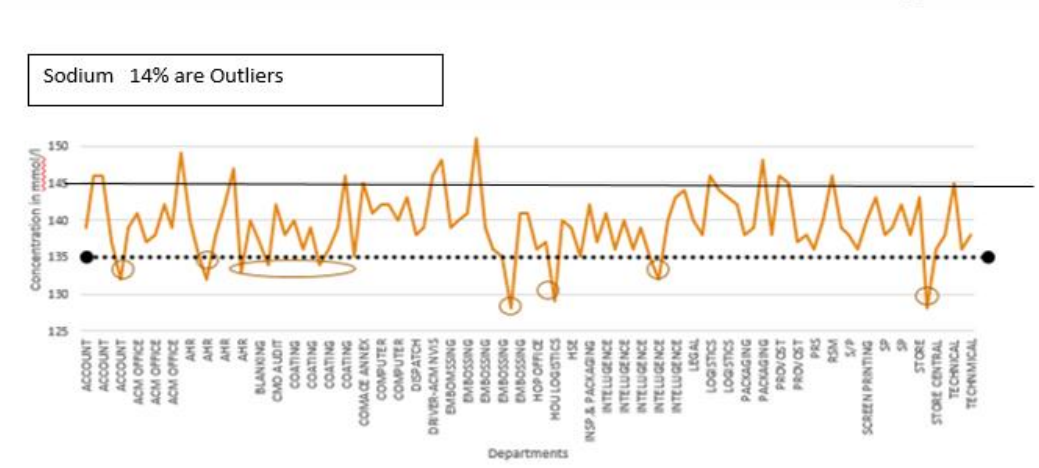


Figure 1: Biochemical analysis of sodium showing 14% outliers from the reference range

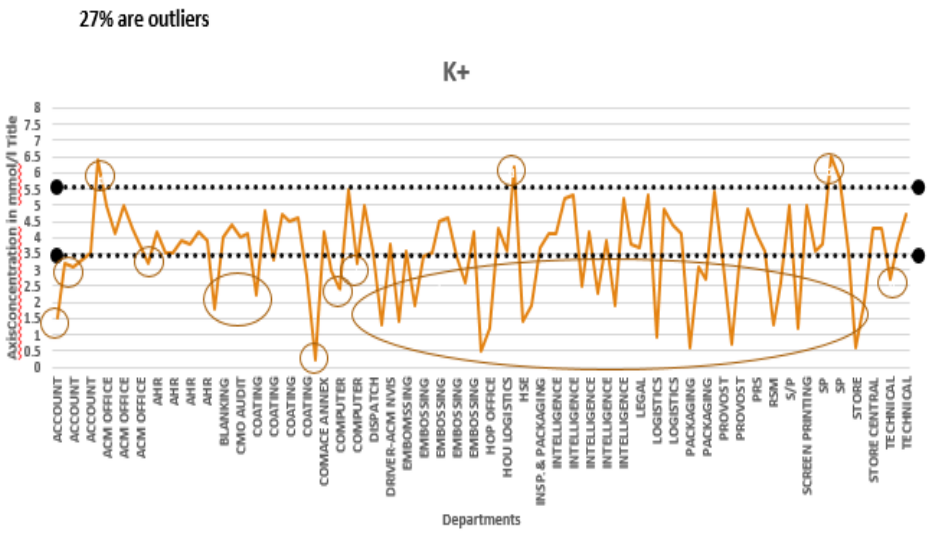


Figure 2: Biochemical analysis of potassium showing 27% outliers from the reference range

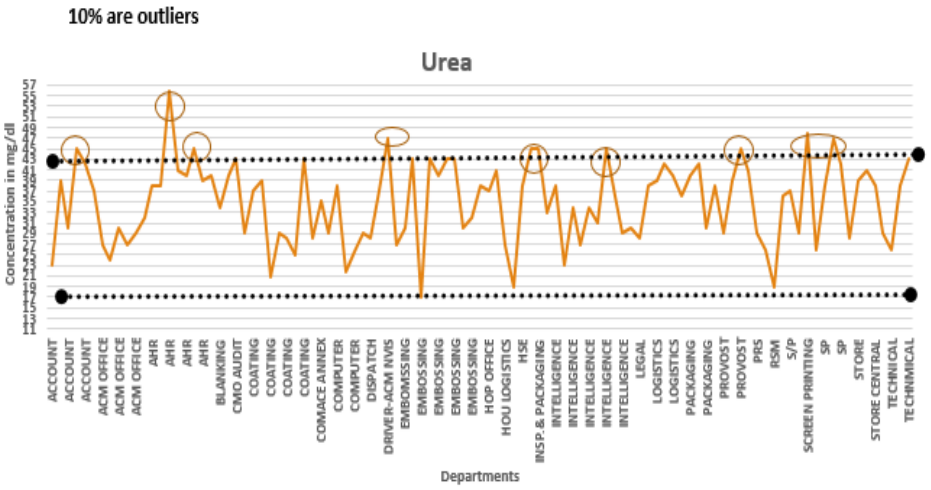


Figure 3: Biochemical analysis of urea showing 10% outliers from the reference range

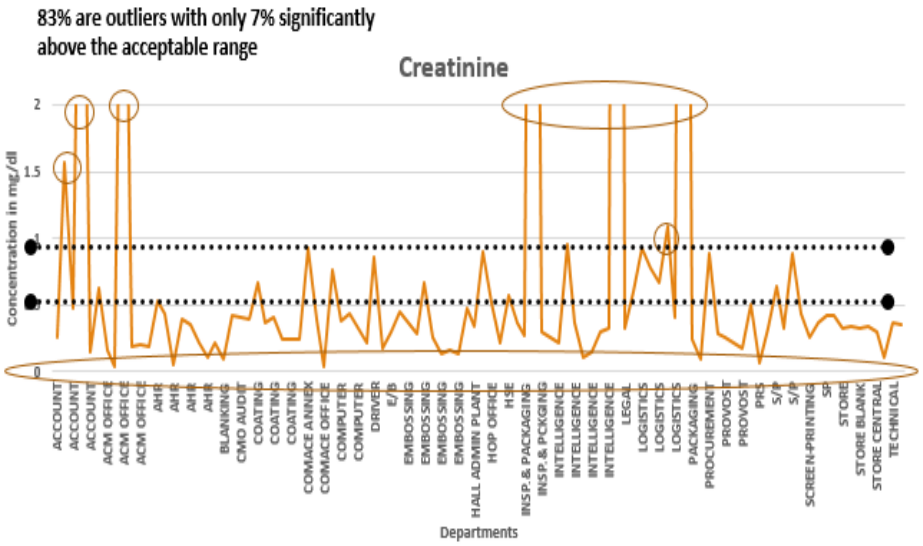


Figure 4: Biochemical analysis of creatinine showing 83% outliers with 7% significantly above the reference range

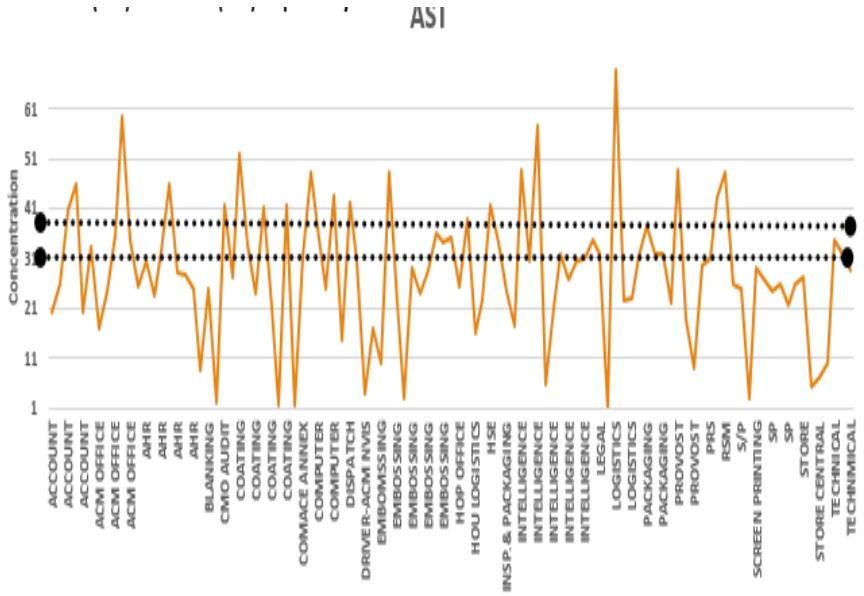


Figure 5: Biochemical analysis of aspartate transaminase(AST) showing 18% outliers

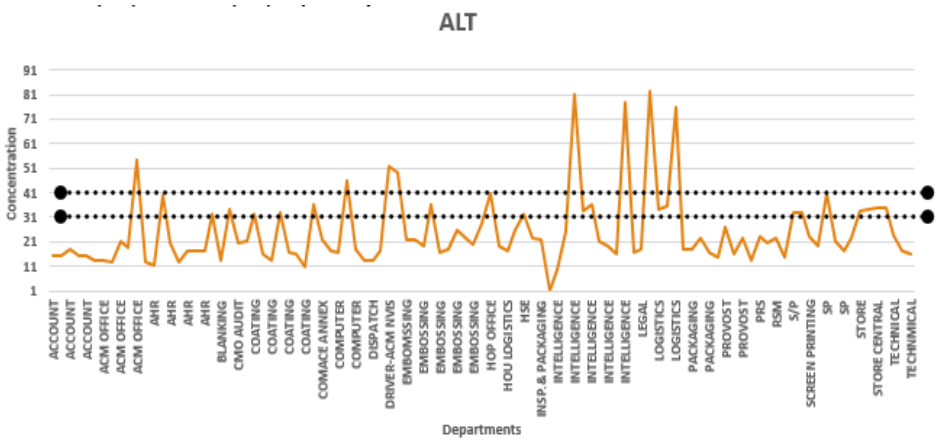


Figure 6: Biochemical analysis of alanine transaminase(ALT) showing 8% outliers

The biochemical values obtained from the biochemical analysis of workers' blood samples stratified by departments are shown below (Table 2).

Except for alanine transaminase, there were no statistically significant differences in mean biochemical values for workers in the production department compared with other units.

Table 2 Biochemical analysis of workers' blood samples stratified by departments n=103

	Departments + Biochemical Values Mean (SD) *			F	p-value
	Production	Logistics	Administration		
Na+	139.08(4.25)	139.32(4.55)	140.03(4.3)	F(2,100)=15	0.86
K+	3.41(1.41)	3.61(1.41)	3.63(1.31)	F(2,100)=0.03	0.97
Cl	96.13(6.33)	97.16(5.15)	96.71(5.35)	F(2,100)=1	0.37
Uric acid	2.82(1.77)	3.09(1.93)	2.91(1.23)	F(2.100)=0.17	3.09

Urea	35.95(7.54)	34.49(6.64)	34.03(8.38)	F(2.100)=0.49	3.09
Creatinine	0.89(2.25)	0.96(3.13)	0.67(1.13)	F(2.99)= 0.12	3.09
AST	26.38(12.43)	27.21(15.54)	31.01(12.08)	F(2.100)=0.94	3.09
ALT	22.94(9.69)	31.40(20.73)	21.21(10.24)	F(2.100)=5.04	0.01
Inorganic Phosphorus	0.40(0.43)	0.40(0.43)	0.79(1.96)	F(2.100)=0.75	0.48

KEY: * Na+: Sodium; K+: Potassium; Cl-: Chlorine; AST: Aspartate transaminase; ALT:Alanine Transaminase

+Production – Blanking, Screen printing,Coating, Inspection and Packaging departments
Logistics - Dispatch department and Store
Administration - Accounts, HSE, Legal Human resource and Medical

Discussion

This study was designed to identify the hazards affecting workers in the vehicle plate manufacturing factory, particularly from the use of raw materials such as aluminum sheets, solvents, thinners and dyes. The common hazards affecting workers were identified to be high light intensity, poor ventilation, heavy machinery, and excessive metal exposure with the highest hazard exposure reported to be toxic chemicals, noise and high-intensity heat.

Toxic chemicals and solvents associated with the processes of screen printing and coating include dyes, toluene, xylene, ketones, alcohols, esters, and glycol ethers.[13] Dyes may cause skin reactions, eye, nose and throat irritations, headache and nausea. They also have the potential to be carcinogenic and teratogenic.[14-15] Some of these symptoms were reported in our study population. Nearly three-quarters of respondents complained of stress and fatigue, skin disorders and chemical burns and more than half reported respiratory symptoms.

Thinners are solvents used to reduce the viscosity of dyes. They have the potential to cause skin or eye irritations, respiratory irritation and central nervous system depression. Solvent exposure is related to adverse disorders of the skin, lung, kidney and nervous system.[16]

Previous studies exploring negative health symptoms associated with factory workers and painters noted an increased incidence of neuropsychological symptoms including impairments of memory, perceptual speed, manual dexterity, psychomotor coordination, nonverbal skills and a decrease in olfactory functions.[17] PPE such as face mask, gloves and coverall should be worn at all times to reduce exposure. Also, women in the reproductive age group should not be allowed to work directly with the dyes and solvents.

Noise-induced hearing loss is one of the commonest occupational health hazards caused either by a one-time exposure to very loud sound or by repeated exposure to various loudness levels over a long period.[18] High noise levels can be a stressor causing hypertension, fatigue, dizziness and headaches. Ear muffs and plugs should be used all the time around noisy machinery. The amount of exposure time should also be limited.

Excessive heat exposure can be from the weather or from heat-generating machines and processes such as in the use of ovens in drying the plates and blanking machines used in cutting the aluminum sheets to size. Excessive heat can lead to mental health problems, and chronic kidney and cardiovascular disease. It can also lead to irritability, fatigue, lack of coordination and concentration.[19] Some helpful preventive measures would be to install fans, and ensure there is adequate cross ventilation. Making available cold drinks and rest areas to enable

workers to refresh while taking short breaks could also be helpful.

This study also established that some preventive measures were already in place in the factory. The majority of the respondents agreed that they were provided with PPE such as safety boots, helmets, hand gloves, coveralls, goggles, ear plugs /muffs and face shields while nearly three-quarters agreed they used them. The use of PPE is strongly recommended and is usually in conjunction with one or more of the other control measures.[20-21] The consequences of not following these practice guidelines could be fatal.

A monthly supply of thirty cans of 157 ml evaporated milk and 30 multivitamin capsules was provided for each factory worker. A daily intake of these might be intended to ameliorate the potential effect of lead on workers' health.[22] Lead is a component of most paints and dyes.[23] Leaded compounds most commonly added to solvent-based paints are pigments.[23] Pigments are used to give the paint its color, make the paint opaque (so it covers well), and protect the paint and the underlying surface from degradation caused by exposure to sunlight. Lead-based pigments are sometimes used alone or in combination with other pigments. A study carried out to check the influence of milk on lead toxicity revealed that drinking about 2 bottles of milk per day might have a protective effect against lead-induced peripheral neurotoxicity.[20] Also, multivitamins have been shown to help relieve stress, therefore their use in this instance seems justified.[24]

The results of biochemical analysis on the blood samples of workers showed deviations above and below normal values. Decreased levels of Na+, K+ and Cl- may produce symptoms such as headache, confusion, restlessness, weakness, irregularities in heartbeat and muscle cramps.[25-26] Some workers in this study experienced fatigue and musculoskeletal pains which could be attributable to derangements in electrolyte levels.

Elevated blood levels of urea, creatinine, ALT and AST observed for between 7% - 10% of the workers were not significantly associated with work post. Workers outside the factory were just as likely to have elevations in biochemical parameters as those who worked in the factory. This might be an indication of the effectiveness of safety measures among factory workers but this finding also emphasizes the need for all workers, whether directly involved in production or not, to take precautionary measures whenever they are in the factory environment. Regular visitors would also need to put on complete PPE whenever they are in the work environment.

It was also noted that only about 10% of workers had worked in the factory for 11 and more years. This might indicate that the majority of workers are not left in the factory for too long to break the cycle of exposure to hazards. However, there is a need for more frequent rotation of workers as nearly 50% had spent between 1 and 5 years at their duty post.

The limitations of this study include the fact that hazards identified in the factory were self-reported by the workers. Scientific measurement of hazards using appropriate instruments such as an industrial thermometer, digital sound level monitor, and a vibrometer would have produced a more valid assessment. Also, the low participation and response of workers to the survey aspect of the study arising from the fact that the questionnaire was self-completed instead of interviewer-administered, as well as fear of job loss should they disclose any work-related ailments allows for only a limited generalization of the findings from this study. In addition, the small sample size of the study limits the application of the findings to all factory working environments.

Conclusions

Hazards present at the FRSC vehicle plate manufacturing factory include exposure to toxic chemicals, excessive exposure to heat and noise, stress, fatigue and machine injuries. Safety measures available in the plate manufacturing factory were the adoption of safe procedures and processes, medical check-ups, presence of a health and safety officer, provision of PPE as well as

multivitamins and milk supplements. Even though PPE was available, utilization was sub-optimal. Pre-employment, pre-placement and periodic medical checkups were not fully implemented.

To improve workplace safety and mitigate hazards, enforcement of safety measures including regular use of PPE, more frequent periodic medical examinations and rotation of work posts as well as educational interventions to both employees and management are recommended.

Acknowledgments

The authors are grateful to the management and staff of the Federal Road Safety Corps (FRSC) Vehicle Plate Manufacturing Plant, Ojodu for their cooperation and to the clinic staff for facilitating sample collection and biochemical analysis.

References

1. Federal Road Safety Commission Establishment Act 2007. Article 10(2). Available from: https://frsc.gov.ng/FRSCACT2007.pdf
2. Balogun S. The relevance of national vehicle identification scheme (NVIS) and customized national drivers' license (CNDL) in national security process. Available from: https://www.academia.edu/3584030/
3. Martínez-Alfaro M, Alcaraz-Contreras Y, Cárabez-Trejo A, Leo-Amador GE. Oxidative stress effects of thinner inhalation. Indian Journal of Occupational and Environmental Medicine . 2011 Sept-Dec;15(3):87–92. Available from: https://doi.org/10.4103%2F0019-5278.93195
4. Hassan AAEH, Elnagar SAEM, Tayeb IME, Bolbol SAEH. Health Hazards of Solvents Exposure among Workers in Paint Industry. Open Journal of Safety Science and Technology . 2013 Dec 13; 3(4):87–95. Available from: http://dx.doi.org/10.4236/ojsst.2013.34011
5. International Labor Organization (ILO). Safety and health at the heart of the future of work: Building on 100 years of experience Switzerland, Geneva (2019). Available from: https://www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_678357.pdf
6. Berhan E. Prevalence of occupational accident; and injuries and their associated factors in iron, steel and metal manufacturing industries in Addis Ababa. Cogent Engineering. 2020; 7():. Available from: htpps://doi.org/10.1080/23311916.2020.1723211
7. ILO: Work hazards kill millions, cost billions. Available from: https://www.ilo.org/global/publications/world-of-work-magazine/articles/WCMS_081326/lang--en/index.htm
8. Safety and health at work: a vision for sustainable prevention. XX world congress on safety and health at work 2014: Global Forum for Prevention, 24 - 27 August 2014, Frankfurt, Germany / International Labour Office. Geneva: ILO, 2014. Available from: https://www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/publication/wcms_301214.pdf
9. United States Department of Labour. Recommended practices for safety and health programs. Available from: http://www.osha.gov/shpguidelines
10. LaDou J, London L, Watterson A. Occupational health: a world of false promises. Environ Health. 2018 Nov 21; 17(1):. Available from: https://doi.org/10.1186/s12940-018-0422-x
11. Bloom DE, Cafiero ET, Jané-Llopis E, Abrahams-Gessel S., Bloom LR, Fathima S, et al. . The global economic burden of non-communicable diseases. Geneva: World Economic Forumand the Harvard School of Public Health. Available from: https://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomicBurdenNonCommunicableDiseases_2011.pdf
12. Semi-automatic Biochemistry Analyzer Chem5v3 (Erba Diagnostic Incorporated Mannhein, Germany). Available from: https://www.erbamannheim.com

13. Park H, Park HD, Jang JK. Exposure characteristics of construction painters to organic solvents. Safe and Health at Work. 2016 Mar; 7(1):63-71. Available from: http: //doi: 10.1016/j.shaw.2015.10.004

14. Ma nzoor, J., & Sharma, M. Impact of textile dyes on human health and environment. Impact of textile dyes on public health and the environment. 2020 Jan: 162-9.Available from: https://doi.org/10.4018/978-1-7998-0311-9.ch008. 2020

15. Lellis B, Fávaro-Polonio CZ, Pamphile JL, Polonio JC, Effects of textile dyes on health and the environment and bioremediation potential of living organisms. Biotechnology Research and Innovation. 2019; 3(2):275-90. Available from: https://doi.org/10.1016/j.biori.2019.09.001

16. Joshi DR and Adhikari N. An overview on common organic solvents and their toxicity. Journal of Pharmaceutical Research International 2019; 28(3):1-18. Available from: https://doi.org/10.9734/jpri/2019/v28i330203

17. Awodele O, Popoola TD, Ogbudu BS, Akinyede A, Coker HA, Akintonwa A. Occupational hazards and safety measures amongst the paint factory workers in Lagos, Nigeria. Safety and Health at Work. 2014 Jun; 5(2):106-11. Available from: htpps: //doi: 10.1016/j.shaw.2014.02.001

18. National Institute for Occupational Safety and Health (NIOSH) and Centers for Disease Control and Prevention (CDC). Workplace safety and health topics. Noise and hearing loss prevention. Available from: https://www.cdc.gov/niosh/topics/noise/default.html

19. Xiang J, Bi P, Pisaniello D, Hansen A. Health impacts of workplace heat exposure: an epidemiological review. Ind. Health. 2014; 52(2):91-101. Available from: https://doi.org/10.2486/indhealth.2012-0145

20. Shrestha BR, Manandhar N, Joshi SK. Knowledge of occupational health hazards and practice of personal protective equipment among fabrication workers in Kathmandu district, Nepal. International Journal of Occupational Safety and Health, 2020, 10(2):115-23. Available from: https://doi.org/10.3126/ijosh.v10i2.33330

21. Khanal A, Sondhi A, Giri S. Use of personal protective equipment among waste workers of Sisdol landfill site of Nepal. International Journal of Occupational Safety and Health. 2021; 11(3): 158-64. Available from: https://doi.org/10.3126/ijosh.v11i3.39768

22. Chuang HY, Tsai SY, Chao KY, Lian CY, Yang CY, Ho CK, Wu TN. The influence of milk intake on the lead toxicity to the sensory nervous system in lead workers. Neurotoxicology. 2004 Dec; 25(6):941-9. Available from: https://doi.org/10.1016/j.neuro.2004.04.003

23. IPEN Global Lead Paint Elimination Report. Lead in solvent-based paints for home use. Available from: https://ipen.org/sites/default/files/documents/ipen-global-lead-report-2020-v1_2-en.pdf Sweden

24. Ford TC, Downey LA, Simpson T, McPhee G, Oliver C, Stough C. The effect of a high-dose vitamin B multivitamin supplement on the relationship between brain metabolism and blood biomarkers of oxidative stress: a randomized control trial. Nutrients. 2018 Dec; 10(12):1860. Available from: https://doi.org/10.3390/nu10121860

25. Hasona NA, Elasbali A. Evaluation of electrolytes imbalance and dyslipidemia in diabetic patients. Med Sci (Basel). 2016 Jun; 4(2):7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5635780/

26. Raza M, Kumar S, Ejaz M, Azim D, Azizullah S, Hussain A. Electrolyte imbalance in children with severe acute malnutrition at a tertiary care hospital in Pakistan: A cross-sectional study. Cureus. 2020 Sep ; 12(9). Available from: htpps://doi.org/10.7759/cureus.10541

FIGURE LEGENDS:

Figures 1- 6

Output of biochemical assay from the Semi-automatic Biochemistry Analyzer Chem 5v3 (Erba Diagnostic Incorporated Mannheim, Germany). Two ml (2ml) of venous blood was collected aseptically, allowed to clot and centrifuged at 3000 rpm for 10 minutes. The resulting serum was stored in a freezer at 20^0C and fed into the analyzer. Dotted lines bounded by the black dots represent the upper and lower median serum levels of respective electrolytes. Peaks outside this range are regarded as outliers. The percentage is obtained by counting the number of peaks that fall outside the reference range.

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Review Article

Major Hazard Competent Person Profession in Malaysia: A document analysis of trends and demands

Rashid RM[1,2], Radin Umar RZ[2]

[1]Department of Occupational Safety and Health Malaysia, 62530, Putrajaya, Malaysia

[2]Fakulti Teknologi dan Kejuruteraan Industri dan Pembuatan, Universiti Teknikal Malaysia Melaka, 76100, Melaka, Malaysia,

Corresponding author:
Radin Zaid Radin Umar,
Dr, Fakulti Teknologi dan Kejuruteraan Industri dan Pembuatan , Universiti Teknikal Malaysia Melaka,
Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
Tel.: +60 18-217 9496,
E-mail: radinzaid@utem.edu.my
ORCID ID:https://orcid.org/0000-0002-7739-9326

Date of submission: 14.02.2023
Date of acceptance: 09.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.52503

ABSTRACT

Introduction: The Malaysian Control of Industrial Major Accident Hazard (CIMAH) Regulations introduced in 1996 resulted in the creation 'Major Hazard Competent Person' (MHCP) profession. However, after two decades of its establishment, there has been limited study conducted on this specific profession. The objectives of this study are to analyze 1) the trend of application and passing rates of MHCP registrations; and 2) the trend of Major Hazard Installations (MHI) registrations, and its relationship with available supply of registered MHCP.

Methods: The study used a document review approach, involving the extraction, examination, and interpretation of data from both published and unpublished documents by the Department of Occupational Safety and Health (DOSH), the regulatory body responsible for overseeing both MHCP and MHI registration status in Malaysia. The study looks into data from 1996 (beginning of 1996 CIMAH Regulation) to 2023, though the available data found and analyzed were from 1998 to 2021.

Results: The study reveals a concerning lack of growth in the number of professionals being certified as MHCP, despite an increase in the number of MHIs over the past two decades. Potential causes of this shortage identified include a demanding certification process, limited availability of MHCP competency courses, and a lack of clear career paths and growth opportunities in the profession.

Conclusion: The inadequate supply of MHCPs could potentially undermine their ability to provide sufficient coverage for MHIs, indirectly jeopardizing the quality of risk management in major hazard facilities. Therefore, there is merit in periodically reviewing the regulations and reforming the MHCP profession in response to changing trends.

Keywords: CIMAH Regulations, Competency, Major Hazard Competent Person, Major Hazard Installation, OSH Profession

Introduction

In Malaysia, facilities regularly handling substantial quantities of hazardous chemicals are categorized by the authorities as Major Hazard Installations (MHIs). These chemicals can cause fires, explosions, or the release of harmful substances, posing risks to people, structures, and the environment. Examples of MHIs include water treatment plants, chemical factories, petrochemical plants, and refineries. In 1996, Malaysia's Parliament enacted the Control of Industrial Major Accidents Hazard (CIMAH) Regulations under the Occupational Safety and Health Act, 1994.[1] This decision was influenced by several major hazard incidents in previous years, within Malaysia and abroad.[2-5] The Regulations aim to oversee preventive measures of the

potential major hazard occurrences in MHIs.

Malaysia's CIMAH Regulations were adopted from the UK's CIMAH Regulations (1984) and the International Labor Organization (ILO) major hazard control manual.[6] One notable distinction is Malaysia's mandate for a designated professional, known as the Major Hazard Competent Person (MHCP), to oversee MHI activities.[4,7] The certification process for MHCP is managed by the Department of Occupational Safety and Health (DOSH), in which candidates must demonstrate relevant competencies before receiving MHCP status.[8] The CIMAH Regulations define the responsibilities of the MHCP, including tasks like creating industrial reports, ensuring compliance, and preparing emergency response plans.[1,8] MHIs must consult with an MHCP before conducting any industrial activities, highlighting the significant role MHCPs play in ensuring Regulation compliance.[1]

Despite the significant roles of MHCP in the establishment of CIMAH Regulations for the last two decades, there have been very limited data-driven publications discussing the profession's career pathway and growth prospects. The article aims to analyze the: 1) trend of registration and passing rates of MHCP; and 2) trend of MHI registration, and its ratio with MHCP. This manuscript provides one of the first documented review analyses on the MHCP profession.

Methods

In this study, a qualitative method design of a document review approach was employed to analyze relevant data trends on MHCP over the past twenty years (1996-2023). The data sources in the qualitative analysis consisted of both hardcopy and online documents. As with other empirical research methods, this qualitative approach involved the identification, extraction, examination, and interpretation of textual data to gain understanding, elicit meaning, and develop empirical knowledge.[9] Similar qualitative method designs of document analysis approaches have been used in previous studies.[10-12]

The majority of the information used in this study was obtained from documents held by DOSH, the regulatory body responsible for overseeing MHCP registration status in Malaysia. The documents were divided into two categories: (1) published documents, such as annual reports, website and online portal information, and departmental statistical data, which are available to the public through DOSH publications; and (2) unpublished documents, such as older annual reports, internal circulars and internal lists of registered MHIs, which are only accessible for internal department reference. Special consent was obtained from the Head of the CIMAH Section to use the second category of documents in the study. As one of the research team members is an employee of the department, permission to access, analyze, and publish the data was granted by DOSH.

The collected data was carefully examined for the relevance of contents, with a particular focus on MHCP and MHI information. The relevant data was extracted and analyzed based on two main categories: (1) Trends of Major Hazard Competent Person Registration; and (2) Trends of Major Hazard Installations Registration, along with the MHCP: MHI Ratio. Although the search for relevant publications was conducted on documents available since 1993, the majority of the publications analyzed were published after 2000. This can be attributed to the fact that the CIMAH Regulation was established in 1996, and relevant data became available only after a few years of its inception.

In addition, personal communication was also established with W. Khafizah W. Abdullah, an officer from DOSH's assessment and competency unit of the CIMAH section. The engagement with the officer was made to clarify extracted data, as well as get some qualitative insight from an experienced DOSH assessor with direct knowledge of the MHCP certification process.

Results

Trends of Major Hazard Competent Person Registration

Overall, the data analyzed from this study

revealed a concerning lack of significant growth in the number of professionals being certified as MHCP in the past two decades. Although the CIMAH Regulation has been enacted since 1996, the first available information on the registered number of MHCP was not found until 1998, when DOSH reported a total of 8 registered MHCP in its annual report.[13] The following year saw a slight drop, with only 5 MHCP officially registered with DOSH in 1999.[14] The subsequent three years showed a promising increase in demand for the profession, with significant registration increases of 68, 74, and 79 MHCP in 2000, 2001, and 2002, respectively.[15-17] However, the following 15 years showed a consistent downward trend in the annual number of registered MHCP. By 2017, only 18 MHCP were registered, representing a 77% reduction from the peak of 79 MHCP recorded in 2002.[18] There was a slightly promising recovery in registered from 1998 to 2021. MHCP registration in the following years, with 28, 34, 38, and 32 registered MHCP found in DOSH's active database from 2018-2021.[19-22] Figure 1 illustrates the number of OYK Major Hazards from 1998 to 2021.

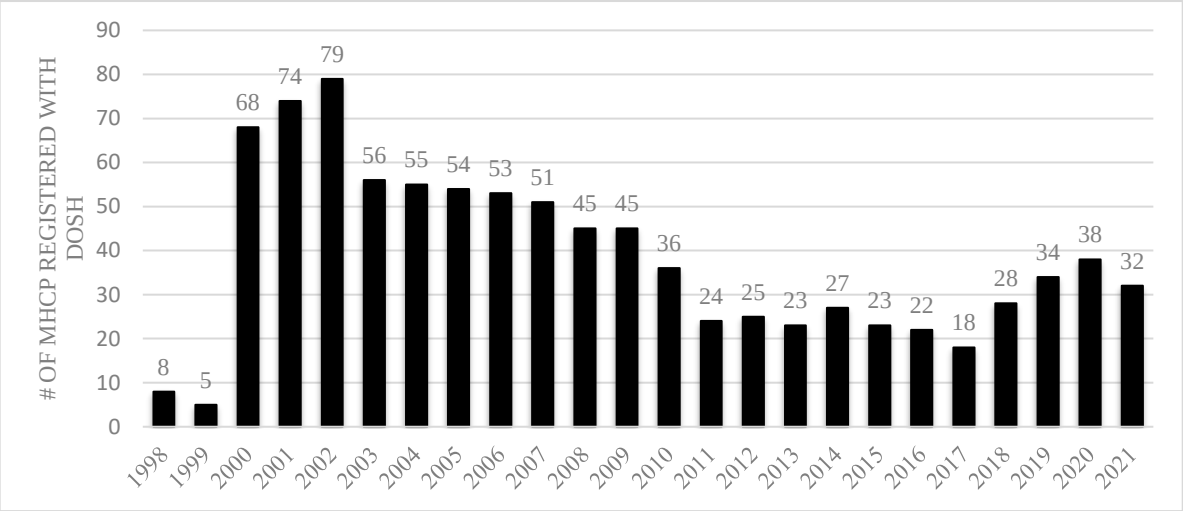


Figure 1: Number of MHCP registrations with DOSH from 1998 to 2021.

In terms of data associated with the application process, overall there is a general downward trend of successful application of professionals to become MHCP from 2005 to 2014. The DOSH's 2005 annual report provides the first official record of the department's efforts to report MHCP application statistics. In 2005, only one MHCP candidate did not pass the final interview which translated to a success rate of 94%.[23] The subsequent years' success rates were 92% in 2006, 86% in 2007, 88% in 2008, 42% in 2009, 44% in 2010 and 29% in 2011.[24] Following a slight increase in success rates in the subsequent years, with 56% in 2012 and 53% in 2013, success rates significantly decreased to 13% in 2014.[24] The following year marks the last spike, as 69% of the MHCP passes the interview in 2015. From thereon, there was another downturn trend, in which the success rates were 60% in 2016, 36% in 2017, 34% in 2018, 32% in 2019, 21% in 2020 and 10% in 2021. The findings provide insight into the historical success rates of MHCP applicants in Malaysia, highlighting a concerning trend of decreasing success rates in recent years. These results have important implications for the field of occupational safety and health and warrant further investigation into the underlying causes of this trend. Figure 2 summarizes the overall trend of MHCP success rates between 2005 to 2021.

Trends of Major Hazard Installations Registration, and MHCP: MHI Ratio.

Although the registration data for MHCP showed a noticeable downward trend, the opposite is true for the number of registered MHIs, which has steadily increased since its first inception. The number of registered MHIs increased almost six-fold from 1996 to 2021.[12] The scenario creates a

concern as there is an imbalance supply of MHCP to provide professional services to growing numbers of MHIs. In 1998 and 1999, the first few years of CIMAH Regulations were in effect, there was a substantial gap between supply and demand, as one MHCP was required to provide professional services to an average of 10 and 19 MHIs, respectively.

However, there was a significant increase in the number of registered MHCPs providing professional services to MHIs between 2000 and 2010. This is evidenced by the smaller gap ratio of only 1:2 between MHCP and MHIs from 2000-2002, 1:3 from 2003-2006, 1:4 from 2007-2008, 1:5 in 2009, and 1:6 in 2010.[24] The ratio continues to grow further apart, with gap consistently in the double digits over the next decade, from 2011-2021. The ratio ranges from 1:11 – 1:14 in those 10 years, with a peak in 2016 as 1 MHCP is expected to provide services to 14 MHIs.[25] The data trend demonstrates the increasing exclusivity and service value of MHCP status, as the number of registered MHCPs could not keep up with the increasing number of designated MHIs over the years. Figure 3 summarizes the dataset showing the trends of MHCPs to MHIs registration from 1998 to 2021

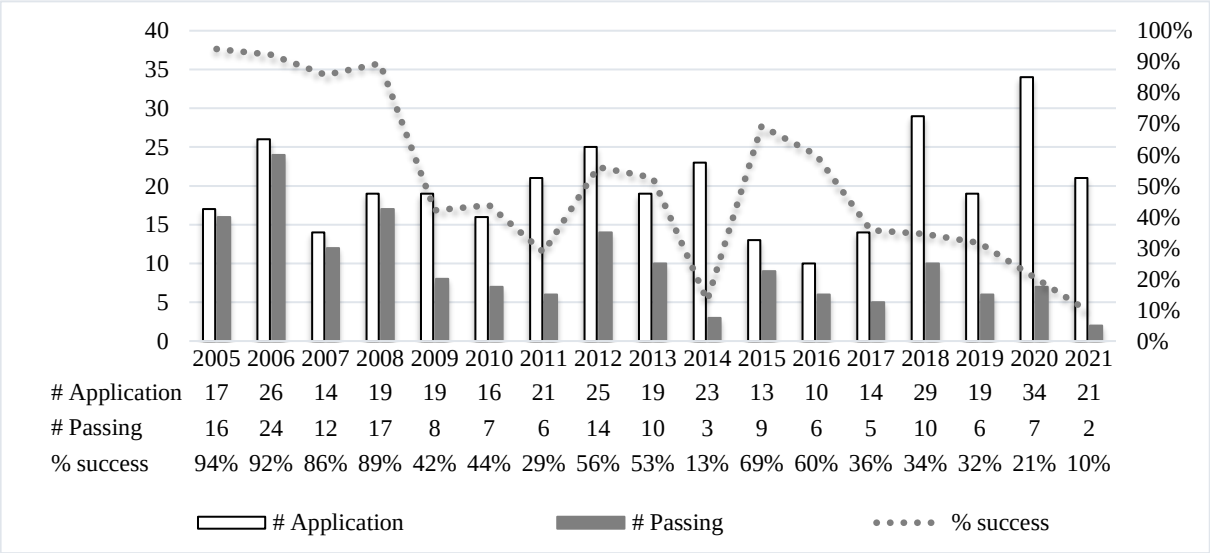


Figure 2: Number of new applications of MHCP, Number of passes, and success rates from 2005-2021.

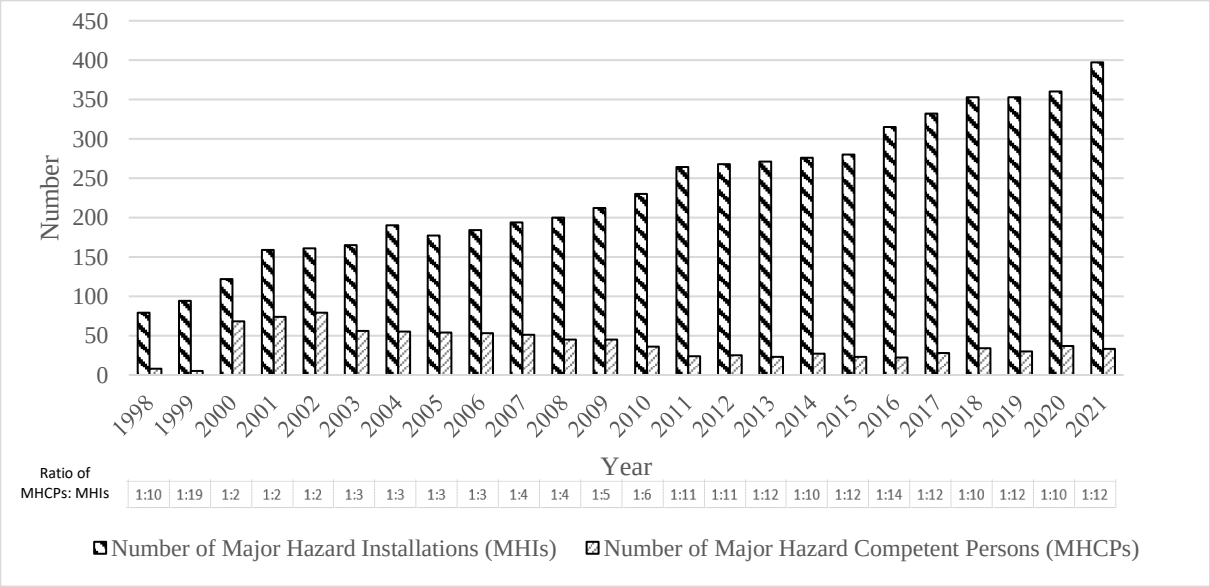


Figure 3: Number of registered MHCPs vs. MHIs from 1998-2021.

Discussion

The present analysis reveals an apparent gap in the overall shortage of MHCP professionals in Malaysia. This trend is concerning given the obvious development of a steadily growing number of MHI facilities over the past two decades, while the supply of MHCPs to serve MHIs has not kept pace over the same period. Inadequate supply of MHCPs could undermine the ability to provide sufficient coverage of major hazard risk management services for MHIs. This issue was verified by an officer from DOSH's assessment and competency unit of CIMAH section in a follow-up personal communication, in which the officer expressed a concern that this shortfall of MHCPs supply poses significant risks to the overall quality of risk management within make Malaysian major hazard facilities. The potential root causes of this MHCP supply gap issue may be attributed to 1) a rigorous MHCP certification process; 2) a limited availability of MHCP competency preparatory courses offered by higher learning institutes or professional training providers; and 3) a lack of a clear career path and growth opportunities in the Major Hazard sector.

Professional certification has always been associated with recognized credentials on core competencies, evidence of adequate qualification to perform specific professional practices, and an indication of good quality standards among industry practitioners.[26] Generally, rigorous certifications that demand higher standards tend to hold greater value and grant increased authority to the certified professional. Multiple studies have shown that one of the key variables to successful certification among applicants is experience and performance in relevant field projects.[26-29] In the context of this study on MHCP certification passing rate, one of the MHCP assessors from DOSH revealed that the two main factors leading to the high rate of failure among past MHCP applicants were due to 1) applicants providing inadequate evidence of relevant professional experience related to major hazards, and 2) their poor performances to demonstrate competency during the formal interview session with DOSH assessors. A rigorous MHCP certification process is essential as practitioners' competency can affect the management of risks involving life and death in the field of Major Hazards. Thus, inadequate evidence of professional experiences and competency to satisfy rigorous certification requirements can then be attributed to the MHCP shortage.

On a related note, the study also found a lack of a publicly accessible assessment rubric detailing specific criteria or requirements during formal MHCP certification interviews. Whether this unavailability of a rubric is attributed to the rigorousness of the MHCP certification process is not clear. However, it is likely that inaccessibility to the rubric can contribute to the low success rate of MHCP certification as it constrains candidates' ability to adequately prepare for formal DOSH interview sessions. Exploring new methods or approaches on how to assist MHCP applicants to demonstrate professional competency while still maintaining the rigorousness level of the certification process may be beneficial to address the current MHCP shortage situation.

Another identified factor potentially contributing to the MHCPs shortage is the scarcity of MHCP competency preparatory courses available to MHCP applicants. The lack of structured and formal training may lead to steeper learning curves and inefficient learning processes, ultimately impeding the development of applicants' knowledge and skills necessary to obtain the minimum competency level status. This is consistent with findings in several studies, which have shown that the curriculum, quality of training, and completion of preparatory courses are among the factors that can affect success rate in professional exams or certification programs.[30-32] Currently, only a handful of public and private Malaysian higher learning institutions offer occupational safety and health-related courses, none of which specifically focus on MHCP competency curricula. Although established training centers, such as the Malaysian National Institute of Occupational Safety and Health

(NIOSH), offer other competency programs and courses recognized by the DOSH, MHCP competency courses have yet to be offered, as per information on their own website. As a result, MHCP candidates have no option other than to adopt a self-paced learning approach. In a study among candidates taking various professional certification programs in Texas, USA, a research team found that the majority of the applicants preferred instructor-led training in their preparation for certification, while the least preferred method was self-paced learning.[33] Exploration of this issue revealed a clear need for higher learning institutes or professional training providers to offer structured MHCP competency preparatory courses to prepare MHCP applicants in order to address the MHCPs scarcity issue.

Lastly, the emerging trend of shortage of MHCP professionals may also stem from a lack of clear professional development pathways for practitioners in major hazard industries. The profession of MHCP has been established primarily due to a specific provision in the CIMAH Regulations, which explicitly defines and mandates the creation of MCHP profession for MHIs to legally operate on Malaysian soil. Given that this profession was created from a legal requirement, it is highly specialized and may exhibit limited flexibility concerning its demand in sectors beyond those associated with major hazard activities. The professional certification process requires significant commitment and investments of time, money and effort, and there is an understandable expectation that the return on investment will be in the form of career advancement. Marketability of the certification has been found by other researchers to be one of the most important drivers to attract applicants to pursue certification status.[26,34] There has been some recognition coming from DOSH, in which MHCPs' contact information, geographical location, experience and competency license validation period was made available to the public in DOSH's online portal since 2007. The effort to recognize MHCPs continued with the formal inclusion of their digital information in the Malaysian national identity card in 2008, which allowed DOSH officers to verify the MHCP status on site. Nonetheless, to date, no documentation or publication has been made regarding the effectiveness of the MHCP information provided through the online portal and MyKad system to enhance the marketability and career prospects of MHCPs.

In addition, there is also a clear absence of a recognized Malaysian Major Hazard competency framework available for young practitioners to guide their career growth and advancement. In general, a recognized competency framework is crucial in standardizing expectations and requirements, providing a clear career development roadmap, helping employers identify and promote competent employees, designing effective training programs, and ensuring quality assurance within the profession.[35-37] In a descriptive study that spans over 6 years, involving more than 1000 professionals in various fields, the researchers found that one of the main motivators for professionals to pursue certification is 'career growth'.[38] The lack of an available framework may contribute to the uncertainty of career growth prospects and advancement, especially for the younger generation of practitioners in the field. Studies by several researchers showed that a clear professional competency or framework can contribute by providing an evident career development pathway to practitioners.[39-40]

Future research could investigate common reasons for high MHCP certification failure rates, from the perspectives of both DOSH assessors and MHCP applicants. In addition, future studies could also include a need and gap analysis of formal and structured competency preparatory training or education process, as well as a clearer career path for professionals in the Major Hazard sector. Familiarity with a recognized Major Hazard competency framework, supported by competency preparatory training or formal education systems, and accessibility to MHCP criteria and requirements rubric could potentially empower aspiring Major Hazard professionals in

developing the necessary knowledge and skills to become competent practitioners.

Conclusions

To conclude, while the number of registered MHIs has steadily increased over the years since the first inception of CIMAH Regulations in 1996, the growth of registered MHCPs has been limited, indicating the stagnant progression of MHCP as a specialized profession. The success rate of applicants to become registered MHCPs has also been declining since 2015, which further contributed to the low supply of MHCPs. This resulted in an imbalanced supply and demand situation as there is an emerging trend of increase in the gap ratio between registered MHCPs and MHIs. The insufficient number of MHCPs may compromise the capacity to offer adequate coverage for MHIs, thereby affecting the overall quality of compliance with the CIMAH Regulations. This issue must be addressed to ensure a consistent and adequate supply of MHCPs providing critical services to MHIs.

CIMAH Regulation 1996 was promulgated more than two decades ago, and since then, there have been emerging calls and recommendations by practitioners and researchers to revisit the contents and execution process to make sure they are still relevant to current industrial contexts and demands. Malaysia's adoption of CIMAH 1996 was modeled on the UK's CIMAH 1984, which has undergone several revisions to update its contents, with the latest revision in 2015. However, Malaysia's CIMAH Regulations have not been reviewed or revised since their introduction in 1996. The study's findings reveal changes and new trends in MHI and MHCP registrations over the past two decades since CIMAH's implementation. Consequently, the calls to have the Regulations periodically reviewed, as well as reformation on the MHCP profession itself may have its merits, especially in light of the changing trends.

Acknowledgments

The authors would like to express sincere appreciation to the Department of Occupational Safety and Health Malaysia, the Ministry of Human Resources Malaysia, for their unwavering support and for granting access to major hazard data. In addition, special recognition is owed to the dedicated DOSH auditors and officers, with a particular emphasis on those from the Petroleum Safety Division, whose invaluable contributions have been instrumental in the successful completion of this study. Special thanks to Universiti Teknikal Malaysia Melaka for additional support. The study was partly funded by research grant PJP/2022/FKP/S01872.

References

1. Department of Occupational Safety and Health Malaysia. Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations. 1996 [Internet]. Available from: https://www.dosh.gov.my/index.php/legislation/eregulations/regulations-under-occupational-safety-and-health-act-1994-act-514/527-07-occupational-safety-and-health-control-of-industrial-major-accident-hazards-regulations-1996/file
2. Lucchini RG, Hashim D, Acquilla S, Basanets A, Bertazzi PA, Bushmanov A, et al. A comparative assessment of major international disasters: the need for exposure assessment, systematic emergency preparedness, and lifetime health care. BMC Public Health. 2017 Jan 7;17(46): 1-12. Available from: http://dx.doi.org/10.1186/s12889-016-3939-3
3. Jaspal ZN, Haider N. Management of chemicals in Pakistan: concerns and challenges. South Asian Stud. 2014;29(2):497–517. Available from: http://pu.edu.pk/images/journal/csas/PDF/10.%20Zafar%20Nawaz_v29_no2_2014.pdf
4. Shaluf IM, Ahmadun F. Major hazard control: the Malaysian experience. Disaster Prev. Manag. 2003 Dec 1;12(5):420–7. Available from: https://doi.org/10.1111/j.1467-7717.2008.01076.x
5. Said AM, Ahmadun FR, Kadir RA, Daud M. Inquiries into Malaysia's socio-technical disasters: recommendations and lessons learnt. Disasters. 2009 Jan 29;33(2):308–28. Available from: https://doi.org/10.1016/j.jclepro.2019.119861
6. Fisher R. Major hazard control: A practical manual. An ILO contribution to the international programme on chemical safety of UNEP, ILO, WHO (IPCS). International Labour Office; 1988. Document No. 88B09_382_engl. Available from: https://www.ilo.org/global/topics/safety-and-health-at-work/resources-library/publications/WCMS_235686/lang--

en/index.htm

7. Zainal Abidin M, Rusli R, Khan F, Mohd Shariff A. Development of inherent safety benefits index to analyse the impact of inherent safety implementation. Proc. Safety and Env. Protection. 2018 Jul;117:454-72. Available from: https://doi.org/10.1016/j.psep.2018.05.013

8. Department of Occupational Safety & Health Malaysia. Certification/competent person info/major hazard competent person. 2021 [Internet].Available from: https://www.dosh.gov.my/index.php/services/enforcement/certification/competent-person-info/1613-mh-cp

9. Bowen GA. Document analysis as a qualitative research method. Qualitative Research Journal. 2009 Aug 3;9(2):27–40. Available from: https://doi.org/10.3316/QRJ0902027

10. Ross H. Tracking and tracing tobacco products in Kenya. Prev. Med. 2017 Dec 1;105:S15-8. Available from: https://doi.org/10.1016/j.ypmed.2017.04.025

11. Lowe M, Coffey P. Effect of an ageing population on services for the elderly in the Northern Territory. Aust Health Rev. 2017 Oct 2;43(1):71-77. Available from: https://doi.org/10.1071/AH17068

12. Mat Rashid R, Radin Umar RZ. Control of industrial major accident hazard regulation in Malaysia: second decade in examination. Int. J. Pub. Health Sci. 2023 Mar 1;12(1):138-45. Available from: http://doi.org/10.11591/ijphs.v12i1.22002

13. Department of Occupational Safety & Health Malaysia. Laporan tahunan 1995-1998. Kuala Lumpur: Government of Malaysia; 1999. http://www.niosh.com.my/images/book/OSHIM.pdf

14. Department of Occupational Safety and Health Malaysia. Laporan tahunan 1999. Kuala Lumpur: Government of Malaysia; 2000.

15. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2000. Kuala Lumpur: Government of Malaysia; 2001.

16. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2001. Kuala Lumpur: Government of Malaysia; 2002.

17. Department of Occupational Safety and Health Malaysia, Laporan tahunan 2002. Kuala Lumpur: Government of Malaysia; 2003.

18. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2017 [Internet]. Putrajaya: Government of Malaysia; 2018. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan

19. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2018 [Internet]. Putrajaya: Government of Malaysia; 2019. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan/3507-laporan-tahunan-jkkp-malaysia-2018/file

20. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2019 [Internet]. Putrajaya: Government of Malaysia; 2020. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan/3697-laporan-tahunan-jkkp-2019/file

21. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2020 [Internet]. Putrajaya: Government of Malaysia; 2021. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan/4090-laporan-tahunan-jkkp-malaysia-2020/file

22. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2021 [Internet]. Putrajaya: Government of Malaysia; 2022. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan/4327-laporan-tahunan-jkkp-malaysia-2021/file

23. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2005. Kuala Lumpur: Government of Malaysia; 2006.

24. Bahagian Major Hazard - Department of Occupational Safety & Health Malaysia. Maklumat Dan Data Ringkas 2013-2014. Putrajaya: Government of Malaysia, 2015. Available from: https://www.dosh.gov.my/index.php/about-us-2/hq-state-branch-office/major-hazard-division

25. Department of Occupational Safety and Health Malaysia. Laporan tahunan 2016 [Internet]. Putrajaya: Government of Malaysia; 2017. Available from: https://www.dosh.gov.my/index.php/download/laporan-1/laporan-tahunan/2800-laporan-tahunan-jkkp-malaysia-2016/file

26. Adams PS, Brauer RL, Karas B, Bresnahan TF, Murphy H. Professional certification. Professional Safety. 2004 Dec;49(12):26-31. Available from: https://aeasseincludes.assp.org/professionalsafety/pastissues/049/12/021204as.pdf

27. Calvo-Amodio, J, Tercero-Gómez VG, Ramirez-Galindo JG, Martínez-Salazar I. A systemic analysis of professional certification rates: the case of a six sigma training certificate program. Eng Manag J. 2014 Dec;26(4):13-22. Available from: https://doi.org/10.1080/10429247.2014.11432024

28. Brahmasrene T, Whitten D. Assessing success on the uniform CPA exam: A logit approach. J Educ. Bus. 2001;77(1):45-50. Available from: https://doi.org/10.1080/10429247.2014.11432024

29. Whitten D, Brahmasrene T. Passing the uniform CPA exam: What factors matter? The CPA Journal. 2002 Nov 2;72(11):60–2. Available from: http://archives.cpajournal.com/2002/1102/dept/d116002.htm

30. Lima Rodrigues L, Pinho C, Bugarim MC, Craig R, Machado D. Factors affecting success in the professional entry exam for accountants in Brazil. Account. Educ. 2017 Aug 8;27(1):48-71. Available from: https://doi.org/10.1080/09639284.2017.1361851

31. Al-Duwaila N, AL-Mutairi A. Factors Affecting the Success in Certified Public Accountant Exam in Kuwait. Asian Soc. Sci. 2020 Dec 30;17(1):98. Available from: https://pdfs.semanticscholar.org/561d/6ac02b966aed69b78533d5d70b5ca3f975f2.pdf

32. Spohn R, Schweinle III W, Berg-Poppe P, South-Winter C, DeJong D. Factors for successfully passing certification exams: a systematic review. Perspect. Health Inf. Manag. 2021 Oct 1;18(4):1k. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8649701/

33. Anderson T, Ogruk G, Bell III TJ. Taking professional certification exams: the correlation between exam preparation techniques and strategies and exam results. J. Hi. Ed. Theory and Prac. 2021 Jun 24;21(5). Available from: https://doi.org/10.33423/jhetp.v21i5.4267

34. Chang SC, Lin CF, Wu WM. The features and marketability of certificates for occupational safety and health management in Taiwan. Saf Sci. 2016 Jun;85:77–87. Available from: https://doi.org/10.1016/j.ssci.2015.12.024

35. Watt K, Abbott P, Reath J. Developing cultural competence in general practitioners: an integrative review of the literature. BMC Fam. Pract. 2016 Nov 15;17(1). Available from: https://doi.org/10.1186/s12875-016-0560-6

36. Kannan KSPN, Garad A. Competencies of quality professionals in the era of industry 4.0: a case study of electronics manufacturer from Malaysia. Int. J. Qual. Reliab. Manag. 2020 Sept 8;38(3):839-871. Available from: https://doi.org/10.1108/ijqrm-04-2019-0124

37. Jenkins-Weintaub E, Goodwin M, Fingerhood M. Competency-based evaluation: collaboration and consistency from academia to practice. J Am Assoc Nurse Pract. 2023 Feb;35(2):142-9. Available from: https://doi.org/10.1097/jxx.0000000000000830

38. Cumberland DM, Petrosko JM, Jones GD. Motivations for pursuing professional certification. Perform. Improv. Q. 2018 Apr 10;31(1):57–82. Available from: https://doi.org/10.1002/piq.21256

39. Adeniji A, Osibanjo O, Salau OP, Falola HO, Igbinoba E, Ohunakin F, et al. Competence model for measuring career development and organisational growth in the health sector. Business: Theory and Practice. 2019 May 3;20:248–58. Available from: https://doi.org/10.3846/btp.2019.24

40. Billings C, Bernard H, Caffery L, Dolan SA, Donaldson J, Kalp E, et al. Advancing the profession: an updated future-oriented competency model for professional development in infection prevention and control. Am J Infect Control. 2019 Jun;47(6):602–14. Available from: https://doi.org/10.1016/j.ajic.2019.04.003

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Review Article

Mental health and well-being of healthcare professionals amid the COVID-19 pandemic in Canada

Karki KK[1], Shrestha A[2], Jain R[3], Al-Saadi R[4]

[1]Assistant Professor, School of Social Work and Human Services, University of the Fraser Valley, BC, Canada
[2]Master of Public Health (Student), Faculty of Health Science, McMaster University, ON, Canada
[3]Adjunct Professor, Master of Counselling Psychology, Yorkville University, BC, Canada
[4]Assistant Professor, School of Social Work, University of Windsor, ON, Canada

Corresponding author:
Dr. Karun Kishor Karki
Assistant Professor
School of Social Work and Human Services
University of the Fraser Valley
British Columbia, Canada
E-mail: karun.karki@ufv.ca
ORCID ID: https://orcid.org/0000-0002-8712-6831

Date of submission: 23.06.2023
Date of acceptance: 17.01.2024
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.55959

ABSTRACT

Introduction: The COVID-19 pandemic posed unique challenges to healthcare professionals (HCPs) with increased risk of mental health and well-being globally. However, the psychological impact of the pandemic on the mental health and well-being of HCPs in Canada is not fully understood. This paper critically reviews broadly available literature on the mental health and psychosocial status of HCPs amid the COVID-19 pandemic in Canada.

Methods: A comprehensive online search was conducted using the guidelines outlined by the Centre for Reviews and Dissemination for combining the findings of diverse primary studies within a single review. Online search was conducted through databases such as AMED (Allied and Complementary Medicine), Embase, Global Health, Ovid Healthstar, Mental Measurements Yearbook, EBM Reviews - ACP Journal Club, EBM Reviews - Cochrane Database of Systematic Reviews, Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review, and Google Scholar for the period between March 2020 and May 2023. Twenty-two studies met the inclusion criteria and were analyzed using a thematic analysis approach to identify the main themes across studies.

Results: The analysis uncovers three key themes: 1) HCPs face diverse mental health impacts during the pandemic; 2) HCPs are dissatisfied with organizational approaches to COVID-19; and 3) HCPs express concerns about personal well-being and the safety of others during the pandemic.

Conclusion: These findings emphasize the need for HCPs to cope effectively with stressors for their own, their patients, and their families' well-being. Therefore, future research should prioritize how HCPs can maintain their emotional, mental, and psychological well-being.

Keywords: COVID-19, Psychological well-being, Mental health, Healthcare professionals

Introduction

In March 2020, the World Health Organization (WHO) announced the worldwide transmission of the novel coronavirus (COVID-19) as a global pandemic.[1] By June 2021, Canada had reported 1.4 million COVID-19 cases and 26,200 deaths.[2] In response, the Canadian government allocated $60.3 billion to support public health responses, including vaccine development, mitigation efforts, and support to Indigenous communities. Healthcare professionals (HCPs), such as nurses, dieticians, physicians, and respiratory therapists, providing care to COVID-19 patients, have faced considerable strain throughout the pandemic. They encountered challenges in adapting to new scientific knowledge and managing the risk of infection, leading to a significant impact on their mental, emotional, and psychological well-being. The WHO defines mental health as "a state of

well-being in which an individual realizes his or her abilities, can cope with the normal stresses of life, can work productively and can make a contribution to his or her community."[3] However, to assess mental health, the absence of mental health disorders is commonly employed as a standard criterion in mainstream healthcare.

This article aims to critically review the existing literature on the impact of the COVID-19 pandemic on the mental health and well-being of HCPs in Canada. The overarching question guiding this paper is: *What are the main themes concerning the mental health impacts on HCPs in Canada amidst the COVID-19 pandemic?* Given the limited understanding of the mental health implications encountered by HCPs in Canada amidst the pandemic, this study fills a significant gap in the existing scholarship. The findings from this study will contribute to the development of mental health promotion policies and interventions aimed at addressing the specific needs of HCPs during the pandemic, such as COVID-19.

Methods

A protocol using a standardized approach for conducting a literature review was devised to avoid unplanned duplication of literature in the study. The databases included: AMED (Allied and Complementary Medicine), Embase, Global Health, Ovid Healthstar, Mental Measurements Yearbook, EBM Reviews - ACP Journal Club, EBM Reviews - Cochrane Database of Systematic Reviews, Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review, and Google Scholar from March 11, 2020 to May 05, 2023. Our review has been informed by best practices outlined by the Centre for Reviews and Dissemination guidelines for combining the findings of diverse primary studies within a single review.[4] In effect, it has been reported through a rigorous process of transparency, increasing replication and reliability of the search strategy.

The search strategy employed the following keywords: "Healthcare professional" OR "front line workers" OR "nurses" OR "doctor" OR "physicians" AND "mental health" OR "mental well-being" OR "psychology*" AND "COVID-19" OR "pandemic" OR "coronavirus disease," explicitly focusing on studies conducted in Canada. Following the database's search (see Figure 1), 2185 studies were identified; however, after incorporating the Canadian context, only 34 studies were retrieved. Among those 34 articles, 11 were deemed irrelevant, and seven were duplicates, leaving 16 relevant studies for analysis. Medline, PubMed, APA PsycINFO, and Google Scholar were also searched using similar keywords, and six studies were identified using the predetermined eligibility criteria. In total, 22 studies met the inclusion criteria. Of the 22 studies, 11 were qualitative, nine quantitative, and two mixed methods. The inclusion criteria included: (a) studies about HCPs who were employed in healthcare settings throughout the COVID-19 pandemic; (b) studies that provided an account of mental health or mental well-being affected by COVID-19; (c) studies that involved Canadian HCPs and (d) studies that were written in English and were published after March 11, 2020 (following WHO's declaration of COVID-19 as a pandemic). Figure 1 demonstrates the flowchart used for search strategies.

Two co-authors independently screened the titles and abstracts of the selected studies. Full texts of articles that successfully passed the initial screening were subsequently evaluated. In the event of any disparities encountered during the screening process, the reviewers engaged in thorough discussions to reach a consensus and resolve the discrepancies. Twenty-two studies met the inclusion criteria and were analyzed using a thematic analysis approach.[5] In this process, each co-author independently reviewed the full text and developed their own themes and sub-themes across the studies. The co-authors met virtually (on Zoom) to compare and contrast their themes and sub-themes. This process involved several meetings on Zoom to critically engage in discussion of their findings, leading to the development of common themes and sub-themes.

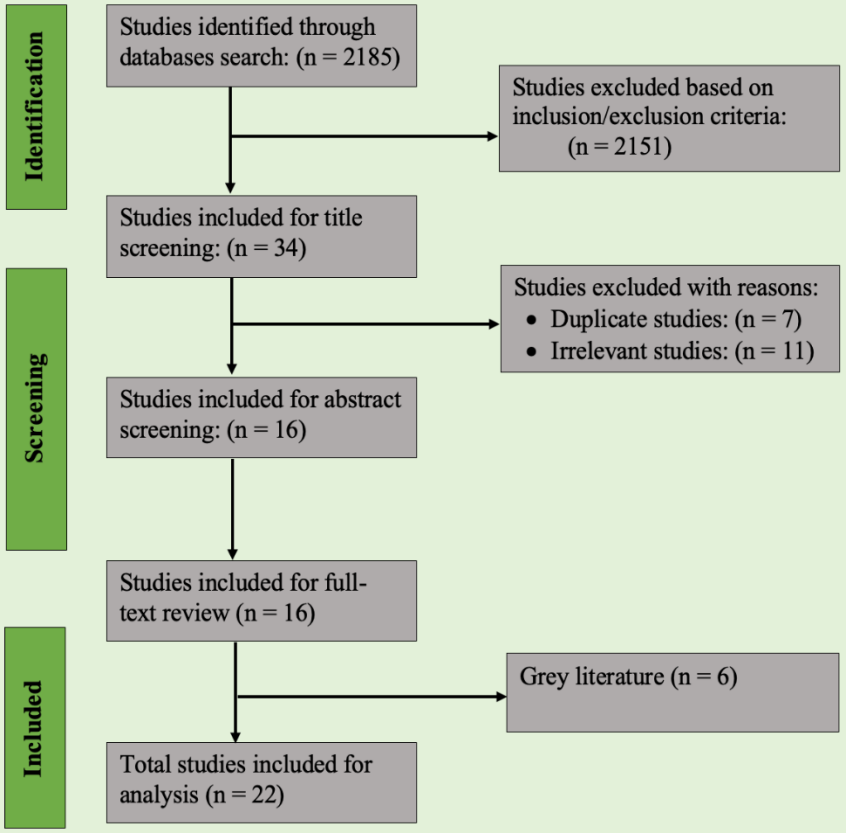


Figure 1. Flowchart

Results and major findings

Our analysis generated three major themes and six sub-themes, which we present and discuss in subsequent sections.

1. Assessing mental health impacts among HCPs

According to the WHO, mental health is "a state of well-being in which an individual realizes his or her abilities, can cope with the normal stressors of life, can work productively and can make a contribution to his or her community."[3] The mental health implications of COVID-19 among HCPs emerged as one of the main themes across the studies. Before the onset of the COVID-19 pandemic, HCPs were already recognized to experience a greater occurrence of mental health challenges in comparison to individuals who are not in the healthcare profession.[6] The main theme incorporated two sub-themes. The first sub-theme focuses on *adverse psychological outcomes*, whereas the second sub-theme highlights *job burnout and its impact on the quality of life* for HCPs. Both themes contribute to the negative mental health effects and psychological distress experienced by HCPs.

1.1 Negative psychological outcomes:

Most studies included in this review have examined the implications of the COVID-19 pandemic on the mental health and well-being of HCPs in Canada. For example, a study found that, of the 3,676 nurses, 38% of the nurses met the diagnostic threshold for anxiety, 47% for post-traumatic stress disorder (PTSD), 60% for emotional exhaustion, and 41% for depression.[6] Another study conducted on 109 critical care registered nurses in Western Canada during the beginning of the COVID-19 pandemic found that the prevalence of PTSD symptoms among the respondents was 73.3%, significantly higher than pre-COVID-19 rates ranging from 8.5% to 20.8%.[7] The study also revealed high rates of anxiety, stress, and depression: 67%, 54% and 57%, respectively.[7] Additionally, the effect of the COVID-19 pandemic on mental health was examined among 159 Canadian medical oncologists, which revealed that 54% of oncologists experienced anxiety, 52% experienced depression, and 57% identified personal wellness as the greatest challenge during the pandemic.[8]

An online survey conducted in Canada involving 5,998 HCPs to investigate their mental health during the COVID-19 pandemic, revealed that over 55% of participants experienced anxiety, while 42% experienced depression.[9] The authors used the Generalized Anxiety Disorder (GAD-2) screener to assess anxiety systems and the Patient Health Questionnaire (PHQ-2) for depression symptoms. These outcomes were associated with the perceived inadequacy of personal protective equipment (PPE) and workplace policies. A study involving 218 Canadian respiratory therapists revealed concerning rates of mental health symptoms, indicating that more than 52% of the participants scored outside the normal range for depression, 51% for anxiety, and 54% for stress.[10] Additionally, 33% of respiratory therapists displayed indicators of PTSD, and 18% scored above cut-offs for depression, anxiety, stress, and PTSD collectively. A study examining the prevalence of PTSD and psychological distress amongst intensive care unit workers found similar results.[11] Their findings indicated that 37% of respondents reported 'PTSD symptoms,' and 18% experienced 'psychological distress.' Additionally, women and nurses were identified as high-risk groups for adverse mental health outcomes.[11] Furthermore, 10 HCPs in long-term care homes and hospitals expressed anxiety, stress, anger and fear during the COVID-19 pandemic.[12] One of the participants in the study mentioned above talked about how stressed she was while working during the pandemic and how such stress had affected her overall well-being:

> "I've come home and cried many times. I'm stressed out. I can't sleep at night. There's a lot of us having trouble sleeping. I try to talk about it to my husband and he says, "You need to decompress, and you need to stop talking about work." But I say, "Work is such a big thing for me right now; I need people to know" (p. 270).[12]

Furthermore, a study involving 86 HCPs (including nurses, pharmacists, and physicians) in New Brunswick found that about 50% of HCPs reported experiencing depression, and 10% indicated having suicidal thoughts.[13] New Brunswick had low COVID-19 case counts at the time of the study, and the results highlight the significance of evaluating the mental health of HCPs, even in regions with low infection rates. At the same time, the findings also raise concerns about the mental health status of HCPs in provinces with higher caseloads, as the distress observed in a relatively unaffected province is already significant.[13] To discern the difference in health outcomes before and after the COVID-19 pandemic, a study conducted in collaboration with the Canadian Federation of Nurses Union investigated the experiences of occupational stress among nurses.[14] The research aimed to establish a baseline, enabling a comparison of mental health outcomes for nurses during the pandemic. This unique approach of establishing a pre-pandemic baseline allows for valuable comparison in understanding the specific impact of the COVID-19 crisis on the mental health of nurses. Such comparative data is not commonly found in published research studies, making this study a valuable contribution to the field.

1.2 Job burnout and quality of life:

The COVID-19 pandemic has globally exerted pressure on healthcare facilities, significantly impacting the HCPs' quality of life. [10,12,15,16] In 2021, HCPs' average overtime hours reached the highest level in over a decade.[16] Approximately 236,000 healthcare employees worked overtime, with an average of 8.2 hours per week of compensated overtime and 5.8 hours per week of unpaid overtime. This practice of continuously exceeding one's capacity can contribute to job burnout. A study conducted in 2022 examined the resilience and psychosocial functioning of psychiatric and general hospital HCPs to identify predictors of stress resilience and quality of life in demanding work environments.[15] The study found that among 240 participants, 26.4% of respondents scored in the clinical range for Coronavirus anxiety score (CAS), indicating significant levels of anxiety associated with the pandemic.[10] The nursing profession was identified as a protective factor that predicted higher

resilience scores. Moreover, HCPs in both settings (i.e., psychiatric and general hospital) demonstrated comparable levels of psychological symptoms.[12,15]

Furthermore, a study examining the functional impairment experienced by 178 respiratory therapists revealed that HCPS reported difficulties in carrying out their work due to health conditions associated with their roles.[10] On average, participants indicated 4.1 days where they had to lessen their workload due to health conditions. These findings suggest an indication of burnout, where HCPs are unable to effectively perform their tasks amidst the stressful conditions of the COVID-19 pandemic. The study applied the World Health Organization Disability Assessment Schedule (WHODAS) scores, which assesses functional impairment. The WHODAS scores were positively correlated with scores for depression (52%), anxiety (51%), and PTSD (33%).[10] As such, increased levels of adverse psychological symptoms were linked to a heightened degree of functional impairment among the participants.

While many studies have extensively examined the occurrence of associated risk factors linked with mental health among HCPs, biological variables have been virtually neglected.[7,9,11,13,15] For example, a study analyzed the correlation between hair cortisol levels and burnout in 467 HCPs (nutritional therapists, occupational therapists, respiratory therapists, nurses, and physicians) from Quebec, indicating that 50% of the participants displayed symptoms of burnout.[17] Burnout revealed symptoms of emotional depersonalization or exhaustion at least once a week. Notably, hair cortisol levels significantly increased by a median increase of 29% after the onset of the pandemic, indicating a physiological influence of increased stress and demands on HCPs. This increase in cortisol was also statistically associated with burnout, further supporting the link between stress and physiological response. Additionally, perceived organizational support and resilience were negatively correlated with burnout experienced by HCPs.[7,12,17,18] These factors played a protective role against burnout among the participants. As such, the study holds great importance in understanding the impact of the pandemic on healthcare workers.[17] Furthermore, exploring the changes in HCPs' stress hormone levels can provide valuable insights. By identifying individuals who may be at higher risk based on their biomarker levels, healthcare organizations can design targeted interventions and support systems to address their specific needs. This personalized approach can significantly contribute to promoting HCPs' mental health and well-being during the pandemic.

In an effort to grasp the pandemic's influence on the quality of life among healthcare professionals, including but not limited to physicians, nurses, dentists, and psychologists, the Canadian government conducted an extensive survey involving 12,246 HCPs. The results indicated that 95% reported the pandemic's impact on their jobs, with 85% experiencing heightened work-related stress during this period.[19] Among HCPs not intending to retire, 17.9% indicated their intention to leave their job or switch to a different job within the next three years. Specifically, a higher proportion of women, 18.5%, were considering a job change compared to men, 15.5%. Notably, job stress or burnout was cited by 63.2% of respondents as the most common reason for leaving their job, followed by concerns about mental health at 53% and job dissatisfaction at 48.8%, which is comparable with other studies mentioned above.[11,15,19] During the pandemic, 67% of HCPs (such as nurses, physicians, ICU pharmacists, occupational therapists, physiotherapists, and personal support workers) reported feeling increased levels of stress at their workplace, and 37% had considered leaving their jobs, and more than 50% of HCPs indicated an increased workload, from working overtime to being assigned tasks they don't typically handle.[11] These findings underline the strain experienced by HCPs during the pandemic, with heightened stress levels and an overwhelming workload contributing to burnout and job dissatisfaction. The desire to leave a job can be attributed to the

challenging working conditions, having a negative impact on the quality of life and mental health of HCPs.[10,11,15,17,19]

2. Dissatisfaction of HCPs with organizational approaches to COVID-19

The response to the COVID-19 pandemic could have been improved if governments, public health agencies, and institutions had adhered to preventive measures. Consequently, the second theme identified in this review pertains to HCPs' discontentment with organizational conditions throughout the pandemic. Within this theme, two sub-themes emerged: *organizational change* and *inadequate access to PPE*. These recurring sub-themes have jeopardized HCPs' safety and have been recognized as contributing factors to the adverse impact on their mental health.

2.1 Organizational change:

Numerous Canadian studies have investigated the connection between HCPs' distress and organizational change.[6,7,10,12,18,20,21] Canadian nurses have reported experiencing anxiety, worry, distress, or fear attributed to various organizational factors, such as frequent policy changes, ambiguous communication, and difficulty reconciling conflicting messages from different departments.[7] In addition, various HCPs working in long-term care homes and hospitals have identified inconsistencies in organizational policies and barriers to implementing necessary changes amidst the COVID-19 pandemic.[12] The awareness of being at a higher risk of infection due to inadequate protection led to fear, anger, a sense of violation and frustration. 91% of respondents expressed feeling abandoned by the provincial government.[12] Insufficient staffing levels were recognized as factors contributing not only to the burnout experienced by HCPs but also compromised patient safety.

Furthermore, the mental health scores of HCPs were reported to be higher when they rated organizational support or preparedness negatively.[6] This included factors such as confidence in how the organization handled the pandemic, frequency of policy changes, transparency in policy decisions, and availability of resources, all of which indicated a need for improved workplace policies and practices to provide better support for HCPs during the COVID-19 pandemic. Additionally, the vaccination rollout has emerged as an important factor concerning organizational support during the pandemic, particularly among Canadian physicians. In a survey conducted by the Canadian Medical Association (CMA) with 1,648 practicing physicians, the majority reported heightened anxiety and fatigue related to COVID-19.[18] When HCPs were asked about factors that negatively impacted their mental well-being, 62% reported concerns about the vaccine rollout, 64% mentioned social restrictions, and 63% expressed uncertainty about the future. Among the physicians surveyed, 20% expressed that Canada should prioritize coordinating an effective vaccine distribution strategy to improve its response to the pandemic. However, 60% felt that the 'federal government's ability to secure vaccine supplies was poor,' while over 50% gave equally low ratings to their territorial or provincial government's handling of the vaccine rollout.[18] Numerous family physicians expressed their willingness to assist with vaccine distribution but reported not being informed about how to do so. This has resulted in frustration with the organizations overseeing the management of the pandemic, echoing findings from prior studies.[6,12,18]

Interviews conducted with respiratory therapists reveal a range of opinions during the pandemic, including disagreements among staff, increased workloads, burnout, conflicts with management, the initial fear of contamination, anxiety about obtaining vaccines for their families, and frustration with the vaccine rollout and prioritization of certain worker groups over others.[10] A study of 18 clinicians in Canadian Pediatric Eating Disorder programs during the COVID-19 pandemic revealed significant challenges in managing increased patient volumes without adequate resources.[20] Consequently, the workload for these professionals substantially increased during the pandemic, which is consistent with other studies.[10,12] Additionally,

HCPs such as physicians, nurses, occupational therapists, and respiratory therapists were reported to face potentially morally injurious events when the community transmission of COVID-19 significantly escalated, resulting in a drastic increase in their workload and limited ability to provide quality care.[22] Alongside the increased workload, many healthcare settings also experienced decreased staffing levels.[19,22,23,24] Policies mandated that staff members with COVID-19 symptoms or close contact with infected individuals could not work, further exacerbating the staffing shortage. Thus, HCPs were left responsible for caring for a larger number of patients than they could safely manage.

2.2 Inadequate access to PPE:

Several studies highlighted the insufficient availability of Personal Protective Equipment (PPE) for HCPs.[6-9,12,21,22] A study conducted in Ontario investigated the connection between the perceived sufficiency of PPE and the mental well-being of 5,988 HCPs.[9] The study found that there were high unmet needs for PPE: only 42.9% of the needed face shields and 29.1% of the needed N95 masks were met. Overall, less than 20% of the participants had their PPE and infection control requirements fulfilled. Furthermore, there was also a high prevalence of general anxiety disorder symptoms among HCPs who did not have their PPE and infection control requirements met.[9] These findings reflect the distress experienced by HCPs who are risking their lives to provide care while lacking adequate support and protection from their organizations.

In a study of 159 Canadian medical oncologists, it was discovered that 33% did not have any routinely used PPE, while 13% reported sporadic usage, often because their institutions discouraged using protective measures beyond handwashing and physical distancing.[8] Only 4% of respondents reported regular use of N95 respirator masks. The study also highlighted concerns about PPE access, with 69% of medical oncologists expressing uncertainty about having adequate PPE at their workplace during the pandemic. Moreover, 61% of participants lacked confidence in their institutions' support during this challenging time.[8] These findings align with a survey conducted by the Canadian Medical Association, which revealed that 75% of physicians expressed uncertainty about PPE availability.[8,9] As such, it is essential to advocate for increased efforts to procure PPE and ensure HCPs are adequately informed about the availability of essential protective equipment. Another study examined the perception of PPE amongst 10 HCPs working in long-term care homes and hospitals and found similar findings that the HCPs expressed dissatisfaction with the level of protection they were provided.[12] Specifically, the HCPs had requested N95 respirators when encountering suspected or confirmed cases, but their requests were mostly denied. They felt that decisions regarding the distribution of PPE were unfair and that their workplace did not prioritize their safety. The absence of clear guidance following the declaration of the pandemic, insufficient protective guidelines, and a lack of preparedness intensified feelings of abandonment and frustration among HCPs. The respondents also expressed being left to fend for themselves not only against COVID-19 infection but also against mental distress and burnout.[11,16,17] Several HCPs pointed out that the policies implementing PPE practices to minimize the risk of exposure to COVID-19 had unintended consequences, making it challenging or even impossible to respond promptly to emergencies.[21] Moreover, organizational decisions aimed at conserving the limited quantity of PPE were perceived by HCPs as unjust, as they seemed to prioritize certain HCPs over others, placing some individuals at a higher risk of infection. For instance, one participant mentioned that their organization withheld PPE supplies for nurses on the mental health team, opting instead to reserve it exclusively for emergency room nurses.[21]

Another study aimed to qualitatively explore the stressors experienced by 74 HCPs (including nurses, physicians, counselors, and therapists) during the COVID-19 pandemic.[22] One significant concern raised by HCPs was the unavailability of

safe PPE, particularly due to instances of receiving defective PPE in the past. This experience of inadequate protection can be traumatic, especially during a pandemic where stringent safety measures are crucial for the well-being of both HCPs and patients. In addition to their attempts to ensure safe patient care requirements, Canadian nurses reported experiencing psychological distress.[7] Higher mental health scores were also observed for negative ratings of access to supplies and PPE.[6] As such, these studies demonstrate an association between HCPs' organizational conditions and the adverse impact on their mental health.[6,7,10,12,18,20,21] Thus, implementing organizational support measures can effectively enhance the mental well-being of HCPs.

3. HCPs' concerns for themselves and loved ones

HCPs have demonstrated unwavering dedication in carrying out their clinical and compassionate duties, often in hazardous working conditions. Throughout this process, they have expressed concerns about their safety, struggled with uncertainty regarding the transmission of the virus to others, experienced isolation from their friends and families, and grieved the loss of loved ones.[22] Consequently, the final theme that emerged is the infection risk faced by HCPs during the pandemic and the subsequent impact on themselves and others. Within this theme, two sub-themes were identified: *Professional stressors* faced by HCPs and *Personal stressors* as they strive to fulfill their roles beyond the confines of their workplaces.

3.1 Professional stressors:

Research studies conducted in Canada have highlighted the genuine apprehension regarding infection among HCPs. Amongst 159 Canadian medical oncologists surveyed, over 70% were worried about 'contracting or transmitting the viruses' to their friends and family.[6,8] Significant connections between adverse mental health impacts and unsafe work environments among nurses have also been established during the COVID-19 pandemic.[6] These impacts encompassed the fear of exposure to COVID-19, the likelihood of transmitting the virus, and the possibility of infecting loved ones within the household. Similarly, nurses expressed worries about falling ill with COVID-19 or inadvertently bringing the virus to their families.[7] These findings collectively underscore the genuine worries experienced by HCPs regarding infection risks and their potential consequences. Another study found that HCPs, including nurses, physicians, counselors, and therapists, expressed significant fear of COVID-19, which hindered their interactions with patients.[22] For some HCPs, fear extended beyond personal safety and encompassed the uncertainty and demands of ensuring the well-being of their patients. Moral distress was also identified among HCPs when their efforts to provide care to vulnerable patients were undermined by uncertainty within workplace policies. Some HCPs prioritized the needs of others, often resulting in the neglect of their well-being.

Additionally, the experiences of 21 HCPs (including nurses, physicians, psychologists, pharmacists, and physical therapists, among others) as they witnessed and encountered their own grief and loss during the pandemic were investigated through journal entries.[25] These HCPs shared accounts of their patients' deaths due to COVID-19. However, they also expressed experiencing their losses at an intensified level, without having the time to emotionally process these losses due to the demands of the pandemic. Additionally, HCPs faced losses in the form of missed opportunities and disruptions.[25] Other HCPs shared how encounters with patients in palliative care resulted in fear of infecting others, leading to self-imposed isolation. Fearing the transmission of the virus, HCPs found themselves suppressing their frustrations, affecting their emotional well-being and exacerbating feelings of loneliness and grief without a supportive community. These findings highlight the emotional toll faced by HCPs as they struggle with grief and loss both personally and professionally throughout the pandemic.

During the COVID-19 pandemic, moral injury also emerged as a significant challenge faced by 32 frontline long-term care staff.[26] It encompassed

various distressing experiences, such as feeling unsupported by management, witnessing residents passing away alone, confronting a lack of preparedness, enduring personal loss or trauma, and dealing with inadequate support following morally injurious events. Each HCP recounted at least one instance of moral injury they had encountered. In these narratives, a prevailing sense of helplessness was identified as a significant component of their experiences, highlighting the profound impact of moral injury on the well-being and professional lives of HCPs during the pandemic.[26]

Additionally, the potential association between personal and work-related concerns and the resultant psychological distress was assessed amongst 455 intensive care unit workers during the COVID-19 pandemic.[11] Among the respondents, 76% of the HCPs had direct contact with confirmed or suspected cases of COVID-19 patients, and 36% reported frequent exposure to the virus. 60% of respondents indicated that their job put them at a higher risk of exposure to COVID-19, and 58% expressed fear of contracting the virus. However, 56% accepted the risk of contracting the virus as part of their job. The study also found that 76% of the respondents expressed concern about the risk of transmitting the virus to their family, 52% to their close friends, 50% to their work colleagues, and 35% to their patients.[11] These findings highlight the significant concerns and fears experienced by HCPs during the pandemic as they continue to provide care while risking infection.

HCPs in critical care units had also recounted experiences where ventilator support was initiated for patients, even when it went against the patients' expected survival outcomes.[21] This contradicts the principles of patient-centered care, which prioritize addressing individual needs and empowering them to actively participate in their healthcare decisions.[27] This resulted in HCPs feeling a sense of failure when their patients were ventilated against their expressed wishes, and they experienced a burden of responsibility for not advocating more strongly on behalf of the patients. Such actions contradicted the moral obligation of HCPs to provide patient-centered care with dignity. Participants in the study reported instances where their professional judgments were disregarded, particularly when patients experienced harm or death. Furthermore, HCPs felt that their employers acted unsupportive toward their well-being. A participant shared an example, stating, "I asked for support from my manager to help deal with burnout and was called over-the-top and mentally ill by senior management."[21] This perception led HCPs to believe that the management placed less emphasis on their well-being and prioritized cost-saving measures, aggravating their frustrations. It underlines the need for supportive leadership, ethical decision-making, and a culture that prioritizes both patient and employee well-being within healthcare organizations.

3.2 Personal stressors:

In the study with 455 intensive care unit workers, social stigma emerged as a concerning issue, where 54% of respondents have experienced avoidance from others due to their job, while 62% of the respondents felt appreciated and acknowledged by society and 45% by their hospital.[11] Only 36% expressed confidence in their employer's ability to provide adequate medical support if they contracted COVID-19, and 21% of HCPs reported resorting to alcohol, marijuana, or other recreational drugs as coping mechanisms. This indicates a problematic situation where HCPs had to rely on substance use rather than receiving the necessary social support.

It was also evident that HCPs (such as nurses, physicians, counselors, and therapists, among others) played multiple roles beyond their professional responsibilities.[22] Participants highlighted the challenges they faced in juggling various roles and responsibilities, and they had to utilize available resources to alleviate some of these struggles. For instance, some participants resided in intergenerational households that included young children and vulnerable elderly adults, adding further complexities to their lives. Additionally, HCPs who had family members residing abroad experienced prolonged

separation and disconnection due to pandemic-related travel restrictions.[22] These accounts shared by participants emphasized that, alongside their frontline HCP roles, they also encountered multiple demands akin to those experienced by the broader general population. However, their personal stressors often remained hidden by the predominant discourse surrounding their professional demands.

The demands of providing care in their own home have created a complex dilemma for HCPs.[22] On the one hand, they are unpaid workers in their personal lives while having to maintain their challenging roles as HCPs at work. The cumulative impact of these intersecting stressors has had significant consequences on the mental and physical health of HCPs. They have experienced bodily pain, sleep disturbances, anger, anxiety, burnout, emotional exhaustion, suicidal ideation, and burnout. The Work and Wellness Survey from Ontario nurses revealed that 60% of respondents indicated high levels of stress.[28] Another study also highlights the immense toll that stressors have taken on HCPs, underscoring the urgent need for support and interventions to address their mental health and well-being.[29]

The experiences of discrimination and racial microaggressions among Asian healthcare workers in the United States and Canada were also prevalent amidst the COVID-19 pandemic.[30] Racial discrimination refers to any form of discrimination directed at individuals based on their skin color, race, or ethnic group.[31] Microaggressions, on the other hand, are subtle and unintentional interactions or behaviors that convey a bias towards historically marginalized groups.[32] Asian HCPs, including nurses, physical therapists, physicians, midwives, pharmacists, and paramedics, have reported elevated levels of racial discrimination alongside the stress of working in healthcare facilities during the pandemic.[30] The primary perpetrators of the microaggressions were members of the public, but participants also reported instances of microaggressions from patients and colleagues. Many participants reported experiencing overt microaggressions relating to COVID-19 that resembled traditional forms of racism.[30] These microaggressions encompassed cases of direct avoidance, such as demands to be attended by a non-Asian doctor, along with derogatory racial stereotypes. As such, the participants reported feelings of anger, fear, and despair, as well as engaging in rumination over the incidents. Additionally, participants expressed hypervigilance and worrying about their safety. All participants reported feeling discontent in regard to how the pandemic was managed by their workplace and the leadership of their countries. Moreover, participants voiced disappointment over the ignorance and lack of attention given to Asian issues and the systemic failure of North American leadership during the pandemic.[30,33,34,35,36]

Discussion and recommendations

This paper provides a critical review of the mental health of HCPs during the COVID-19 pandemic. However, the studies published to date are homogenous, resulting in a limited understanding of the challenges to mental well-being HCPs endured throughout the pandemic. The limited research methods do not uncover some of the nuanced experiences HCPs encounter. Future research needs to address the following knowledge gaps.

The research methods employed in many studies are largely homogenous, primarily relying on online self-report surveys and descriptive statistics to categorize participants into mental health disorders.[6,8,11] This might have limited participants' ability to express concerns beyond the scope of the questionnaires used. Thus, research findings are interpreted through the researcher's lens, limiting the representation and contextualization of participant experiences.[37] Alternatively, the qualitative research designs included in this review revealed unique findings not captured by other methods. For example, one study conducted semi-structured interviews, revealing the anxiety, fear, worry or distress of frontline long-term care and hospital staff with regard to managing their commitments to self and

family.[12] Thus, this design enables a broader understanding of the impacts affecting the mental health of HCPs. For example, as stated in one of the studies, a nurse working in a large urban hospital talked about how the stress of working during the pandemic is affecting her overall well-being and even family relationships: "I've come home and cried many times. I'm stressed out. I can't sleep at night. There's a lot of us having trouble sleeping" (p 270).[12] Thus, studies utilizing structural approaches (e.g., feminist approach) can bring a unique viewpoint in contrast to conventional research approaches on issues such as the mental health and well-being of HCPs, a profession that is heavily female-dominant.[11]

Similarly, various studies collected limited demographic information, missing the opportunities to determine demographic differences.[8,9,11,17] For instance, a study examining the impacts of the pandemic on medical oncologists in Canada only collected minimal demographic information such as practice setting, years in practice and province of practice.[8] This limited information hinders the exploration of mental health concerns across gender and racial backgrounds. Considering that racialized individuals experience poorer mental health outcomes related to COVID-19, demographic information should be included to understand the similarities between HCPs. To gain a deeper understanding of HCPs' experiences, it is crucial to apply a feminist perspective.[11] Majority of participants in the Canadian studies identified as female, reflecting the gender composition of HCPs.[12] These HCPs, especially nurses, are often hailed as "heroes" during the COVID-19 pandemic; however, no improvements have been implemented regarding their well-being and pay equity.[22] Since 2019, HCPs in Ontario have been advocating for the repeal of Bill 124, a policy that imposes wage restrictions of a maximum of 1% on predominantly female HCPs, while frontline professionals which are predominantly male, such as, firefighters and police officers are not subjected to the same limitations.[38] This gender disparity in Canadian healthcare calls for a feminist political economy approach to address both structural inequities and the mental well-being of HCPs.

Our analysis revealed that most studies were based on a medical model to identify mental health symptoms.[6,8,9,15,16] Such a model primarily focuses on physical causes but largely ignores environmental or psychological causes. In other words, these studies have prioritized symptom identification and treatment rather than investigating underlying factors of psychological distress. Various studies assessed anxiety, depression, PTSD, burnout, and stress symptoms using psychometric instruments or indicators among Canadian HCPs during the pandemic.[10,15] Although these studies offer valuable insights into the mental health effects of COVID-19 on HCPs, their focus on symptoms and treatment overlooks the wide range of factors that may contribute to HCPs' psychological distress.

Furthermore, several studies acknowledged that insufficient information impeded their ability to compare mental health status between pre-pandemic and mid-pandemic levels.[6,8,12,15,17] For example, Havaei et al. (2021) found a high prevalence among nurses for PTSD, anxiety, depression, and increased emotional exhaustion.[6] However, the authors are unable to make a causal relationship due to the absence of pre-pandemic workplace conditions and mental health impacts. Stelnicki et al. (2020) is the only article encountered that references a survey sent to nurses pre-pandemic, which could serve as a baseline for comparing pre-pandemic and mid-pandemic occupational stress levels among nurses in Canada.[14] As such, future research should involve tracking HCPs' mental health over more extended periods (i.e., longitudinal study) during the pandemic. These suggestions provide a glimpse of numerous directions for future research on this novel topic.

Overall, the insights provided in this review emphasize the importance of considering the research findings and recommendations in developing and implementing health policies and practices to support HCPs and prioritize their mental health. By acknowledging the mental health impacts, addressing systemic and structural inequities, and embracing a feminist

political economy approach, we can create an environment that promotes the well-being and resilience of HCPs, leading to improved healthcare outcomes for both HCPs and patients in Canada.

Conclusions

The global impact of COVID-19 has affected healthcare systems worldwide, with HCPs experiencing mental health implications. This paper endeavoured to explore the mental health and well-being impacts of the pandemic on HCPs in Canada. Most of the studies reviewed in this paper primarily followed a medical model approach, which tends to emphasize authority and medical perspectives. However, it is important to note that alternative research methods, including those from social work perspectives, have the potential to contribute valuable insights to the existing knowledge base on this topic. Approaches such as critical social justice research can help unveil the role of systemic oppression and its intersections in influencing the adverse mental well-being impacts experienced by HCPs throughout the COVID-19 pandemic. By incorporating these perspectives, our understanding of the topic can be broadened, and we can gain valuable insights into how to effectively support HCPs during these challenging times.

Acknowledgments

The authors are grateful to three anonymous reviewers of the *International Journal of Occupational Safety and Health* for their insightful comments on the earlier versions of this article, which have helped improve the quality of the manuscript

References

1. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Geneva: World Health Organization; 2020. Available from: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed May 9, 2023).
2. Policy Responses to COVID-19. IMF 2021. Available from: https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19 (accessed May 6, 2023).
3. World Health Organization. Promoting mental health: concepts, emerging evidence, practice: summary report. Geneva: World Health Organization; 2004. Available from: https://www.who.int/publications/i/item/9241562943 (accessed May 6, 2023).
4. Systematic reviews: CRD's guidance for undertaking reviews in health care. *Cent Rev Dissem*, 2009. Available from: https://www.york.ac.uk/crd/SysRev/!SSL!/WebHelp/SysRev3.htm (accessed June 20, 2023).
5. Ryan C, Hesselgreaves H, Wu O, Paul J, Dixon-Hughes J, Moss JG. Protocol for a systematic review and thematic synthesis of patient experiences of central venous access devices in anti-cancer treatment. *Syst Rev* 2018; 7:61. Available from: https://doi.org/10.1186/s13643-018-0721-x.
6. Havaei F, Ma A, Staempfli S, MacPhee M. Nurses' workplace conditions impacting their mental health during COVID-19: A cross-sectional survey study. *Healthcare*, 2021; 9:84. Available from: https://doi.org/10.3390/healthcare9010084.
7. Crowe S, Howard AF, Vanderspank-Wright B, Gillis P, McLeod F, Penner C, et al. The effect of the COVID-19 pandemic on the mental health of Canadian critical care nurses providing patient care during the early phase pandemic: A mixed method study. *Intensive Crit Care Nurs*, 2021; 63:102999. Available from: https://doi.org/10.1016/j.iccn.2020.102999.
8. Gill S, Hao D, Hirte H, Campbell A, Colwell B. Impact of COVID-19 on Canadian medical oncologists and cancer care: Canadian association of medical oncologists survey report. *Curr Oncol*, 2020; 27:71–4. Available from: https://doi.org/10.3747/co.27.6643.
9. Smith PM, Oudyk J, Potter G, Mustard C. The association between the perceived adequacy of workplace infection control procedures and personal protective equipment with mental health symptoms: A cross-sectional survey of Canadian healthcare workers during the COVID-19 pandemic. *Can J Psychiatry Rev Can Psychiatry*, 2021; 66:17–24. Available from: https://doi.org/10.1177/0706743720961729.
10. D'Alessandro-Lowe AM, Ritchie K, Brown A, Xue Y, Pichtikova M, Altman M, et al. Characterizing

the mental health and functioning of Canadian respiratory therapists during the COVID-19 pandemic. *Eur J Psychotraumatology*, 2023; 14:2171751. Available from: https://doi.org/10.1080/20008066.2023.2171751.

11. Mehta S, Yarnell C, Shah S, Dodek P, Parsons-Leigh J, Maunder R, et al. The impact of the COVID-19 pandemic on intensive care unit workers: a nationwide survey. *Can J Anaesth J Can Anesth*, 2022; 69:472–84. Available from: https://doi.org/10.1007/s12630-021-02175-z.

12. Brophy J, Keitch M, Hurley M, McArthur J. Sacrificed: Ontario healthcare workers in the time of COVID-19 2021; 30:4. Available from: https://doi.org/10.1177/10482911209743.

13. Wilbiks JMP, Best LA, Law MA, Roach SP. Evaluating the mental health and well-being of Canadian healthcare workers during the COVID-19 outbreak. *Healthc Manage Forum*, 2021; 34:205–10. Available from: https://doi.org/10.1177/08404704211021109.

14. Stelnicki AM, Carleton RN, Reichert C. Nurses' mental health and well-being: COVID-19 impacts. *Can J Nurs Res Rev Can RechEn Sci Infirm*, 2020; 52:237–9. Available from: https://doi.org/10.1177/0844562120931623.

15. Anzola D, Limoges J, McLean J, Kolla NJ. Effects of the COVID-19 pandemic on the mental health of healthcare providers: A comparison of a psychiatric hospital and a general hospital. *Front Psychiatry*, 2022; 12:720693. Available from: https://doi.org/10.3389/fpsyt.2021.720693.

16. Jones AM, writer Ctvn ca, Contact F|. Healthcare workers logged more hours of overtime in 2021 than in a decade: report. CTVNews, 2022. Available from: https://www.ctvnews.ca (accessed May 14, 2023).

17. Marcil M-J, Cyr S, Marin M-F, Rosa C, Tardif J-C, Guay S, et al. Hair cortisol change at COVID-19 pandemic onset predicts burnout among health personnel. *Psychoneuroendocrinology*, 2022; 138:105645. Available from: https://doi.org/10.1016/j.psyneuen.2021.105645.

18. Duong D. Canadian physicians frustrated with vaccine rollout. *CMAJ Can Med Assoc J*, 2021;193: E458–9. Available from: https://doi.org/10.1503/cmaj.1095929.

19. Government of Canada SC. The Daily — Experiences of health care workers during the COVID-19 pandemic, September to November 2021, 2022. Available from: https://www150.statcan.gc.ca (accessed May 8, 2023).

20. Novack K, Dufour R, Picard L, Taddeo D, Nadeau P-O, Katzman DK, et al. Canadian pediatric eating disorder programs and virtual care during the COVID-19 pandemic: a mixed-methods approach to understanding clinicians' perspectives. *Ann Gen Psychiatry*, 2023; 22:16. Available from: https://doi.org/10.1186/s12991-023-00443-4.

21. Ritchie K, D'Alessandro-Lowe AM, Brown A, Millman H, Pichtikova M, Xue Y, et al. The hidden crisis: Understanding potentially morally injurious events experienced by healthcare providers during COVID-19 in Canada. *Int J Environ Res Public Health*, 2023; 20:4813. Available from: https://doi.org/10.3390/ijerph20064813.

22. Sato C, Adumattah A, Abulencia MK, Garcellano PD, Li AT-W, Fung K, et al. COVID-19 mental health stressors of health care providers in the pandemic acceptance and commitment to empowerment response (PACER) intervention: Qualitative study. *JMIR Form Res*, 2022;6: e35280. Available from: https://doi.org/10.2196/35280.

23. Mark Giunta. Ontario hospitals continue to deal with significant staffing shortages [Internet]. Canada: Globalnews; 2022 Oct 21. Available from: https://globalnews.ca/news/9216828/ontario-hospitals-significant-staffing-shortages-october-2022/ (accessed September 17, 2023).

24. Sheena Goodyear. Hospitals are under "unprecedented" strain from staff shortages, says Ontario Health VP [Internet]. Canada: CBC Radio; 2022 Aug 8. Available from: https://www.cbc.ca/radio/asithappens/as-it-happens-the-monday-edition-1.6545121/hospitals-are-under-unprecedented-strain-from-staff-shortages-says-ontario-health-vp-1.6545122 (accessed September 19, 2023).

25. Ansari D. An accumulation of distress: Grief, loss, and isolation among healthcare providers during the COVID-19 pandemic. *SSM - Ment Health*, 2022; 2:100146. Available from: https://doi.org/10.1016/j.ssmmh.2022.100146.

26. Reynolds KA, Pankratz L, Jain B, Grocott B, Bonin L, King G, et al. Moral injury among frontline long-term care staff and management during the COVID-19 pandemic. *Front Health Serv*, 2022; 2:841244. Available from: https://doi.org/10.3389/frhs.2022.841244.

27. Reynolds A. Patient-centered care. *Radiol Technol*, 2009; 81:133–47. Available from: https://pubmed.ncbi.nlm.nih.gov/19901351/

28. RNAO. Work and well-being survey results - 2021. RNAOCa 2021. Available from: https://rnao.ca/policy/work-and-wellbeing-survey-results-2021 (accessed May 14, 2023).

29. Siu HY-H, Kristof L, Elston D, Hafid A, Mather F. A cross-sectional survey assessing the

preparedness of the long-term care sector to respond to the COVID-19 pandemic in Ontario, Canada. *BMC Geriatric*, 2020; 20:421. Available from: https://doi.org/10.1186/s12877-020-01828-w.

30. Shang Z, Kim JY, Cheng SO. Discrimination experienced by Asian Canadian and Asian American health care workers during the COVID-19 pandemic: a qualitative study. *CMAJ Open,* 2021;9: E998–1004. Available from: https://doi.org/10.9778/cmajo.20210090.

31. International convention on the elimination of all forms of racial discrimination. OHCHR. Available from: https://www.ohchr.org (accessed September 19, 2023).

32. Limbong A. Microaggressions are a big deal: How to talk them out and when to walk away. NPR 2020. Available from: https://www.npr.org (accessed September 19, 2023).

33. Chakraborty C. Contagious minorities: Chinese Canadians during the COVID-19 Pandemic. *J Can Stud*, 2022; 56:393–409. Available from: https://doi.org/10.3138/jcs-2022-0017.

34. Leigh JP, Moss SJ, Tiifu F, FitzGerald E, Brundin-Mathers R, Dodds A, et al. Lived experiences of Asian Canadians encountering discrimination during the COVID-19 pandemic: a qualitative interview study. *CMAJ Open*, 2022;10: E539–45. Available from: https://doi.org/10.9778/cmajo.20220019.

35. Wang SC, Santos BMC. "What support?": A qualitative study on social support for Asian American victims of racism during the COVID-19 pandemic. *Frontiers in Public Health*, 2022;10. Available from: https://doi.org/10.3389/fpubh.2022.961215

36. Gover AR, Harper SB, Langton L. Anti-Asian hate crime during the COVID-19 pandemic: Exploring the reproduction of inequality. *Am J Crim Justice*, 2020; 45:647–67. Available from: https://doi.org/10.1007/s12103-020-09545-1.

37. Reid C, Greaves L, Kirby S. Experience research social change: Critical methods, Third Edition. University of Toronto Press; 2017. Available from: https://utorontopress.com/9781442636071/experience-research-social-change/

38. Mohammed S, Peter E, Killackey T, Maciver J. The "nurse as hero" discourse in the COVID-19 pandemic: A poststructural discourse analysis. *Int J Nurs Stud*, 2021; 117:103887. Available from: https://doi.org/10.1016/j.ijnurstu.2021.103887

International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Review Article

Riding to the Rescue: A Comprehensive Review of Health and Safety Measures in Ambulance Cars

Almaazmi AM[1*], Alhammadi SH[1*], Al ali AA[1], Alzaabi NI[1], Makoukji J[1#]

[1]Higher Colleges of Technology, Faculty of Health Sciences, Sharjah Women Campus, Sharjah, United Arab Emirates
*These authors contributed equally to this work

Corresponding author:
Joelle Makoukji Kiklikian, PhD
Higher Colleges of Technology, Sharjah Women Campus, Faculty of Health Sciences, University City Road, Sharjah, United Arab Emirates
Telephone: +971 2 206 6291
Fax: +971 6 558 5435
Email: jkiklikian@hct.ac.ae
ORCID ID: https://orcid.org/0000-0001-7343-4801

Date of submission: 05.06.2023
Date of acceptance: 19.12.2023
Date of publication: 01.04.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i2.55311

ABSTRACT

Paramedics are registered health professionals in numerous countries. Whilst ambulance services must prioritize their patients, they also require personnel to be healthy to perform at their utmost to provide optimal patient care.

Ambulance transport is associated with predictable and likely preventable occupant hazards. These include injuries, serious infections, high rates of musculoskeletal diseases, stress, and mental health problems.

This review article aims to identify the occupational risks in an ambulance service, assess their impact on the health of employees, and explore control measures that can be implemented to reduce the risks and improve the safety of healthcare workers and patients. It underscores the significance of implementing robust risk management strategies to safeguard the well-being of EMS professionals and their patients. Drawing from established risk management principles, it offers insights into hazard prioritization and control measures. It emphasizes the importance of proactive measures such as ergonomic design, infection control, and noise reduction, as well as the need for ongoing training and support for EMS workers.

Ultimately, this comprehensive review article explores the hazards associated with ambulance work across different income-level countries and offers practical solutions to enhance the safety and effectiveness of this critical healthcare service.

Keywords: Control measures, Emergency medical service, Hazards, Occupational health and safety, Risk factors.

Introduction

The word "ambulance" has its origin in the Latin word ‘ambulare’, which means ‘to walk or to move about’. In medieval times, the term ‘ambulant’ was used to refer to a hospital that provided medical care to patients who could still walk or move around.[1]

In the early modern period, the French adopted the word ‘ambulance’ to describe a military field hospital that was staffed by trained medical personnel and used to provide emergency medical care and transport for wounded soldiers. This concept of the ambulance as a mobile medical unit was later adopted by other countries, and the term ‘ambulance’ became widely used to refer to a vehicle used for transporting sick or injured people. In the mid-19th century, civilian ambulance services began to emerge, particularly in urban areas where horse-drawn carriages were used to transport patients to hospitals. In the late 19th and early 20th centuries, motorized ambulances became more common, and ambulance services began to be organized on a

more formal basis. During World War I and World War II, advances in medical technology and transportation led to significant improvements in the care of injured soldiers, and many of these advances were later adapted for civilian use.[1]

Nowadays, ambulances are equipped with a wide range of medical equipment and are a critical component of emergency medical services (EMS) around the world. Ambulance personnel are essential first responders in the community, providing rapid and life-saving advanced medical care to patients in need, during transport to hospitals or other medical facilities. Across different countries, they are known by a variety of terms such as paramedics, emergency medical technicians, emergency medical personnel, emergency dispatch personnel and call-takers. Their role is to directly provide or coordinate the communication of response for out-of-hospital or pre-hospital emergency medical care in the community.[2]

However, working in an ambulance car can be a hazardous occupation, exposing healthcare workers and patients to a variety of potential risks. These hazards can include traffic collisions, biological hazards, ergonomic hazards, noise, and emotional stress. The risks associated with these hazards can have serious consequences for the health and safety of both healthcare workers and patients. Therefore, it is important to understand the potential hazards and risks associated with working in an ambulance car and to implement appropriate control measures to minimize the risk of harm.[3]

In this review article, we will examine the hazards associated with working in an ambulance car, whether in low-, middle- or high-income countries and explore the control measures that can be implemented to reduce the risks and improve the safety of both healthcare workers and patients.

Risk management in the ambulance car

EMS professionals treat approximately 22 million patients each year in the United States of America (USA), and most of the care delivered by EMS involves ambulance utilization, whether transporting patients to the hospital or responding to a call.[4] The ambulance can be a challenging work environment, with potential hazards to both patients and healthcare providers.[5] The out-of-hospital setting is unique to health care and presents many challenges to providing safe, high-quality medical care in emergencies. The challenges of the prehospital environment require thoughtful design of systems and processes of care. Risk management (RM) is a formalized proactive process that has been used in a range of occupational settings, including firefighting and mining, to reduce workplace hazards and injuries.[6] Organizations use formal RM to manage risks and hazards through identification, assessment, and prioritization of risks for mitigation and intervention. RM follows a cyclical set of three phases, including hazard scoping, risk assessment, and implementation of controls within a feedback loop (Figure 1).[6]

ISO 31000 is a risk management standard published by the International Organization for Standardization (ISO). It was first released in 2009 and offers a collection of recommendations designed to help firms streamline risk management. The risk management process typically begins with a risk assessment. Included in the risk assessment is the identification of risk, an analysis of the risk, and an evaluation of that risk. Following the risk assessment, an organization will decide what risk treatment to approach and then monitor and review the risk and results. Fundamentally, the risk management process endeavors to identify risk and then implement a management system to minimize the chance of that risk occurring or, if the risk does occur, to reduce its harm and assure a speedy recovery.[7]

The goal of this review article is to apply risk assessment processes in an ambulance car to identify risks and hazards associated with EMS practices and determine potentially effective control measures.

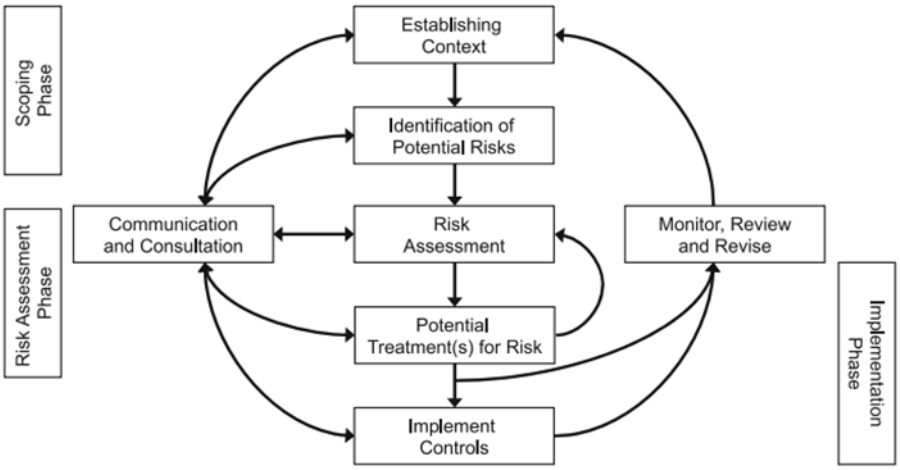


Figure 1: An overview of the Risk Management process, adapted from ISO 31000:2009.[6]

Risks and hazards identified in the ambulance car

EMS personnel encounter a hazardous and difficult work environment in a moving ambulance while providing lifesaving and life-sustaining emergency patient care. The most common occupational hazards in an ambulance car are traffic accidents and collisions leading to injuries due to emergency response driving; biological hazards due to exposure to pathogenic microorganisms leading to serious occupational infections such as hepatitis B and C or Acquired Immunodeficiency Syndrome (AIDS); ergonomic hazard leading to physical strain and musculoskeletal injuries due to unsafe patient handling; physical hazard such as noise in ambient work environment which may cause harm and stress to workers; and psychological hazard leading to occupational stress, burnout and fatigue among ambulance personnel (Table 1).

Table 2: Summary of hazards and their potential associated risks

Hazards	Associated Risks
Emergency Response (Lights & Siren)	Traffic accidents & collisions leading to injuries
Biological Hazard (Pathogens)	Nosocomial infections, Infectious diseases like Human Immunodeficiency Virus (HIV), Hepatitis B, and Hepatitis C
Ergonomic Hazard (Physical strain)	Musculoskeletal Disorders (MSDs), Chronic pain
Physical Hazard (Noise)	Noise-Induced Hearing Loss (NIHL), Stress
Psychological Hazard (Stress)	Mental health issues, Post-traumatic stress disorder (PTSD)

Emergency response driving is cited as a major risk factor in many studies. Custalow and Gravitz reported that 91% of emergency vehicle collisions in Denver occurred under lights and sirens, and the association is driven by generally higher speeds and reduced reaction times during emergencies.[8] High speeds reduce the driver's ability to react to hazards, to safely control the vehicle, and to navigate traffic. A growing body of research demonstrates that ambulance crashes are common. Deadly events may be preventable with attention to the ambulance's external design and the internal configuration of the rear compartment.[9]

Ambulances can conceivably be a potential source

of different pathogenic microbes by virtue of their role in transporting patients from a scene to a healthcare facility. Not only the patients but also the paramedical staff and relatives of the patients may be exposed to various pathogens, some of which may cause serious infections and diseases.[10] A regional study examined the levels of bacterial contamination in Welsh ambulances over 12 months on a monthly schedule. The results showed a variety of microbes at unacceptable levels were present in the samples before cleaning of emergency vehicles, re-emphasizing the need for more stringent infection control programs.[11] Another study also showed that the EMS ambulances of the Kingdom of Saudi Arabia (KSA) can carry pathogenic bacteria that are hazardous to the paramedical personnel, as well as, to the patients that are transported within these ambulances. The pathogens isolated, such as Bacilli, Staphylococci, and Enterococci can pose a substantial risk for nosocomial infections, not only for patients who have weak immune systems but also for personnel. In addition, these pathogens can also be transmitted to new patients or relatives who may travel along with the patient.[10]

Paramedics can be exposed to blood when treating trauma victims who may be experiencing uncontrolled bleeding. Exposure of paramedics to blood can also occur from a sharp injury, such as a needlestick after use on a patient or a cut from a contaminated sharp object while performing advanced life support procedures under unpredictable, adverse conditions. A national survey of paramedics was conducted in the USA, between 2002–2003, to measure the incidence of exposure to blood among paramedics. The survey showed that 22% of paramedics had at least one exposure to blood in the previous year.[12,13] The sharps injury rate for paramedics was also high compared with most hospital workers. Also, exposure of broken skin to blood was extremely high among paramedics. Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV) are all bloodborne pathogens that are transmitted through broken skin; thus, these exposures should be medically evaluated immediately (some treatments, such as for HIV exposure, should be started as soon as possible, preferably within hours). Infected workers who remain undiagnosed could place other people at risk of infection.[14]

In an attempt to ensure timely treatment for their patients, paramedics often place their bodies in high-risk situations. This means paramedics make choices to lift, pull, or push heavy loads all the time. As a result, paramedics have one of the highest overall risks for musculoskeletal injuries among healthcare workers. Roberts et al. demonstrated that paramedics had between 3.5- and 13 times greater risk of lower back injury compared to nurses.[15] In the USA, ergonomic risk factors, such as excessive physical effort, awkward postures, or repetitive movements, were the leading causes of injuries amongst EMS workers, of which 90% were attributed to lifting, carrying, or transferring a patient and/or equipment.[16]

Noise is a ubiquitous potential hazard to our bodies. The World Health Organisation reported that 16% of hearing loss in adults is attributed to occupational noise.[17] Noise-induced hearing loss (NIHL) is a sensorineural hearing loss, explained by a permanent threshold shift of hearing sensitivity. International standards recommend an 'equivalent sound pressure level of 85 dB(A) at 8-h working day average as the exposure limit for occupational noise', to preserve the personnel's hearing when working in a noisy environment. Several studies gave evidence that noise creates physical and psychological stress, commonly presented as reduced assessment, sleep disturbances, cardiovascular dysfunction and mental health alteration. Ambulance service workers are exposed to noise during their shifts in ambulance vehicles, and the noise level varies during signal and non-signal trips, and with different speed levels.[18] A study showed that the Latvian and German ambulance service personnel demonstrate an exposure to hazardous noise level of approximately 85–90 dB(A) during signal trips, which reaches and partly exceeds the exposure limits of 85 dB(A).[19] Another study also

demonstrated that the noise exposure levels among prehospital personnel in Denmark exceeded the recommendations described in the European Regulative for Noise (>80 dB(A)). Although no evidence of occupational hearing loss was demonstrated in the EMS personnel, however a reduced function of the outer sensory hair cells was found in the EMS group following missions.[20] High noise levels can also contribute to serious workplace accidents and injuries. Noise can reduce workers' awareness of what is happening around them, including signals, alarms, and verbal warnings. Studies show that repeated exposures to sounds that are 85 A-weighted decibels (dBA) or higher can cause stress and fatigue, as well as several health problems including ringing in the ears (tinnitus), high blood pressure (hypertension) and cardiovascular disease.[21]

The nature of ambulance work, the uncontrolled and often unpredictable environments, the everyday experience of trauma, and the cumulative nature of that trauma all play a key role in the development and impact of mental distress and psychological injury among EMS personnel.[22-24] In addition to the nature of the work, organizational and occupational factors such as workload, work demands, shift work, limited time for debriefing or downtime, the hierarchical nature of supervision, and the lack of recognition are clearly shown to have effects on the well-being of ambulance personnel that are as significant as, if not greater than, the nature of the work itself. Moreover, several studies have addressed the prevalence of post-traumatic stress disorder (PTSD) symptoms in ambulance services to be much higher than in the general population.[25]

		Hazard Effect/Consequences			
		1 (Minor)	2 (Moderate)	3 (Major)	4 (Maximal)
		First aid case; exposure to minor health risk; little to no economic costs incurred.	Medical treatment; lost time injury; reversible impact on health; exposure to major health risk; economic costs are low.	Loss of quality of life; irreversible health impact; economic costs are moderate.	Single/Multiple fatalities; health impact is ultimately fatal; economic costs are high.
Likelihood		Risk Ranking			
4 (Almost Certain)	The incident occurs with regularity and will continue to occur (>75% likelihood)	7 (M)	11 (H)	14 (EX)	16 (EX)
3 (Likely)	The incident has occurred frequently, and is expected to occur (30-75% likelihood)	4 (L)	8 (M)	12 (H)	15 (EX)
2 (Possible)	The incident has happened at some time (infrequently), and will occur under some circumstances (10-30% likelihood)	2 (L)	5 (M)	9 (M)	13 (H)
1 (Unlikely)	The incident has happened in the past (rarely), and may occur in exceptional circumstances (<10% likelihood)	1 (L)	3 (L)	6 (M)	10 (H)

Figure 2: Hazard matrix used in ranking and prioritizing risks and hazards identified in the ambulance car.[6]

Ranking and prioritizing risks and hazards identified in the ambulance car

The risks and hazards in the ambulance car were prioritized and ranked using a risk matrix approach commonly employed in formal risk assessments. Risk matrices rank hazards based on a product of two domains: the likelihood of the considered hazard to occur; and the severity of bodily injury or harm produced if the hazard occurred.[26] An ordinal likelihood score is assigned

for each hazard on a scale from 1 (unlikely) to 4 (almost certain). Severity was qualitatively assessed and scored on an ordinal scale from 1 (minor) to 4 (maximal) (Figure 2). Risks with a ranking of 1 – 4 (in green) were assigned as 'low priority', 5 – 9 (in yellow) as 'medium priority', 10 – 13 (in orange) as 'high priority', and 14 – 16 (in red) as 'extremely high priority' (Figure 2). Risks and hazards ranked as 'high' to 'extremely high' should be prioritized first for immediate intervention.

The above-mentioned hazards have been evaluated based on their severity and likelihood and assigned a risk level. Based on the risk assessment matrix (Figure 2), the highest priority hazards are emergency response, biological hazard, and ergonomic hazard, all of which have been assigned a 'high risk' level (Table 2). These hazards should be addressed with particular attention and resources to minimize the risk of harm to patients and healthcare workers.

Table 2: Summary of hazards, potential risks, and their priority ranking

Hazards	Potential Risks	Severity	Likelihood	Risk Level
Emergency Response (Lights & Siren)	Traffic accidents & collisions leading to injuries	**Major**	**Likely**	**High (12)**
Biological Hazard (Pathogens)	Nosocomial infections, Infectious diseases like HIV, Hepatitis B and C	**Major**	**Likely**	**High (12)**
Ergonomic Hazard	MSDs, Chronic pain	**Moderate**	**Almost certain**	**High (11)**
Physical Hazard (Noise)	NIHL, Stress	**Minor**	**Likely**	**Low (4)**
Psychological Hazard (Stress)	Mental health issues, PTSD	**Moderate**	**Possible**	**Medium (5)**

Control measures to reduce the risk

Before discussing control measures to reduce the potential risks, it is important to take a step back and think about the hierarchy of controls. Occupational Safety and Health Administration (OSHA) considers the hierarchy of control, as a way to determine what controls would be feasible and most effective (Figure 3).[27]

- Eliminate: This is the preferred method and most effective solution. It is controlling the hazard at the source.
- Substitute: If elimination is not possible, consider substituting or replacing the known hazard with a material, process, or equipment that is less hazardous.
- Engineering controls: A strategy involving denying access to the hazard by installing physical barriers. This could be a redesign of equipment or work processes to reduce the frequency of performing dangerous tasks. Or the isolation of the hazard by installing screens or barriers around hazardous areas.
- Administrative & work practice controls: When exposure to the risk is not, or cannot be

minimized by other means, you should introduce safe work practices, as well as training and education in order to reduce the risk.

- Personal Protective Equipment: Introduce PPE to increase protection and when other measures are not practical.

To prevent hazards associated with working in an ambulance car, healthcare workers should implement control measures that can reduce the risk of exposure to potential hazards (Table 3).

Figure 3: Hierarchy of control.[27]

Table 3: Summary of selected control measures to reduce the risks associated with hazards in the ambulance car

Hazards	Potential Risks	Control Measures
Emergency Response	Traffic accidents & collisions leading to injuries	Modification of rear compartment, secure equipment in place, use seatbelts and helmets, education about traffic laws, follow safe driving practices, use driving assistance technology
Biological Hazard	Nosocomial infections, Infectious diseases like HIV, Hepatitis B and C	Frequent fumigation techniques, use of safety devices, use appropriate personal protective equipment, follow infection control standard procedures
Ergonomic Hazard	MSDs, Chronic pain	New ergonomic design of rear compartment, use lifting equipment and proper body mechanics, job rotation and take regular breaks to rest and stretch
Physical Hazard	NIHL, Stress	Wear appropriate hearing protection (ear muffs or earplugs), turn off unnecessary alarms and sirens, active noise reduction, better insulation of ambulances
Psychological Hazard	Mental health issues, PTSD	Social support systems, receive regular debriefings and counselling, education on stress management techniques

Unfortunately, conventional ambulance designs have been suboptimal and often place EMS

personnel in health-compromising situations, contributing to their high rates of injury, fatality, and early retirement. For example, conventional ambulances were not conducive to seatbelt usage because the patient and supplies were out of reach for seated and restrained EMS personnel. Further, the limited work surfaces resulted in EMS personnel using their seats or their patients' bodies to hold supplies, including sharps. Both the unrestrained EMS personnel and supplies could become dangerous projectiles in a collision and could result in serious injuries.[16] Failure to use current methods of occupant protection for each occupant or to secure equipment effectively can result in catastrophic outcomes for all occupants. Therefore, attention must be given to modifications to the rear compartment, including rounded corners on cabinets, straps to secure equipment thereby preventing projectiles, and the installation of airbags. Results of crash tests showed that EMS personnel and patients in the rear compartment have to be restrained by seatbelts and that seatbelts should even be worn when administering care. The patient should be always restrained by a vacuum stretcher because the risk of expulsion and impact against a sharp corner of a storage compartment is high. Medical equipment and stretchers in the rear compartment are an additional risk during a crash and fixations must be stronger than belts and tested in crash tests. It would be preferable if each piece of medical equipment was provided with a quick-release system. Seatbacks should be placed parallel to the road and secured by seatbelts anchored in three points. There is an urgent need for the dissemination of this safety information and to development of data-driven performance-based safety standards and designs.[28] Education and knowledge are also critical elements in the prevention of ambulance crashes. One study indicated that EMS personnel may not possess adequate knowledge of traffic laws pertaining to driving an ambulance with lights and sirens. Technology is making significant inroads into assisting drivers in carrying out their duties. Notably, several investigators have explored driver monitoring and feedback systems to help change dangerous driving behavior. Devices are available that can alert drivers entering intersections to the presence of other vehicles, notify them when they are too close to a vehicle (to prevent a collision), and warn drivers when they are about to run off the road.[9]

A study confirmed the importance of evaluating the frequency and efficiency of various fumigation techniques as an ambulance is a potential reservoir for microbial transmission to patients and staff. Comprehensive education and infection control programs that help in understanding disease transmission and the etiology of infections are important for paramedics. This will decrease the transmission of nosocomial infections due to better infection control processes by all the staff and cleaning personnel. There is a definite need for stricter implementation of ambulance disinfection programs with more frequency. Many occupationally acquired infections can be limited by proper awareness programs, training initiatives, and stringent guidelines for ambulances.[10] Studies show that 80% of needlestick injuries involved the use of non-safety devices by EMS personnel, and the main predictor for the use of safety devices was whether employers provided them. Major factors for eye and nose exposures to blood included: the patient vomited, spit, or coughed; the patient was uncooperative, combative, or being resuscitated; or the blood/body fluid splashed. Although more than 80% of paramedics said their employers provided safety goggles and face/surgical masks, most splashes to the eye or nose occurred when protection was not used. Paramedics need more training on how to use personal protective equipment (PPE), better-designed PPE, or additional PPE to protect themselves. Note that paramedics had significantly fewer exposures to blood if their supervisors emphasized following Standard Precautions and if paramedics were evaluated on following safety procedures.[14]

Carpal tunnel syndrome, tendinitis, rotator cuff injuries, muscle strains, and other work-related musculoskeletal disorders (MSDs) such as these can be prevented. By implementing ergonomic

solutions in the workplace, you can help reduce the number and severity of work-related MSDs. The standard ambulance's interior design is unsatisfactory based on perceived discomfort and postures that constrain paramedics and medical staff, resulting in unsafe treatment of patients, mainly when being transported. In order to increase risk prevention, ergonomically optimized stretchers should be utilized. Several concrete changes in the design of the ambulance are also recommended in order to reduce the extraordinarily high strain on the paramedics and to increase the safety and user-friendliness of the system during a rescue operation. The new ergonomic design should aim to less effort needed during the transport of the patient, which, at the same time, means lower physical strain on the paramedics' backs and their hand–arm–shoulder systems. Where engineering controls are unable to be implemented, it may be appropriate to consider administrative or work practice controls that establish efficient processes and procedures, such as requiring a two-person lift when materials exceed a certain weight or are awkward in shape/size, and establish a job rotation system to minimize the duration of continual exertion, repetitive motions, and awkward postures, allowing the employee to use different muscle groups.[29]

Education of the ambulance workers about preventive measures to reduce noise hazards, the importance of NIHL development and its health risks, as well as regular audiometry check-ups, are needed. Moreover, there are several ways that noise levels can be monitored such as using personal protective devices like filter-type earplugs, planning to avoid streets of bad quality, which produce excessive noise or need prolonged signal use due to crowded traffic, acoustic insulation and soundproofing to doors, walls and ceilings, and positioning sirens as far away as possible from the personnel, e.g., front of the spoiler.[19] If elimination or reduction of the noise to a safe level is not possible, simple changes in scheduling and operations can significantly decrease the total amount of noise exposure for each worker. Examples of administrative control measures that can be implemented include adapting work procedures to minimize the number of workers exposed to noise and the duration of their exposure, and training workers to be aware of noise hazards, providing them with strategies to limit exposure, and encouraging them to avoid activities which would increase their exposure.[21] The most stressful emergencies according to paramedics are critical and traumatic situations such as road accidents, emergencies with children, family members, or other people they know, and situations where the location is unknown or there is not enough information about the situation. The majority of ambulance personnel must be able to deal with potentially traumatic events reasonably well, and they use different strategies depending on the moment and the situation. Nonetheless, social support is an important protective factor against the negative effects of potentially traumatic events and occupational stress. Besides family and friends, the support given by work colleagues and supervisors is an important emotional support source and may reduce the severity of PTSD symptoms, burnout, and psychological distress. Another strategy to cope with emotional stress is to promote among EMS personnel, through training and educational sessions, health habits and psychosocial skills, such as communication skills, psychological first aid, stress management, teamwork and decision-making skills.[30]

Conclusion

In conclusion, the ambulance system, by the wide range of services it provides and the increasing number of accepted claims, is a job characterized by multiple occupational health hazards for its employees and patients. These hazards include traffic accidents due to emergency response, biological hazards, ergonomic hazards, noise, and emotional stress. To prevent harm to healthcare workers and patients, it is important to implement control measures to reduce the risk of exposure to these hazards. Control measures can include following safe driving practices, using appropriate personal protective equipment, using

lifting equipment and proper body mechanics, and receiving regular debriefings and counseling.

By using a risk assessment table and risk assessment matrix, it is possible to identify and prioritize the hazards and control measures needed to reduce the risk of harm. By addressing the highest priority hazards, healthcare workers can improve their safety and the safety of their patients, and reduce the risk of accidents, injuries, and other health problems associated with working in an ambulance car. The identification of risk factors is part of an extensive technical-administrative and educational prevention program; occupational safety and health training for workers must aim to prevent specific hazards and risks.

References

1. Bravo M. The history of the Ambulance Service [Internet]. Emergency Services Ireland. 2018 [cited 2023 May 19]. Available from: https://emergencyservices.ie/history-of-the-ambulance-service/

2. Lawn S, Roberts L, Willis E, Couzner L, Mohammadi L, Goble E. The effects of emergency medical service work on the psychological, physical, and social well-being of ambulance personnel: a systematic review of qualitative research. BMC Psychiatry [Internet]. 2020;20(1):348. Available from: http://dx.doi.org/10.1186/s12888-020-02752-4

3. Brânduşa Constantin, S Morariu, Olga Odetta Duma, Occupational hazards in a public ambulance service. Rev Med Chir Soc Med Nat Iaşi. 2013 Jul-Sep;117(3):777-80. Available from: https://pubmed.ncbi.nlm.nih.gov/24502049/

4. Maguire BJ, Smith S. Injuries and fatalities among emergency medical technicians and paramedics in the United States. Prehosp Disaster Med [Internet]. 2013;28(4):376–82. Available from: http://dx.doi.org/10.1017/s1049023x13003555

5. Blau G, Chapman S, Boyer E, Flanagan R, Lam T, Monos C. Correlates of Safety Outcomes During Patient Ambulance Transport. Journal of Allied Health Online. 2012;41(3):e69-72. Available from: https://www.jstor.org/stable/48721771

6. Bui DP, Pollack Porter K, Griffin S, French DD, Jung AM, Crothers S, et al. Correction to: Risk management of emergency service vehicle crashes in the United States fire service: process, outputs, and recommendations. BMC Public Health [Internet]. 2017;17(1). Available from: http://dx.doi.org/10.1186/s12889-017-4946-8

7. The ISO 31000 Risk Management Process. (2023, February 8). Available from: https://reciprocity.com/the-iso-31000-risk-management-process/

8. Custalow C. Emergency medical vehicle collisions and potential for preventive intervention*1. Prehosp Emerg Care [Internet]. 2004;8(2):175–84. Available from: http://dx.doi.org/10.1016/s1090-3127(03)00279-x

9. Brice JH, Studnek JR, Bigham BL, Martin-Gill C, Custalow CB, Hawkins E, et al. EMS provider and patient safety during response and transport: Proceedings of an ambulance safety conference. Prehosp Emerg Care [Internet]. 2012;16(1):3–19. Available from: http://dx.doi.org/10.3109/10903127.2011.626106

10. Alrazeeni D, Al Sufi MS. Nosocomial infections in ambulances and effectiveness of ambulance fumigation techniques in Saudi Arabia. Phase I study. Saudi Med J. 2014;35(11):1354–60. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4362147/

11. Nigam Y, Cutter J. A preliminary investigation into bacterial contamination of Welsh emergency ambulances. Emerg Med J [Internet]. 2003;20(5):479–82. Available from: http://dx.doi.org/10.1136/emj.20.5.479

12. Boal WL, Leiss JK, Ratcliffe JM, Sousa S, Lyden JT, Li J, et al. The national study to prevent blood exposure in paramedics: rates of exposure to blood. Int Arch Occup Environ Health [Internet].

2010;83(2):191–9. Available from: http://dx.doi.org/10.1007/s00420-009-0421-x

13. Leiss JK, Ratcliffe JM, Lyden JT, Sousa S, Orelien JG, Boal WL, et al. Blood exposure among paramedics: incidence rates from the national study to prevent blood exposure in paramedics. Ann Epidemiol [Internet]. 2006;16(9):720–5. Available from: http://dx.doi.org/10.1016/j.annepidem.2005.12.007

14. Preventing exposures to bloodborne pathogens among paramedics. National Institute for Occupational Safety and Health. Centers for Disease Control and Prevention. 2010. Available from: https://www.cdc.gov/niosh/docs/wp-solutions/2010-139/default.html

15. Roberts MH, Sim MR, Black O, Smith P. Occupational injury risk among ambulance officers and paramedics compared with other healthcare workers in Victoria, Australia: analysis of workers' compensation claims from 2003 to 2012. Occup Environ Med [Internet]. 2015;72(7):489–95. Available from: http://dx.doi.org/10.1136/oemed-2014-102574

16. Du B, Boileau M, Wierts K, Karch SB, Yung M, Fischer S, et al. Exploring the need for and application of human factors and ergonomics in ambulance design: Overcoming the barriers with technical standards. Appl Ergon [Internet]. 2020;88(103144):103144. Available from: http://dx.doi.org/10.1016/j.apergo.2020.103144

17. Hong, O., Kerr, M. J., Poling, G. L., & Dhar, S. (2013). Understanding and preventing noise-induced hearing loss. Dm Disease-a-month, 59(4), 110–118. Available from: https://doi.org/10.1016/j.disamonth.2013.01.002

18. Johnson, D. W., Hammond, R., & Sherman, R. S. (1980). Hearing in an ambulance paramedic population. Annals of Emergency Medicine, 9(11), 557–561. Available from: https://doi.org/10.1016/s0196-0644(80)80224-1

19. Indulis Dundurs J, Janna Janssen I. Influence of noise in ambulance vehicles on emergency service personnel. In: Noise and Environment. IntechOpen. 2021. Available from: https://www.intechopen.com/chapters/71619

20. Hansen, M. C. T., Schmidt, J. H., Brøchner, A. C., Johansen, J. K., Zwisler, S. T., & Mikkelsen, S. (2017). Noise exposure during prehospital emergency physicians work on Mobile Emergency Care Units and Helicopter Emergency Medical Services. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 25(1). Available from: https://doi.org/10.1186/s13049-017-0459-9

21. Preventing Occupational Noise-Induced Hearing Loss. National Institute for Occupational Safety and Health. Centers for Disease Control and Prevention 2023 May 3. Available from: https://www.cdc.gov/niosh/topics/noise/preventocunoise/default.html

22. Cheng M, Joseph J, Ferguson D. A cognitive behavioural model of first responder posttraumatic stress disorder. J Cogn Psychother. 2018;32(3):184–91. Available from: https://doi.org/10.1891/0889-8391.32.3.184

23. Lanza A, Roysircar G, Rodgers S. First responder mental healthcare: Evidence-based prevention, postvention, and treatment. Prof Psychol Res Pr [Internet]. 2018;49(3):193–204. Available from: http://dx.doi.org/10.1037/pro0000192

24. Lewis-Schroeder NF, Kieran K, Murphy BL, Wolff JD, Robinson MA, Kaufman ML. Conceptualization, assessment, and treatment of traumatic stress in first responders: A review of critical issues: A review of critical issues. Harv Rev Psychiatry [Internet]. 2018;26(4):216–27. Available from: http://dx.doi.org/10.1097/HRP.0000000000000176

25. Sterud T, Ekeberg Ø, Hem E. Health status in the ambulance services: a systematic review. BMC Health Serv Res [Internet]. 2006 [cited 2023 May 19];6(1):82. Available from: http://www.biomedcentral.com/1472-6963/6/82

26. Komljenovic D, Kecojevic V. Risk management programme for occupational safety and health in surface mining operations. Int J Risk Assess Manag [Internet]. 2007;7(5):620. Available from: http://dx.doi.org/10.1504/ijram.2007.014090

27. Clark G. Ergonomics: Controlling the hazards [Internet]. Thegibsonedge.com. [cited 2023 May 20]. Available from: https://www.thegibsonedge.com/blog/ergonomics-controlling-the-hazards

28. Fournier M, Chenaitia H, Masson C, Michelet P, Behr M, Auffray J-P. Crew and patient safety in ambulances: Results of a personnel survey and experimental side impact crash test. Prehosp Disaster Med [Internet]. 2013;28(4):370–5. Available from: http://dx.doi.org/10.1017/s1049023x13003543

29. Kluth K, Strasser H. Ergonomics in the rescue service—Ergonomic evaluation of ambulance cots. Int J Ind Ergon [Internet]. 2006;36(3):247–56. Available from: http://dx.doi.org/10.1016/j.ergon.2005.10.002

30. Oliveira AC, Neto F, Teixeira F, Maia Â. Working in prehospital emergency contexts: Stress, coping and support from the perspective of ambulance personnel. Int J Workplace Health Manag [Internet]. 2019;12(6):469–82. Available from: http://dx.doi.org/10.1108/ijwhm-01-2019-0004